Environment in the European Union at the turn of the century

European Environment Agency

Layout:
Folkmann Design

Cover design:
Rolf Kuchling

European Environment Agency
Kongens Nytorv 6
DK-1050 Copenhagen K
Denmark
Tel. (+45) 33 36 71 00
Fax (+45) 33 36 71 99
E-mail: eea@eea.eu.int
Home page: http://www.eea.eu.int

Contents

Foreword

The Agency has previously reported that despite more than 25 years of Community Environmental Policy – which has been successful in its own terms – general environmental quality in the European Union is not recovering significantly, and in some areas, it is worsening. This present report confirms both that situation and the fact that the unsustainable development of some economic sectors is the major barrier to improvement.

Up to now what has been missing has been an assessment of whether the actual economic, sectoral and environmental policies over the next decade or so will bring improvements, or whether there are trends and developments pushing us off target and seriously challenging substantial progress.

This report, *Environment in the European Union at the turn of the century,* is designed to address this issue, providing information on the current state and future trends that is of direct use for deciding on sound and effective measures to really improve and protect the environment and to move towards more sustainable development (Amsterdam Treaty, Articles 2 and 6).

What do we see?

In summary, most of the major challenges will continue over the next decade, namely significant societal developments (in gross domestic product, population, consumption) and, despite some notable exceptions, a general failure to de-link these from environmental pressures; increasing environmental burdens from the growth of road and air transport, and general urbanisation and 'suburbanisation'; degradation of the rural environment; and increasingly significant risks to the valuable natural and biodiversity assets of central and eastern European countries, as well to those remaining in southern and Mediterranean countries and in northern and western Europe.

But we also see some small yet fast-growing positive signals that should be known about more widely, disseminated and encouraged: growth in wind energy; cycling taking higher percentages of some cities' traffic; pesticide-free areas or municipalities being declared in many countries; significant growth in organic agriculture; improving energy efficiency in many countries; some EU countries establishing indicators and even quantitative targets to master unsustainable development; and many municipalities and companies embracing sustainability as a feasible and profitable process, developing their own local Agenda 21 programmes at local and business level.

What else do we need to identify and report on that could help improve environmental quality and overcome unsustainable trends?

As the Agency has struggled to build a seamless monitoring and reporting system, what has been missing is a more structured reference model with indicators and eventually targets for the main issues. In short, we have not had the instruments to make the socio-economic system accountable, in environmental and sustainability terms, to encourage and reward it to take a sustainable path.

The Agency will now move a further step forward by implementing the new obligation (Review of the 1210/1990 Council Regulation) to issue regular reports based on indicators. The first report to be published to provide a set of EU Environment Signals, by the end of 1999, will present an extended package of indicators to show progress and trends. From this a set of so-called 'headline indicators' will be identified. Together with GDP and other key welfare indicators, attempts are being made to produce a so-called 'well-being index' beyond GDP, to better represent quality of life including environmental quality and progress with sustainability.

Since all this implies change, the political framework is also important. Environmental policy may have eased some problems, but economic and sectoral policies beyond the control of environmental policy have created new and bigger ones. The integration of environment into other policies is destined to face conflict. However, the 'Cardiff Initiative' (European Council of June 1998), has begun to operationalise this by calling upon the key economic and sectoral policies (Agriculture, Transport, Energy, Internal Market, Industry, Finance, Development) to be accountable in environmental and sustainability terms. The Helsinki Council in December 1999 should take stock of progress and link these sectoral developments with a Global Assessment of the Fifth Environmental Action Programme (to which this report is an input). A coordinated report on indicators (to which the EEA 1999 Environmental Signals report is a main contribution) is also to be presented by the European Commission.

The present report is one step on the way to more effective reporting. The approach taken here is expected to allow for more successful partnerships tackling environment and sustainability issues: partnerships involving policy makers, users and consumers, the ordinary citizen, and not least of all, business and industry, which now understands that there will be no business if it is not sustainable business. Such developments are part of the move from 'environment as a burden' to 'environment (and sustainability) as an opportunity'. Forthcoming reports, in particular our yearly 'EU Environmental Signals' report based on indicators, should allow a more frequent monitoring of progress than our three or five-yearly report have hitherto allowed. These reports will also be the opportunity to identify, and perhaps even to focus upon, emerging positive experiences and trends, including indicators on encouraging issues or topics, disaggregated spatially (by Member State) or sectorally.

Both the reporting and accountability frameworks seem to be improving as do the political will, the readiness of the business sector and the public's demands and expectations. We have two big challenges ahead of us: the climate change challenge or reducing greenhouse gases with the rational use of fossil fuels (from climate change to a climate for change), and the enlargement of the EU (taking sustainability as a goal and compliance as a result). Both challenges could become increasing opportunities for ultimately testing our will and our capacities to improve the environment, quality of life and progress towards sustainable development. Let us do it.

Domingo Jiménez-Beltrán
Executive Director

Acknowledgements

This report was written with the collaboration of a large number of individuals. This list serves to acknowledge their work. However, the responsibility for the assessment rests with the European Environment Agency. The editors apologise for the involuntary omission of any individual who contributed to the report.

National Contact Points and other national contributors

Austria: Johannes Mayer;
Belgium: Jan Voet, Anne Teller, Alain Derouane, Daniel Rasse;
Bulgaria: Nikola Matev;
Cyprus: Nicos Georgiades;
Czech Republic: Jaroslav Benes, Vaclav Krejci;
Denmark: Bjarne Nørup, Torben Moth Iversen;
Estonia: Leo Saare;
Finland: Tapani Säynätkari;
France: Cécile Rechatin, Jean-Louis Weber;
Germany: Karl Tietmann;
Greece: Mata Aravantinou;
Hungary: Elemer Szabo, Pal Bozo;
Iceland: Hugi Ólafsson;
Ireland: Larry Stapleton, Annmarie Tuohy;
Italy: Angela Spagnoletti, Claudio Maricchiolo;
Latvia: Ieva Rucevska, Ilze Kirstuka;
Liechtenstein: Petra Bockmühl;
Lithuania: Liutauras Stoskus;
Luxembourg: Jean-Paul Feltgen;
The Netherlands: Adriaan Minderhoud;
Norway: Berit Kvæven;
Poland: Zbigniew Kamienski, Anna Bobiñska;
Portugal: Maria Leonor Gomes;
Romania: Mihai Lesnic, Serena Adler;
Slovak Republic: Juraj Bebej, Jan Jezny;
Slovenia: Doroteja Carni, Anita Velkavrh;
Spain: Juan Martínez Sánchez;
Sweden: Ebbe Kvist, Ingvar Andersson;
United Kingdom: Chris Ward.

European Commission contacts

Steering group: Robert Hull, Nicholas Hanley, Robert Donkers, Kevin Flowers

Contributions received from Commission services from many individuals; co-ordinated by Alan Huyton, Robert Donkers, Lara Manovil (DG XI: Environment, Nuclear Safety and Civil Protection)

Contributors by chapter

Chapter 2.1 Meeting needs and consuming resources
Co-ordination
David Gee (EEA)
Author
David Gee (EEA)
Contribution
Stephan Moll (EEA)

Chapter 2.2 Economic development
Co-ordination
Teresa Ribeiro (EEA)
Authors
Teresa Ribeiro (EEA); Hans Vos (DHV Environment & Infrastructure, NL; EEA since 01.01.99)
Contributions
Stephan Moll, (EEA); David Wilkinson, David Baldock, Malcolm Ferguson (IEEP); Pantelis Capros (NTUA, GR)

Chapter 2. 3 Land use footprints
Co-ordination
Chris Steenmans, Ronan Uhel (EEA)
Author
Barry Wyatt (Institute for Terrestrial Ecology, UK); Chris Steenmans (EEA)
Contributions
Margaret Hall (GIM, LU); Jean-Louis Weber (IFEN, Fr); Michel-Henri Cornaert (European Commission, DG XII); Simon Turner, Hester Lyons (ADAS, UK), Katherine Kaye (Oxford University, UK)

Chapter 3.1 Greenhouse gases and climate change
Co-ordination
André Jol (EEA)
Authors
Tinus Pulles (ETC-AE/TNO, NL); André Jol (EEA)
Contributions
Simon Eggleston (ETC-AE/AEA, UK); Manfred Ritter (ETC-AE/UBA, A); Pantelis Capros (NTUA, GR); Marcel Berk (RIVM, NL)

Chapter 3.2 Ozone depleting substances
Co-ordination
Gabriel Kielland (EEA)

Author
Guus Velders (ETC-AQ/RIVM, NL)
Contributions
Harry Slaper (RIVM, NL); Ankie Piters (KNMI, NL); Christos Zerefos, (AUT, GR)

Chapter 3.3 Dispersion of hazardous substances
Co-ordination
Paolo G. Meozzi (EEA)
Author
Eberhard Falck, DE
Contributions
David Gee, Niels Thyssen (EEA), Allan Astrup Jensen (dk-TEKNIK, DK), Søren Lindholt, David Santillo (Greenpeace UK), Prof. Philippe Bourdeau (Université Libre de Bruxelles, B), Prof. Bo Jansson (Institute of Applied Environmental Research, ITM, SE), Tom Feijtel (Procter and Gamble, B); Winand Smeets, Addo van Pul, Ton van der Linden (RIVM, NL)

Chapter 3.4 Transboundary air pollution
Co-ordination
Gabriel Kielland (EEA)
Authors
Jeannette Beck (ETC-AQ/RIVM, NL); Frank de Leeuw (ETC-AQ/RIVM, NL); Leonor Tarrason (ETC-AQ/DNMI, NO)
Contributions
Jaroslav Fiala (PTL-AQ/CHMI, CZ); Jan F. Henriksen (ETC-AQ/NILU, NO); David Simpson (ETC-AQ/DNMI, NO); Markus Ammann, Janusz Cofala (IIASA, AT); Jean-Paul Hettelingh (RIVM, NL)

Chapter 3.5 Water stress
Co-ordination
Niels Thyssen (EEA)
Authors
Teodoro Estrela, (ETC-IW/CEDEX, ES); Peter Kristensen (ETC-IW/NERI, DK); Concha Lallana (ETC-IW/CEDEX, ES)
Contributions
Wolfgang Krinner, (ETC-IW/CEDEX, ES); Steve Nixon (ETC-IW/WRc plc, UK); Niels Thyssen, Jock Martin (EEA); Blue Plan (Mediterranean Action Plan)

Chapter 3.6 Soil degradation
Co-ordination
Anna Rita Gentile (EEA)
Author
Anna Rita Gentile (EEA)
Contributions
Gundula Prokop (ETC-S/UBA Vienna, AT); Winfred Blum (University of Agriculture and Natural Resources, Vienna AT); Mike Pollack (WPA, AT); Gert Jan van den Born (RIVM, NL); Peter Loveland, Bronwyn Syed (ETC-S/SSLRC, UK); Diego de la Rosa, Juan José Ibañez, (ETC-S/CSIC, ES); Peter Kristensen (ETC-IW/NERI, DK): Gert-Jan van den Born (RIVM, NL)

Chapter 3.7 Waste generation and management
Co-ordination
Anton Azkona (EEA)
Authors
Kim Michael Christiansen, Jan Riemer, Christian Fischer (ETC Waste, DK)
Contributions
Matt Crowe (EPA, IRL); Hans Jörg Krammer, Patrizia Dreier (Umweltbundesamt, AT); Jürgen Schmit (ABAG-ITM)

Chapter 3.8 Natural and technological hazards
Co-ordination
David Stanners (EEA)
Author
Glenn Pettitt (ERM, UK)
Contributions
Stephanie Haywood (NRPB, UK), Christian Kirchsteiger (JRC, MAHB/ISIS)

Chapter 3.9 Genetically modified organisms
Co-ordination
David Gee, Ronan Uhel (EEA)
Author
Brian Wynne, (Lancaster University, UK)
Contributions
Sue Mayer (Lancaster University, UK), AM Chevre; R von Schomberg; Eileen Buttle (EEA Scientific Committee); David Gee (EEA); Astrid Thomas, Doug Miller (International Environment Monitor, Canada)

Chapter 3.10 Human health issues
Co-ordination
David Gee (EEA)
Authors
Michal Krzyzanowski (WHO), David Gee (EEA)
Contributions
Katherine Kaye (Oxford University, UK); Andrew Watterson (De Montfort University, UK); Jim Bridges (Surrey University, UK); Rory O'Neill (Hazards, UK); Astrid Thomas, Doug Miller (International Environment Monitor, Canada); Valeska Stupak (Global Health and Environment Monitor, USA); Kyriakos Psychas (EEA)

Chapter 3.11 Changes and loss of biodiversity
Co-ordination
Ulla Pinborg (EEA)
Author
Dominique Richard (ETC Nature)
Contribution
Eileen Buttle; Ole Osterman (ETC-NC); Dirk Wascher (ECNC); Dorian Moss (ITE, UK); Hans-Werner Koeppel (BfN); Johan Abenius

(SEPA); Ben ten Bring, Rob Alkemade, Michel Bakkenes (RIVM, NL); Blue Plan (Mediterranean Action Plan)

Chapter 3.12 Urban areas
Co-ordination
Ronan Uhel (EEA); Margaret Hall (GIM, LU)
Authors
Knut Felberg (Asplan Viak/NORPLAN, NO); Philip Mellen, Daniel Puig (COWI, DK); Nicolas Moussiopoulos, Sophia Papalexiou (ETC-AQ/AUT, GR); Gijsjan van Blokland (M+P, NL); Kyriakos Psychas (EEA)
Contributions
Gabriel Kielland (EEA); Hans Eerens (RIVM, NL); Volker Stabernak (World Systems Europe, LU); Blue Plan (Mediterranean Action Plan)

Chapter 3.13 Rural areas
Co-ordination
Ronan Uhel (EEA); Margaret Hall (GIM, LU)
Author
Kevin Bradley (ERM, IR)
Contributions
David Gee (EEA); Margaret Hall (GIM, LU); Volker Stabernak (World Systems Europe, LU)

Chapter 3.14 Coastal and marine zones
Co-ordination
Evangelos Papathanassiou, Ronan Uhel (EEA); Margaret Hall (GIM, LU);
Authors
Evangelos Papathanassiou (EEA); Paola Picco (ETC-MC/ENEA-CRAM, IT);
Contributions
Kari Nygaard (ETC-MCE/NIVA, Norway); Argyro Zenetos (ETC-MCE/NCMR, GR); Gunni Ærtebjerg (ETC-MCE/NERI DK); Stefano Moretti (ENEA, I); Hein Rune Skjoldal (IMR, N); François Desrentes (CRPM, F); Nicos Georgiades (Environment Institute, CY); Blue Plan (Mediterranean Action Plan)

Chapter 3.15 Mountain areas
Co-ordination
Ronan Uhel (EEA); Margaret Hall (GIM,LU)
Authors
Stephan Marzelli, Monika Bissinger, Manuela Wurmer (Ifuplan, DE)
Contributions
Martin Price (University of Oxford, UK); Vincent Briquel (CEMAGREF, F); Jörg Wyder (SAB, CH); Jérôme Laurent (JRC, IT); Volker Stabernak (World Systems Europe, LU)

Chapter 4.1 Environment/Economy integration
Co-ordination
Peter Bosch (EEA)
Authors
David Pearce, Paul Steele, Tannis Seccombe-Hett (EFTEC, UK)

Chapter 4.2 Environmental information: needs and gaps
Co-ordination
Ernst Klatte, Ronan Uhel (EEA)
Authors
Jock Martin (EEA); David Gee (EEA)
Contributions
Gordon McInnes, Ernst Klatte, Ivone Pereira Martins, Louise Rickard, Sanni Manninen and many other project managers (EEA); Jane Hunt (Lancaster University, UK); Dorothy Williams (Robert Gordon University, UK); Ralph Hallo (Stichting Natuur & Milieu, NL); Jeremy Wates (EEB, IRL); Roger Fouquet (Imperial College London, UK); Astrid Thomas, Doug Miller (International Environment Monitor, Canada)

Data collection and processing

EEA: Sofia Vaz, Sanni Manninen, Robert Enesund, Sheila Cryan, Anna Rita Gentile, Jaak Claessens, Britt Ehlers, Louise Rickard, Stephan Moll, Thien Le Tri

EEA/Phare co-ordination: Adriana Gheorghe

ETC-Nature Conservation: Sophie Condé, Marie-Paule Vignault (ETC-NC), Barry Wyatt, Sandrine Petit (ITE, UK), Ruud Foppen (UBN-DLO), Risto Päivinen (EFI, SF)

PTL/Nature Conservation: Julius Oszlanyi, Lubos Halada, Marcel Suri, Peter Gajdos, Mircea Oltean, Ulo Mander

ETC-Marine and Coastal Environment: Paola Picco, Stefano Moretti, Kari Nygaard, Argyro Zenetos, Gunni Ærtebjerg

ETC-Air Emissions: Dietmar Koch, Manfred Ritter

ETC-Inland Waters: Peter Kristensen, Teodoro Estrela, Concha Lallana

PTL/Inland Waters: Janos Feher, Danuse Berankova, Lidija Globevnik, Waldemar Jarosinski, Ferenc Laszlo, Marta Konkoly

ETC-Land Cover: Rolf Bergström, Robert Enesund

ETC-Soil: Sigbert Huber, David Moreno, Gundula Prokop

ETC-Air Quality: Roel van Aalst, Sofia Papalexiou, Nicolas Moussiopoulos, Evelina Tourlou, Rob Sluyter, Inga Fløysand, Jozef Pacyna

PTL/Air Quality: Jaroslav Fiala, Hana Livorova, Miriam Dvorakova
ETC-Waste: Christian Fischer

Carl Bro Group (under contract to the Phare Programme): Birthe Thode Jacobsen, Hans Olsson

Eurostat: Inger Öhman, Rosemary Montgomery, Hermann Peifer (EEA as of mid-1998)

EMEP: Ann-Gunn Skjellbrekke, Svetlana Tsyro, Sophia Mylona

WHO: Alexander Kuchuk, Kees Huysmans

International Energy Agency (IEA): Karen Treanton

University of Gent: Eric Van Ranst, Giete Callaert (soil)

RIVM: Jaap van Woerden, Kees Klein Goldewijk (soil)

Maps: design and production

Co-ordination: Chris Steenmans (EEA)

Production: GRID Warsaw (under contract to the Phare Programme): Marek Baranowski, Maria Andrzejewska

Graphs: design and production

Co-ordination: Sanni Manninen, Louise Rickard (EEA)

Production: Alan Cooper, David Davies, David Cooper (Lovell Johns); Sven Lund; Rolf Kuchling (EEA)

Outlooks

Co-ordination and editing: Teresa Ribeiro, Hans Luiten (EEA), Paul Rump

Baseline Scenario

EEA co-ordination: Teresa Ribeiro in co-operation with RIVM.

RIVM co-ordination: Bronno de Haan, Bart Strengers, Jean-Paul Hettelingh, Keimpe Wieringa

Contributors: RIVM; NL; IIASA, AT; DHV, NL; IVM, NL; ETC-AE; ETC-AQ; ETC-IW; ETC-NC; ETC-W; André Jol, Gabriel Kielland, Anna-Rita Gentile; Stephan Moll, (EEA); Paul Rump

Co-ordination, Editing and Support

Ronan Uhel; Robert Barrass; Lois Williamson; Julia Tierney; Leena Mikkonen

EEA Editorial Committee

Ronan Uhel (overall co-ordination); David Stanners (chair); Gordon McInnes; Peter Bosch; Teresa Ribeiro (Outlooks); Jock Martin, David Gee, Hans Luiten, Sanni Manninen

1.1. Introduction

1. Objective and structure of the report

1.1. Regular state-of-the-environment reporting: to situate EU98 scope

The European Environment Agency was established in 1994 to provide objective, reliable, and comparable information on the state, pressures and sensitivity of the environment in the European Union and its surroundings. One of the vehicles to communicate this information are 'State of Environment reports', of which the Agency has published until now three: (i) *Europe's Environment: The Dobris Assessment* (1995); (ii) *Environment in the European Union 1995: report for the review of the Fifth Environmental Action Programme* (1995) and (iii) *Europe's Environment: The Second Assessment* (1998). These reports are intended to support strategic environmental planning, and are linked to important steps in EU (or European) policy processes.

Now, in 1999, the time has come for an update on the European Union's environment. A comprehensive new assessment has been carried out over the past two years and is published here under the title '*Environment in the European Union at the turn of the century*'.

The Regulation (EEC/1210/90) which establishes the Agency requires that the state of the environment report (SoER) should describe the present and the foreseeable state of the environment from the following points of view: the quality, the pressures and the sensitivity (art. 3). The Regulation also mentions priority areas and, in particular, transfrontier, plurinational and global phenomena which shall be covered. Trends and developments in economic sectors that influence the trends in the state of the environment should also be taken into account. The state of the environment report then contributes to the provision of information necessary for framing and implementing sound and effective environmental policies (art. 2.ii).

Measurement and factual diagnosis of the state of the environment therefore form the core of the report, including an assessment of the main causes (driving forces and pressures) and the major problems (in terms of impacts on ecosystems and human health for example). This assessment uses as much as possible statistical and numerical measurements (i.e. information from the European Information and Observation Network, known as the EIONET monitoring network, including Eurostat) to show the state of previous years and contains information on the most recent years available (see Box 1.1.1; see Chapter 4.2 for a complete overview of the environmental information situation).

Future trends of the state of the environment constitute a second important element of the report. The time horizon established for this prospective analysis in this report is generally 2010, although for specific issues such as climate change a longer time frame is used. The environmental trends are derived from an economic scenario (reflecting 'business-as-usual' development) based on a consistent set of socio-economic assumptions, the current state of the environment, and existing and proposed policies prior to August 1997 at the EU level. Where possible, the projected trends are compared to established standards, either policy targets or sustainable reference values. Only one relatively high-growth scenario was used in this exercise. This scenario – referred to as the baseline – provides an initial indication of whether targets and reference values will or will not be met under existing and proposed policies under a number of assumptions that are described below and in the

Box 1.1.1. Geographical coverage and shortcomings

The report focuses primarily on the state of the environment in the 15 European Union (EU) Member States. In discussing the EU Enlargement issues, the report also covers 11 Accession Countries: Bulgaria, the Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, the Slovak Republic, Slovenia and Cyprus. Finally, Economic Free Trade Area (EFTA) countries (Iceland, Liechtenstein, Norway, Switzerland), are marginally treated. Regions on the margin (Mediterranean, Baltic, Arctic) have been considered if information is available. In other words, the EU98 report provides information on the present and future environmental situation of the EU, taking into account, where possible, enlargement and the wider European context, in support of the EU policy debate.

The report does not cover an assessment of the following environmental issues: nuclear waste; natural radioactivity; non-ionising radiation; energy security; microbiological and thermal pollution of surface waters; pests and locusts; and loss of cultural heritage. The report is also limited in consistently covering specific and positive developments or 'success stories', either geographically (Member States doing better) or sectorally (e.g. organic farming growth).

respective chapters. It also enables the report to provide a perspective on new and emerging priority issues. It does not, however, provide an evaluation of current policies or propose options for additional measures. The baseline scenario was developed in agreement with the European Commission services (jointly with Directorate-General XI). In order to complement the information on the baseline which only covered EU Member States, the EEA developed a number of outlook studies to cover possible future development in the Accession Countries (EEA, 1999a, b, c).

Part of the picture drawn by the report, therefore, includes emerging problems, either as a result of a worsening trend in a recognised area (following the results of the above-mentioned trend analysis) or information on new issues.

Environmental indicators, which are closely linked with the previous three points, offer the way to synthesise and substantiate the analysis. Currently, indicators are also gaining increasing political recognition and importance, and at the end of 1999 the EEA will publish its first indicator-based report to be repeated perhaps on a annual basis (see Box 1.1.2).

The work in this report does not stand alone. It links with other reporting activities at the Agency on topics, sectors and themes. It also connects to the indicator-based reporting through the use of common data sets and indicators, as well as reporting at the global scale organised by the United Nations Environment Programme (UNEP, the GEO report series). By linking such activities, the aim is to develop a single monitoring-to-reporting system which can be used for consistent and reliable reporting at many different levels.

Box 1.1.2. Towards regular indicator-based reports

The EEA is developing a regular indicator-based report, which would become the tool for making regular environmental performance reviews. Such a report would be an outlet for the most aggregated data coming out of the EIONET (the European Environmental Observation and Information Network linked to the EEA). The report would not only be a collection of selected environmental statistics and fact sheets, but would also include an assessment of developments using the DPSIR framework for the analysis. To emphasise this difference, the term 'indicator-based report' is used here.

The development of sectoral reporting mechanisms to monitor integration of environment in sectoral policies, as a follow up to the 1998 Cardiff and Vienna European Councils, is further shaping the indicators and the content of the planned report.

1.2. Construction and structure of the report

The structure and contents of the report have been designed with two main objectives in mind: (i) to provide a clear analytical framework, which embraces integrated environment assessment (IEA) methodologies; and (ii) to develop a consistent forecast of the state of the environment.

IEA is defined by the EEA as: '*the interdisciplinary process of identification, analysis and appraisal of all relevant natural and human processes and their interactions which determine both the current and future state of environmental quality, and resources, on appropriate spatial and temporal scales, thus facilitating the framing and implementation of policies and strategies'*. This set of methodologies is represented by the D-P-S-I-R framework, where there is a chain of causal links starting with 'driving forces' (economic sectors, human activities) through 'pressures' (emissions, waste) to 'states' (physical, chemical and biological) and 'impacts' on ecosystems, human health and functions, eventually leading to political 'responses' (prioritisation, target setting, indicators) (see Chapter 4.2).

Thus, the report is laid out according to these interconnected processes and is constructed around four sections: Introduction; Societal developments and use of resources; Environmental problems, including specific spatial cross-cutting chapters; and Integration issues. Under each section individual chapters are structured more or less as follows:

- What are the current and future trends in the state of the environment, and what are the driving forces and pressures causing these trends?
- Framing of the main issue(s) (and their causes), including emerging issue(s). This section sets up and frames the *raison d'être* and scope of the assessment developed further in the chapter.
- Looking at these focused issues and analysing them in more detail, how do/will they affect the state of the environment and consequently to what sort of impacts do/will they lead? The detailed description of the issues substantiates and disaggregates the above (regionally/geographically or by sectors), and indicates what is the scientific basis for the past, present and foreseeable changes in environmental quality. The reasons are addressed why these changes and impacts matter, i.e. what are the scientific, economic and social reasons

for being concerned about their occurrence.

- What is being done to respond to the problem and in particular where in DPSIR are the responses being focused? The main line of reasoning is to characterise in qualitative terms the response to the problems drawing from: a) expert knowledge of the policy framework; b) available information on policy measures in place and in the pipeline (European Union and Member States, mandatory or voluntary) and, c) what the available performance indicators show.

2. Prospective reporting methodology

2.1. Outlooks future trends

The current report focuses on the state of the environment for the EU and the Accession Countries as, obviously, a main development within the outlook period will be the expected accession to the EU of countries in central and eastern Europe. However, consistent projections as developed under the baseline scenario (see section 2.1.1 below), are not available for current non-EU countries. Some information from the baseline projections, for example in map form, cover other parts of Europe, but this does not provide a complete picture for all priority issues. In addition, external influences on the EU environment are not part of the baseline scenario.

2.1.1. The baseline scenario

As previously noted, the report goes beyond a presentation of environmental trends from the past to the present day to complete for the first time at EU level an integrated assessment of future environmental trends. Wherever possible, the chapters of the report provide a perspective on the future state of the environment usually to the year 2010. This is based on three factors: the current state of the environment with a base year of either 1990 or 1995 depending on data availability; the projected changes in socio-economic parameters (Chapter 2.2.); and the implementation of existing and proposed EU policies. Future environmental trends are discussed primarily in the chapters on Greenhouse gases and climate change (3.1), Ozone-depleting substances (3.2), Dispersion of hazardous substances (3.3), Transboundary air pollution (3.4), Water stress (3.5), Soil (3.6), Waste generation and management (3.7), Changes in biodiversity and in ecosystems (3.11), and Urban areas (3.12).

The development of future trends is necessary in order for the report to:

- be policy-relevant for decision makers;
- identify new emerging problems;
- take into account socio-economic uncertain economic developments, such as GDP growth, restructuring CEE economies, investment cycles, and implementation of regulations; and
- assess the impact of chemical and biological time-lags in the environmental system.

In this report, one baseline scenario is presented which uses an integrated environmental assessment methodology developed through a collaboration between the European Commission-DGXI and the EEA in conjunction with a consortium of RIVM (leader), EFTEC, NTUA and IIASA (EEA, 1998; European Commission, 1999). The assessment addresses: (i) prominent European environmental problems (PEEPs), described in the Dobris report (EEA, 1995) together with relevant environmental targets, policy objectives, and goals; and (ii) the economic sectors that constitute the driving forces of the PEEPs, with projections for individual countries. The integrated assessment methodology assumes that both current policies and, in general, those proposed by the European Commission to the European Council prior to August 1, 1997, will be fully implemented by 2010. The methodology combines economic models, energy use models, emission data sets and models, and environmental effects models (see Table 1.1.1).

In this prospective analysis, consensus over societal trends was desirable in order to ensure consistency within the European Commission. Therefore, the macro-economic and energy outlooks are taken from DG XVII 'business-as-usual' pre-Kyoto scenarios (The energy dimension of climate change, COM(97)196, 1997). New transport and agriculture outlooks have been commissioned by the EEA and developed in consistency with the economic and energy outlooks. The results have been the object of review and discussions with DGs VII and VI respectively. The baseline scenario is therefore defined by a conforming set of outlooks, starting with the socio-economic assumptions and ending, as far as possible, with impacts on the various environmental media, ecosystems, and human health. This baseline scenario has been used in other studies conducted for the European Commission (DG XI) and the UNEP.

2.2.1. Components of the modelling work

The baseline scenario depends upon a linked chain of predictive models (Table 1.1.1). The chain starts with an initial scenario at the global level generated by WorldScan which, for the European region, is then disaggregated by GEM-E3 (General Equilibrium Model for Energy-Economy-Environment) to the national level, before being used by MIDAS/PRIMES to generate energy-use and CO_2 emission forecasts. These in turn provide input data for a number of economic and environmental models, to project the development of driving forces and the state of the environment.

The temporal horizon of the macro-economic trends cover two distinct periods: before and after 2000. Macro-economic forecasts up to 2000 are taken from European Commission-DGII estimates for 12 EU Member States. For the longer term, macroeconomic forecasts from the OECD 'high five' scenario (OECD, 1995) have been slightly moderated on the basis of recent developments. This global scenario is based on high growth of all economies in a 'globalising' world. Under favourable conditions, the economies of the 'Big Five' (China, India, Indonesia, Russia and Brazil), together with the rest of the developing world, are modelled to grow rapidly as all regions drive to attain affluence levels comparable to those of OECD countries. A significant increase in pollution is expected to accompany this rapid economic growth. Furthermore, energy demand in the EU is expected to grow at high rates (1.5-1.8% per year) during the 1995-2030 period. This scenario describes probable and positive general economic developments for the longer term and therefore does not accommodate possible short-term fluctuations that may take place in some countries (such as in Russia, Indonesia, Brazil).

Macro-economic forecasts to 2030 at the European level are derived from these global forecasts using the GEM-E3 model which provides a preliminary long-term scenario for each EU Member State. These forecasts provide the level of sectoral desegregation demanded by energy models such as PRIMES and MIDAS. Using these models, there is an attempt to build a separate sectoral perspective for each EU country. The projections are made in two steps:

- the GDP of each country is developed, assuming gradual convergence of EU economies in terms of per capita income;
- the driving forces for each economy are then identified and used to deduce sectoral growth based on an understanding of the present situation and trends in each country.

In addition, new model calculations were made for transport and agriculture. As freight transport is closely related to economic developments, new runs were made with the NEAC transport model based on the 'high five' scenario. For agriculture, new calculations were made for the development of livestock assuming full adoption of the CAP reform measures of 1992, using the CAPMAT model developed by SOW-VU. The very recent Agenda 2000 reforms are outside the definition of the baseline and are therefore not considered.

Despite the emphasis on an integrated assessment, some inconsistencies remain due to ambiguous data sets and to resolution differences in the set of models used. The estimation of the degree of uncertainty for such a complex sequence of models is problematic. A full Monte Carlo analysis is impractical, given the very large number of input parameters in the model chain. The uncertainty analysis, therefore, has been limited to a series of comparisons with actual measurements. Clearly, future work in this area will be a priority for state-of-the-environment reporting.

2.2. The "What if?" studies for Accession Countries

The accession process, together with the economic restructuring of the 1990s, is significantly changing the economy, legislative systems, and personal lifestyles in Accession Countries. In order to have a better insight into the potential impacts of the ongoing and future changes in Accession Countries, a selected number of environmental issues have been studied in so-called "What if?" studies. The term "What if?" is used to reflect potential effects under different assumptions. There is a high degree of uncertainty in such studies, associated with the questions: which countries will become member of the EU and when; and what socio-economic development and environmental trends will occur in these countries. Due to these uncertainties, the impacts of two or three different assumptions in each study are explored for the 10 Accession Countries (EEA,1999a, b, c). The objective is not to 'predict the future', but to contribute to decision-making by showing a range of potential impacts to 2010.

Models and main sources used for the baseline scenario — Table 1.1.1.

Chapter	Model/Source name	DPSIR indicator	Model/Source description
2.2. Economic developments	WorldScan (CPB)	EU15 GDP (driving force).	This model has been used for OECD to perform macro-economic projections for 12 world regions (OECD, 1997). Europe is included as one single aggregated region. The 'High growth' variant on world scale delivered the assumptions about average European growth.
	GEM-E3 (NTUA; Capros *et al.*, 1997)	GDP by country and by sector; energy supply and demand (driving force).	A general equilibrium model detailing the macro-economy for EU and its Member States, and the interactions with the environment and the energy system.
	MIDAS/PRIMES (NTUA; Capros *et al*, 1997)	Energy consumption (driving force).	Energy systems model simulating market equilibrium solutions for energy supply and demand for Europe.
	NEAC Transport Simulation System (NEA) (EEA, 1998)	Freight transport.	The model uses a demand-oriented approach: total transport of a commodity group between two regions is explained as a function of economic production and 'attraction' indicators.
	CAPMAT (SOW-VU) (EEA, 1998)	Livestock.	An applied general equilibrium model to simulate overall medium-term effects in generating the basic developments with respect to supply, demand and cross-commodity substitution.
3.1. Greenhouse gases and climate change	MIDAS/PRIMES (NTUA; Capros *et al*, 1997)	CO_2 emissions (pressure).	Energy systems model simulating market equilibrium solutions for energy supply and demand for Europe. CO_2 emissions have been derived from energy use.
	Ecofys,1998a, b; AEA, 1998a, b	CH_4 , N_2O, HFC, PFC, SF_6 emissions (pressure).	Models/studies providing baseline 2010 projections of CH_4 , N_2O, HFC, PFC, SF_6 emissions.
	IMAGE 2.0 (RIVM)*	Atmospheric concentrations of CO_2, CH_4, and N_2O (state). Sea level rise and temperature increase (impact).	Integrated model of global climate change providing forecasts of CO_2, CH_4, and N_2O emissions and concentrations; temperature increase, and sea-level rise.
3.2. Ozone-depletion substances	Daniel *et al*, 1995 (EEA-ETC-AQ)	Total stratospheric chlorine and bromine (pressure).	Model of stratospheric concentrations from estimates of current and future production of halocarbons.
	Bordewijk and van der Woerd, 1996 (EEA-ETC-AQ)	Ozone layer thickness and UV change (state).	Calculated on the basis of measured total ozone, ignoring cloud effects. The calculation is based on skin cancer weighted UV data.
	UV-CHAIN (RIVM)*	Excess skin cancer incidence (impact).	Model integrating the dynamic aspects of ozone depletion using a source-risk approach.
3.3. Dispersion of hazardous substances	EMISSIONS (EEA-ETC-AE,1998a)	Emissions of heavy metals and persistent organic pollutants (POPs) (pressure)	Model of pollutant emissions providing baseline projections for Cd, Cu, Hg, Pb, NO_x, SO_x, PM_{10}, dioxins, benzene, PAC, Lindane, and Endosulphane.
	EUTREND (RIVM)*	Cadmium concentrations (state).	European long-term atmospheric transport model.
	EUROS (RIVM)*	Concentration and deposition of dioxin (state).	Long-range atmospheric transport of POPs providing baseline projections of concentrations and depositions.
	GEO-PESTRAS (RIVM)*	Leaching of pesticides from agricultural soils (state).	One-dimensional model for assessing leaching and accumulation of pesticides.
3.4. Transboundary air pollution	RAINS (IIASA)*	Emissions of SO_2, NO_x, NH_3 and NMVOC (pressure). Acid and nitrogen compound depositions (state). Exceedance of critical loads in ecosystems (impact). Exceedance of health and vegetation critical levels for tropospheric ozone (impact)	The RAINS (Regional Air Pollution Information and Simulation) model focuses on acidification, eutrophication, and rural concentrations of tropospheric ozone. It consists of modules on emission generation, atmospheric deposition of pollutants, environmental sensitivities and emissions control options and costs.
3.5. Water stress	Projections (EEA-ETC/IW, 1998a)	Water demand (pressure).	The projections have been derived with linear regression analyses using the most recent data from member countries.
	CARMEN (RIVM)*	Nutrient concentrations in rivers and coastal waters (state).	A one-layer GIS-based model to forecast European nitrogen and phosphorous concentrations and loads in surface and groundwater.
	Projections (EEA-ETC/IWb; EWWG, 1997)	Waste water treatment (response).	The projection has been based on information from countries on expected waste water treatment after implementation of Urban Waste Water Treatment Directive.

.../...

Chapter	Model/Source name	DPSIR indicator	Model/Source description
3.6. Soil degradation	IMAGE 2.0 (RIVM)*	Water erosion risk on agricultural areas (pressure).	The model used has been adapted from the water erosion risk module of the integrated IMAGE 2 model. The model generates a water erosion risk index based on three main parameters: terrain erodibility (based on soil type and land form), rainfall erosivity, and land use pressure. Actual water erosion risk is calculated from potential risk by considering the different degree of protection against erosion exerted by different types of crops. The model has been applied to agricultural areas only.
3.7. Waste generation and management	Projections (EEA-ETC/W, 1998)	Generation of selected waste streams: municipal/household waste, paper and cardboard waste, glass waste and end-of-life vehicles (driving force).	The projection has been derived with linear regression analyses using the most recent data from member countries and the trends in GDP-related consumption.
3.11. Changes and loss of biodiversity	MIRABEL (Petit *et al.*, 1998)	Changes in biodiversity and habitat types.	MIRABEL (Models for Integrated Review and Assessment of Biodiversity in European Landscapes) is a conceptual framework for evaluating major environmental pressures in the form of 13 impact matrices; one for each ecological region. The matrices have been derived from literature, expert opinions and semi-quantitative modelling.
	EUROMOVE (RIVM)*	Climate change effects on plant species (impact).	European effects model for vegetation, providing forecasts for shifting species patterns, and loss of species and populations.
3.12. Urban areas	EUTREND (RIVM)*	Concentrations and exposure to inert air pollutants.	Dispersion model used for the calculation of annual averaged concentrations and depositions.
	OFIS (RIVM)*	Concentrations and exposure to urban ozone.	Two-dimensional photochemical dispersion model for calculation in and around urban areas.
	PNE (M+P; Blockland *et al.*, 1998)	Population exposure to road traffic noise (state).	Population Noise Exposure (PNE) model uses the relation between the EU15 city size and the amount of inhabitants exposed to road traffic. For these relations measurements data and former inventories are used.
	Air traffic noise (M+P; (Blockland *et al.*, 1998)	Population exposure to air traffic noise (state).	Relationship between air passengers and population exposed to noise, based on the location of 35 airports covering 85% of the total capacity.

*: European Commission, 1999

Three studies have been chosen:

- the effects of trade liberalisation, especially on transport and agriculture;
- the potential development of air emissions; and,
- the impacts of the full implementation of the Urban Waste Water Treatment Directive.

These issues have been selected because of their transboundary effects and their huge potential impacts. For air emissions, compliance with current EU standards is very pertinent considering the expected increase of industrial activities as well as improved energy efficiency in Accession Countries. A scoping study on the liberalisation of trade in 1997 showed that transport and agriculture are expected to be particularly influenced by reduced border restrictions between the EU and Accession Countries. In addition, the application of the EU Common Agriculture Policy to Accession Countries will probably have significant impact on agriculture. The implementation of the Urban Waste Water Treatment Directive in Accession Countries is likely to ameliorate the condition of many international river basins and seas. The costs and benefits of such changes are expected to be significant for both the Accession Countries and the EU.

All three studies are based on the same macro-economic and demographic assumptions in order to maintain consistency. The macro-economic developments for the EU are derived from the pre-Kyoto business-as-usual scenario used by DG XVI. GDP development in Accession Countries is based on national sources and forecasts of the EBRD (EBRD, 1996). A rather moderate GDP rate of growth is assumed to follow the depression period of the early 1990s. Energy baseline projections are taken from the Official Energy Pathways (OEP, 1996). United Nations forecasts are used for population projections in the Accession Countries (United Nations, 1994).

3. Policy context

3.1. Goals to serve: sustainability, integration, enlargement

Since environmental policy is becoming ‘a policy of policies’ as a main instrument for sustainable development, the EEA role to provide sound and reliable information to support the framing and implementation of environmental policies is crucial. Now enshrined since 1997 as a European Union goal in the Amsterdam Treaty, sustainable development reinforces the demand for reliable and relevant environmental information.

This is an important step forward reinforced also by: i) the review of the Fifth European Environment Action Programme ‘Towards Sustainability’ which in 1998 was the object of a co-decision stressing the need for targets in the economic sectors and a mechanism to follow progress; and, ii) the ‘global assessment’ of this programme which will be discussed in 1999 as basis for a future EU environmental policy framework from 2000.

3.2. Need to focus on integration

The Kyoto meeting on climate change (December 1997) illustrated to the world the close links between environment and economic policy. At the EU level, the Agenda 2000, adopted by the March 1999 Berlin European Council, covers proposals for the development of EU policies (notably agriculture and cohesion), a comprehensive strategy for enlargement and an analysis of the EU’s financial requirements in the medium term (2000-2006) taking account of future accessions to the European Union. A second volume gives a detailed assessment of the implications of enlargement for the EU policies and presents a pre-accession strategy for all candidate countries. Simultaneously the Commission issued its Opinions on the accession applications from the 10 countries of central and eastern Europe.

It is widely agreed that the principle of integrating environmental policy into other policy areas is one of the key elements for the Global Assessment of the EC’s Fifth Environmental Action Programme.

Integration is a key element in environmental policy. It has been gaining increasing attention since the Maastricht Treaty and was reinforced by the Amsterdam Treaty which underlines its importance and defines it as a way to achieve sustainable development. At the Cardiff European Council (June 1998) the Commission Communication on Integration was endorsed and the Agriculture, Energy and Transport Councils were invited to report on integration progress at the following summit in Vienna (December 1998).

For Vienna these Councils presented reports committing themselves to integration and reporting on the actions already taken. The European Council invited them to continue their work with a view to submitting comprehensive strategies in these sectors, including a timetable for further measures and a set of indicators, to the Helsinki European Council. In addition it invited the Development, Internal Market and Industry Councils to undertake work on the integration issue.

Within the process of the Global Assessment of the Fifth Environmental Action Programme, the European Environment Agency is focusing its contribution on this key element: integration.

When publishing *‘Europe’s Environment: The Second Assessment’* in 1998, the EEA presented a set of criteria for assessing the integration of environmental actions into sectoral policies. These criteria have now been further developed and applied in an assessment (EEA, 1999d) to support the Global Assessment and to identify integration strategies for the sectors analysed: Industry, Agriculture, Energy and Transport. The objective of this first analysis is to take stock of the current situation in the Member States in relation to eco-efficiency, market integration and management integration. The present criteria (Table 1.1.2) focus on the important role of prices, taxes and subsidies in encouraging particular forms of sectoral activity (market integration), and on the use of environmental impact assessments, management systems and product policies to anticipate and minimise environmental impacts (managing integration).

Indicators that monitor eco-efficiency gains and progress towards the internalisation of environmental and infrastructure costs are of major importance for the new sectoral reporting mechanisms requested by the recent Cardiff and Vienna European Councils. Important progress has been made in particular with the transport sector, and the Transport and Environment Reporting Mechanism (TERM), initiated by the EEA in co-operation with the EC as the mechanism to deliver regular information on environ-

Table 1.1.2. **Some criteria for assessing the integration of environmental actions into sectoral policies**

Source: EEA

A	**Economic integration**
1	Have eco-efficiency targets and indicators been developed and used to monitor progress towards 'more well-being from less nature'?
B	**Market integration**
2	To what extent have negative environmental effects been quantified?
3	To what extent have negative environmental effects been internalised in market prices through market-based instruments?
4	How effective have these instruments been in reducing the negative environmental effects?
5	To what extent have revenues of these instruments been directly recycled to maximise behaviour change?
6	To what extent have revenues of these instruments been directly recycled to promote employment?
7	To what extent have environmentally damaging subsidies and tax exemptions been withdrawn or refocused?
8	To what extent have market-based instruments been introduced which encourage environmental benefits?
C	**Management integration**
9	Is there adequate environmental impact assessment of projects before implementation?
10	Is there strategic environmental impact assessment of policies, plans and programmes at different spatial levels?
11	Is the purchasing of 'green' supplies by public/private institutions encouraged?
12	Are other sector-specific environmental measures applied /monitored?

mental integration in transport, is the forerunner in this field of sectoral reporting (EEA, 1999e).

The EEA regular indicator-based report will also contribute to a harmonisation of approaches to monitoring progress with integration via an assessment of both environmental themes and sectors throughout the Member States.

When the EEA adopted its DPSIR framework, based on the OECD PSI approach, it was already developing a more holistic perspective in the way environment should be assessed. By adding, or making more explicit, 'driving forces' and 'responses' in the analysis framework, environmental assessments become more complete and the information provided more effective for policy analysis. Learning how important and effective actions could be in the driving forces 'box' has been the trigger for developing more and more work on the integration of environment into sectoral policies. The results increasingly show that as each economic sector contributes to several environmental problems – usually through just a few pollutants – environmental actions within a single sector can deliver benefits in several areas.

Measuring integration of environmental policy is, however, much more difficult than the established monitoring of the deterioration or improvement of the environment, or of pressures acting on it. Assessing or judging the effectiveness of integration is a difficult task which requires an agreed set of criteria and relevant information available for these criteria. However, the time lag between identifying environmental problems and devising policy measures provides another important reason to attempt this 'higher' level policy evaluation, regardless of the difficulties.

The success of sectoral integration can be measured by the extent to which sectors decouple their economic activity (measured by output indicators, such as GVA, industrial production or passenger kilometres in transport) from their environmental impacts, with associated increases in their eco-efficiency. This concept is the first criteria where an assessment of past and future trends is presented. It is expected that with further work the criteria, and the information supporting them, will be improved and expanded.

3.3. Enlargement: from EU15 to EU25?

The Heads of State and Government of the EU countries agreed in Copenhagen in June 1993 that the associated countries of central and eastern Europe which so desired would be able to be members of the EU once they had met the agreed political and economic conditions. This accession process was perceived as an opportunity since these countries were anyway going to have to undertake structural reforms of all kinds. Consequently, doing this as part of an adhesion process would help bring them into step with the development of the EU countries, something which is considered vital for the future political and economic stability of Europe. Accession negotiations were opened on 31 March 1998 with the six countries recommended by the Commission (Cyprus, Hungary, Poland, Estonia, the Czech Republic and Slovenia).

The expansion of the internal market to include 100 million consumers in rapidly growing markets will increase trade and provide substantial new output and employment opportunities for European firms. Enlargement is expected to bring major benefits in terms of peace and security in Europe by providing stability and prosperity in the region. This enlargement can also be seen a great environmental opportunity, not only for the 10 associated countries but also for EU countries.

Environmental benefits of enlargement are a challenge, as are the economic costs associated with environmental compliance. These benefits should be greater than the economic costs, although it is fair to describe these as considerable: they have been evaluated at about EUR 100 000 million or about EUR 1000 per inhabitant. This cost is more than the total annual budget of the European Union and is of particular significance if it is remembered that the average income of these countries is one-third that of Europe.

The process of enlargement thus poses questions regarding economy. The EU's political commitment to integration and overall strategy (Agenda 2000) means that the enlargement of the EU offers an opportunity, through the financing and co-operation process for application of Community environmental legislation, to aim that effort at focusing the Accession Countries' socio-economic development along sustainable pathways and, thereby, to contribute to steering this process at the level of the entire future EU. In this context, it has been commented that present and future EU countries are all 'economies in transition'.

In these circumstances it is clear that these countries have had to be associated in the process of drawing the environmental picture of this enlarged EU, which the present report provides. Representatives of the Accession countries have therefore participated in the compilation and review of this report.

References

AEA, 1998a. *Options to reduce methane emissions*, draft report prepared for the Commission (DGXI), September 1998.

AEA, 1998b. *Options to reduce nitrous oxide emissions*, draft report prepared for the Commission (DGXI), September 1998.

Blokland G.J., Beckenbauer, Th. *et. al.*, 1998, Present state and future trends on transport noise in Europe, Report prepared for the EEA, M+P Raadgevende Ingenieurs bv. and Muller BBM

Bordewijk, J.A. and van der Woerd, H.J., 1996. Ultraviolet dose maps of Europe, a remote sensing/ GIS application for public health and environmental studies. In *BCRS report* n°96-3_. Delft, the Netherlands.

Capros, P. *et al.*, 1997. *Business- as-usual scenario for the EU Energy System 1995-2000 - Final report to the European Commission DG XVII/A2.* National Technical University of Athens.

Council Regulation EEC N° 1210/90 of 7 May 1990 on the establishment of the EEA and the EIONET - (A Council Regulation amending the original regulation is in process).

Daniel, J.S., Solomon S. and Albritton D.L., 1995. On the evaluation of halocarbon radiative forcing and global warming potentials. *J. Geophys. Res.* 100, 1271-1285.

Ecofys, 1998a. *Reduction of the emissions of HFCs, PFCs and SF6 in the EU*, draft report prepared for the European Commission, October 1998.

Ecofys, 1998b. *Emission reduction potential and costs for methane and nitrous oxide emissions in the EU*, draft report prepared for the European Commission, June 1998.

EEA, 1995. *Europe's Environment: The Dobris Assessment*. Eds: D.A. Stanners & P. Bourdeau. European Environment Agency, Copenhagen.

EEA, 1998. Report on Economic Outlooks (unpub.) Report prepared by DHV for the European Environment Agency.

EEA, 1999a (forthcoming). Environment and European Enlargement. Appraisal of future trends. Agriculture and Transport (working title). Scenarios & Prospects no 2. Technical report.

EEA, 1999b. *Environment and European Enlargement. Appraisal of future trends*. Air Emissions. Scenarios & Prospects no 1. Environmental issues no 8. European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EEA, 1999c (forthcoming). Environment and European Enlargement. Appraisal of future trends. Implementation of the Urban Waste Water Treatment Directive (working title). Scenarios & Prospects n° 3. Technical report.

EEA, 1999d (forthcoming). Monitoring Progress Towards Integration: a contribution to the Global Assessment of the EC's Fifth Action Programme. EEA Technical report.

EEA, 1999e. *TERM - the Transport and Environment Reporting Mechanism*. EEA Technical Report

EEA-ETC/AE - Visschedijk, A., Pulles, T., Coenen, P. and Berdowski, J., 1998. Emissions of selected Heavy Metals and Persistent Organic Pollutants in Europe - A Background Study for the SoER98 and EU Priority Study Report. *TNO Report* TNO-MEP-R 98, Apeldoom NL, 35 pp.

EEA-ETC/IW, 1998a. Contribution from the European Topic Centre on Inland Waters to RIVM's study on priorities, Water demands in Europe. European Topic Centre on Inland Waters. Report for European Environment Agency.

EEA-ETC/IW, 1998b. Nutrient discharges from point (industry and consumers) in the 10 Accession countries. Technical Report to the EEA from the European Topic Centre on Inland Waters. December 1998.

EEA-ETC/IW, 1999. Implementation of the Urban Waste-water treatment Directive in the 10 Accession Countries. Report prepared for EEA.

EEA-ETC/W, 1998. European Topic Centre on Waste. Methodology Report. Baseline projections of selected waste streams, June 1998

European Commission, (1999) (forthcoming). Economic Assessment of Priorities for a European Environmental Policy Plan (working title). Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environment, Nuclear Safety European Commission, (1999) (forthcoming). Economic Assessment of Priorities for a European Environmental Policy Plan and Civil Protection).

EWWG, 1997. Urban waste-water treatment in the EU. Report from the European Waste Water Group.

OECD, 1997. Towards a global age: challenges and opportunities. Draft analytical report. SG/Links(97)1, 52602

Petit, S *et.al*., 1998, MIRABEL, Models for Integrated Review and Assessment of Biodiversity in European landscapes, Report to the EEA-ETC on Nature Conservation.

1.2. Summary

1. Some progress, but a poor picture overall

What has been achieved, and in what areas – and what is the outlook?
From the summary table below, which shows the situation and prospects for both pressures and impacts for the main environmental problems, it appears that apart from significant and positive cuts in ozone-depleting substances, progress in reducing other pressures on the state of the environment has remained largely insufficient – in spite of positive trends in some areas such as reducing emissions contributing to acidification, or phosphorus discharges to rivers.

The outlook for most of the pressures is also not encouraging, in particular with future emissions increasing in problem areas that have appeared difficult to tackle: greenhouse gas emissions, chemicals and waste. These

Pressures		Environmental Issues	State & Impact	
Present	*Future*		*Present*	*Future*
😐	☹	Greenhouse Gases and Climate Change	☹	☹
🙂	😐	Ozone Depletion	☹	😐
😐	☹	Hazardous Substances	😐	?
😐	😐	Transboundary Air Pollution	😐	😐
😐	😐	Water Stress	😐	😐
☹	☹	Soil Degradation	☹	?
😐	☹	Waste	☹	☹
😐	?	Natural and Technological Hazards	😐	?
😐	?	Genetically Modified Organisms	?	▭
☹	☹	Biodiversity	😐	?
😐	😐	Human Health	☹	?
😐	😐	Urban Areas	😐	😐
☹	☹	Coastal and Marine Areas	☹	?
☹	?	Rural Areas	☹	▭
☹	?	Mountain Areas	☹	▭

Legend: 🙂 positive development; 😐 some positive development but insufficient; ☹ unfavourable development
▭ no quantitative data available; ? uncertain (partial quantitative/expert analysis available)

Assessment of progress over the past 5-10 years and trends up to 2010 (2050 for Climate Change and Ozone Depleting Substances). The indications about the pressures show how factors, such as emissions of pollutants or land use, which give rise to the problems, are changing. The information about state and impacts indicate how these pressures are feeding through into changing environmental quality.

pressures feed through into an equally troubling story about the state of the environment. Here, no overall positive trends can be depicted within the scope of the outlooks. For most of the issues there has either been insufficient progress towards recovery of a healthy environment, or unfavourable underlying developments. Adverse developments are expected concerning impacts from climate change and waste generation. Some limited developments are nevertheless anticipated where impacts relate, for example, to transboundary air pollution, water pollution and air quality in cities, are expected to improve.

There remain, however, considerable uncertainties. Due either to a lack of data in some areas (such as in soil, biodiversity or pesticides in groundwater) or to uncertainties about future socio-economic developments, it is difficult to understand clearly the direction in which we are heading. It is particularly difficult to assess the prospects of important emerging issues, which are also of rising public concern such as human health issues, hazardous substances and genetically modified organisms.

Consequently, the state of the European Union's environment remains a serious concern. And while the evidence is that actions in some areas – e.g. acidification – to pre-empt and prevent environmental damage are improving, and yielding major dividends, it is clear that more needs to be done across a large front to improve environmental quality and ensure progress towards sustainability. In particular, environmental actions need to be integrated more closely into economic measures.

Box: Where are we now?

Greenhouse gases and Climate change

- Carbon dioxide emissions fell about 1% between 1990 and 1996, with considerable variation between Member States. Methane emissions are decreasing.
- Global and European annual mean temperatures have increased by 0.3-0.6°C since 1900; 1998 was the warmest year on record.

Ozone-depleting substances

- The potential 'chlorine plus bromine' concentration (total potential depletion of the ozone layer) peaked in 1994 and is now decreasing.
- The use of ozone-depleting substances has decreased sharply, faster than required by the international measures, but atmospheric concentration of halons is still increasing against expectations.

Hazardous substances

- Various control measures have reduced chemical risk and some emissions, and environmental concentrations of persistent organic pollutants and heavy metals are declining.
- However, for 75% of the large volume chemicals on the market, there is insufficient analysis of toxicity and eco-toxicity available to support minimal risk assessment.

Transboundary air pollution

- In most countries, sulphur dioxide, volatile organic compounds and, to a lesser extent, nitrogen oxide emissions have declined. But success in abating emissions from stationary sources was almost counterbalanced by increased emissions due to rapid transport growth; emissions from international shipping are expanding their share.
- Harmful effects of transboundary air pollution on ecosystems have been reduced.
- All threshold values for summer smog set under the Ozone Directive have been exceeded since 1994.

Water stress

- There has been a significant decrease in the number of heavily polluted rivers due to reductions in point source discharges (such as phosphorus); organic matter discharges have fallen by 50 to 80% over the last 15 years.
- Nitrate concentrations in EU rivers have shown little change since 1980, contributing to eutrophication in coastal waters. Nutrient input from agriculture is still high.
- EU countries are yearly, on average, abstracting around 21% of their renewable freshwater resources, which is regarded as a sustainable position. Big water losses occur in southern EU countries – around 18% of the resource is lost each year in irrigation, and overexploitation and salinisation of groundwaters in the coastal areas continue to be critical.

Soil degradation

- Damage is increasing and leads to irreversible losses due to growing water erosion, continuing local and diffuse contamination, and sealing of soil surfaces.

Waste

- The EU is generating and transporting more solid waste. EU Waste Strategy goals have not been reached: waste prevention measures have not stabilised production, and landfilling is still the most common treatment method despite significant progress in recovery and recycling.
- Recycling of glass and paper has been increasing but not sufficiently quickly to reduce overall generation for these waste streams.

Hazards

- Between 1990-96, economic losses due to floods and landslides were four times those in the whole of the preceding decade. As yet, there is no targeted policy to reduce natural hazards.

... / ...

- Major industrial accidents continue to occur; over 300 accidents have been reported since 1984 in EU. There is indication that many of the often seemingly trivial 'lessons learned' from accidents have not yet been sufficiently evaluated and/or implemented in industry's practices and standards.
- The overall risk to the European environment from accidental releases of radionuclides, even if small, cannot be quantified.

Genetically modified organisms (GMOs)
- The issue of the genetically modified organisms remains beset by scientific uncertainty and political controversy.
- They have been released experimentally to the environment – as new crop plants – since 1985/86, and four commercial food crops have been approved.
- Under EU legislation which regulates their release – deliberate and accidental – and their safety in food, EU marketing consent for GMO products takes at least 1-2 years; and none has been approved unanimously so far.

Human health
- Traditional environmental health problems from unsafe drinking water, inadequate sanitation and poor housing have largely disappeared from the EU.
- According to the World Health Organisation, available evidence suggests that the environment has a limited (i.e. responsible for less than 5%) direct impact on public health. Particulate air pollutants possibly cause, per year, 40-150 000 deaths in adults in the EU cities, and a proportion of the rising skin cancer rates is caused by increased radiation through a thinning ozone layer.
- Low level exposure to a complex of pollutants in air, water, food, consumer products and buildings may be affecting overall quality of life or significantly contributing to asthma, allergies, food poisoning, some cancers, neuoro-toxicity and immune-suppression.

Urban areas
- Ambient pollutant concentrations in cities have fallen over the last decade, contributing to some improvement in urban air quality. But the evidence on particulates is mixed – the general trend is down, but concentrations still exceed World Health Organization guidelines in a majority of cities.
- In terms of noise exposure, it is estimated that more than 30% of the EU population live in dwellings with significant exposure to road noise, in spite of significant reductions of noise limits from individual sources.

Coastal and marine areas
- Some 85% of the coasts, where about a third of EU population lives, are at high or moderate risk from different kinds of pressures while urbanisation, in general, has increased in most of the coastal areas.
- Among the 25 less favoured areas in EU in 1983, 23 were coastal areas; 19 remain so in 1996. The lack of economic growth curbs the conditions for environmental management.
- All EU seas are covered by Regional conventions, yet to be fully enforced; remaining poor water quality, coastal erosion and the lack of integrated coastal zone management are the main problems.

Nature and biodiversity
- Integrating biodiversity issues into other policies has started through agri-environment measures (on 20% of the agricultural land) and more targeted conservation approaches (management for multiple use, on-site and off-site conservation).
- Growing fragmentation (in particular the suburbanisation of rural areas), uniformity and simplification of landscapes continues to threaten biodiversity via severe reduction of areas available for fauna and flora. Natura 2000 has been implemented very slowly.
- Pollution (eutrophication, acidification) and introduction of species continue to facilitate the spreading of robust generalist species at the expense of specialist species.

As Box 'Where are we now?' also shows, the overall picture is a very mixed one.

The amount of business still unfinished sets a wide-ranging and formidable agenda for the coming years. What are the prospects for accomplishing this? The results of the baseline scenario, which assumes full implementation of policies in place or in the pipeline by August 1997, shows the extent of the challenges ahead. With a few exceptions such as production of ozone depleting substances, acidification and urban air quality, much ground has still to be made up to secure further across-the-board improvements to EU's environment.

These challenges are being exacerbated because people are leaving new 'footprints' on the environment. Dramatic changes in land use patterns are having a particular impact. Although more than 70% of Europeans live in urban areas, there has been a remarkable tendency since the 1950s for a dispersal and sprawling of urban settlements – by building more roads and other infrastructures , converting land permanently from other uses, sealing soils, opening up areas to tourism – causing new 'hot spots' to emerge.

Today, most of the EU countries have at least 80% of their territory given over to 'productive' uses like agriculture, forestry, urban centres, transport and industry, leaving limited margin for further uses; before the next 10 years is out, the length of motorways is proposed to be extended by more than 12 000 km. And a 5% increase in urban population will, according to present

Box: What's ahead for selected environmental issues?

- **Greenhouse gas** emissions are projected to increase in the EU by about 6% from 1990 to 2010. Atmospheric concentrations of carbon dioxide, methane and nitrous oxide could rise by as much as 45%, 80% and 20% respectively to 2050. Temperatures and sea levels are projected to keep on rising as well.

- The **ozone layer** is benefiting from the phasing out of ozone depleting substances, but it will only start to recover after the mid 2030s, and is not expected to recover fully before 2050. Consequently, ultra-violet radiation levels and associated damaging effects, e.g. skin cancer rates, are expected to continue to increase.

- Chemical production and total **hazardous substances** emissions in the EU are predicted to increase, with significant regional differences. Important increases in emissions of mercury, cadmium and copper are expected by 2010, while emissions from some pesticides would only increase slightly. However, thanks to enforcement of existing and proposed policies, emissions, depositions and concentrations of lead, dioxins and polychlorinated biphenyl should all decrease, substantially in the case of lead.

- Emissions from all major gases contributing to **acidification** and **eutrophication** are expected to be reduced – leading to significant improvements to ecosystems threatened by these phenomena.

- The quality of the EU's **rivers and lakes** should improve – due to decreased input of nitrogen and phosphorus – because of measures to reduce water pollution from point sources; in particular urban waster treatment contributes to this improvement, but the quantity of contaminated sludge will increase accordingly. Rivers and lakes in intensively farmed regions will likely remain a problem unless there is also action to reduce the impact of phosphorus and nitrogen from agriculture. **Total water demand** is predicted to remain relatively stable or increase only slightly until 2010.

- **Recycling** has been highly successful in a number of EU Member States. In some areas of middle and northern Europe, the post-recycling residual waste is down to one-third, even less of the original amount of waste. However, despite policy initiatives at EU and national levels, the **volume of waste** – household, paper and cardboard and glass – is expected to increase.

- **Urban air quality** should continue to improve. The average exposure of cities' inhabitants to above recommended levels is expected to decrease for all substances but concentration levels of particulate matters, nitrogen dioxide, benzo(a)pyrene, and ozone are forecast to remain above air quality guidelines in most cities to 2010.

- **Noise exposure** is forecast to worsen in certain situations, e.g. along ring roads and motorways, at regional airports, because of the growth in transportation, especially freight and air traffic.

- The threat to **biodiversity** stems primarily from land use and changes in land use, from pollution and introduction of alien species. These factors are expected to remain significant for virtually the whole of Europe to 2010. During the period 1990 to 2050 increasing temperature will probably have impacts in arctic and mountaineous regions, while changing precipitation levels may have important effects in southern Europe: a significant change in species distribution may be the result.

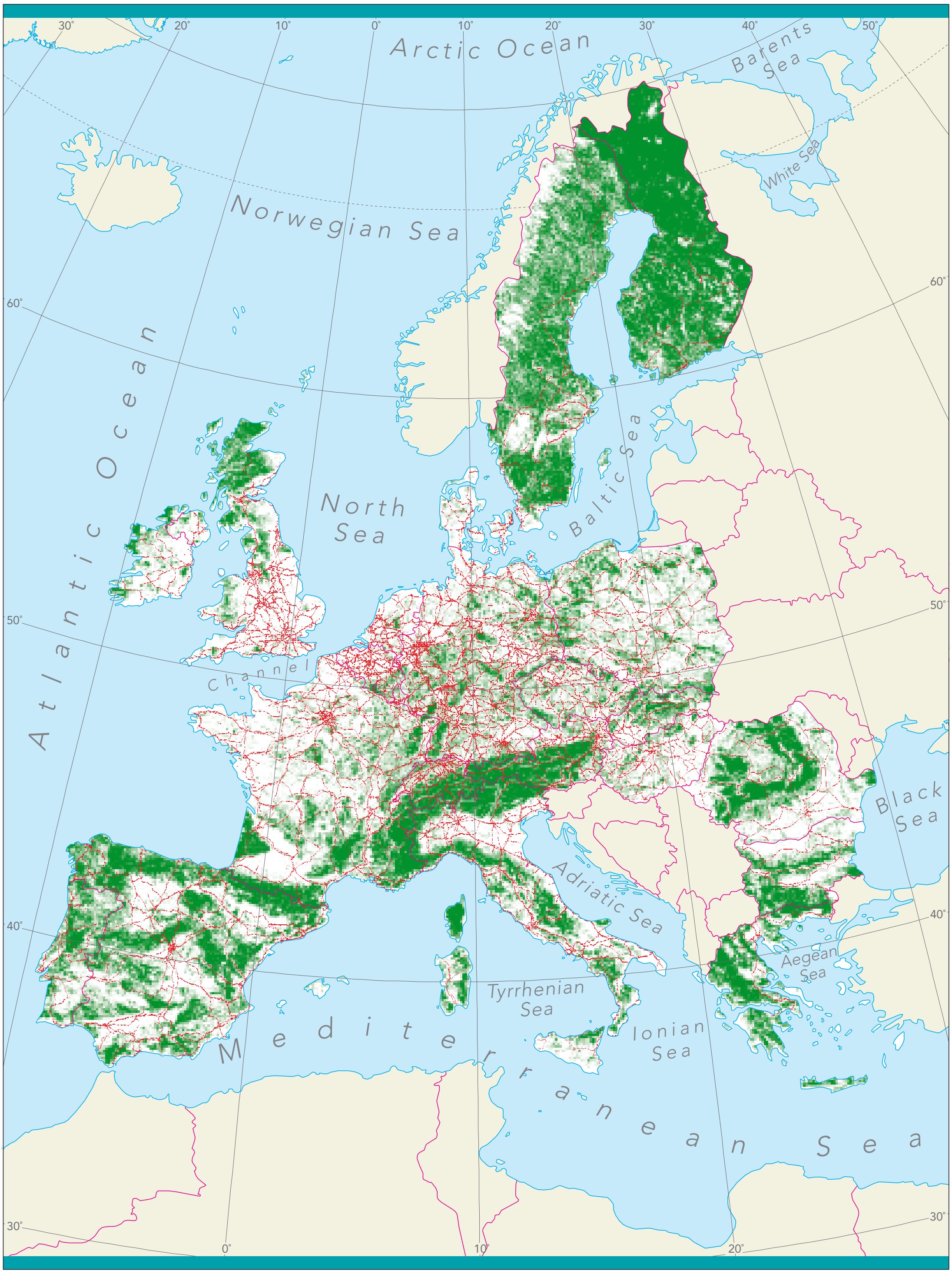
- Air and water pollution, noise, chemical emissions, food contamination and ozone depletion will be the key environmental issues as far as **people's health** is concerned. Exceedances in the concentration levels of particulate matter, nitrogen dioxide, benzo(a)pyrene, and ozone in most cities to 2010 will have implications for life expectancy and mortality, and will push up asthma and respiratory allergy rates further. People face risks from nitrate and pesticide residues, and water pollution – particularly in areas relying on drinking supplies from shallow groundwater wells – while the expected growth in the production of certain manufactured chemicals known to cause adverse affects on humans, and increases in certain toxic wastes will accentuate future health impacts. More noise exposure in certain situations is expected – causing hearing problems, stress leading to hypertension and increasing the risk of cardiovascular disease. In addition, despite the planned reduction in ozone-depleting substances, skin cancer rates are projected to rise sharply, peaking around 2055.

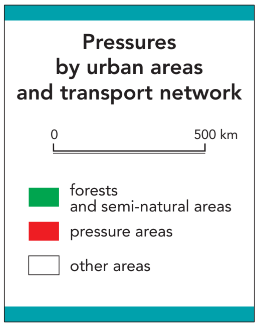
trends, require at least an equal increase in the take of urban land. This whole issue is an increasingly important one – the more so since existing EU, national and regional policies on land use tend to encourage these problems – and it needs more attention from policy-makers.

2. On target – on time?

A feature of many of today's major environmental issues is that they were only recognised after their causes had gone unchecked, activities and pressures increased further, and it was finally clear there were significant effects on health and the environment.

A good example is the damage to the ozone layer: while the use of ozone-depleting substances has now been curbed drastically, the ozone layer is not expected to recover fully until the middle of the next century. A similar case will happen with greenhouse gases; there is a considerable time delay between a reduction of emissions of green-





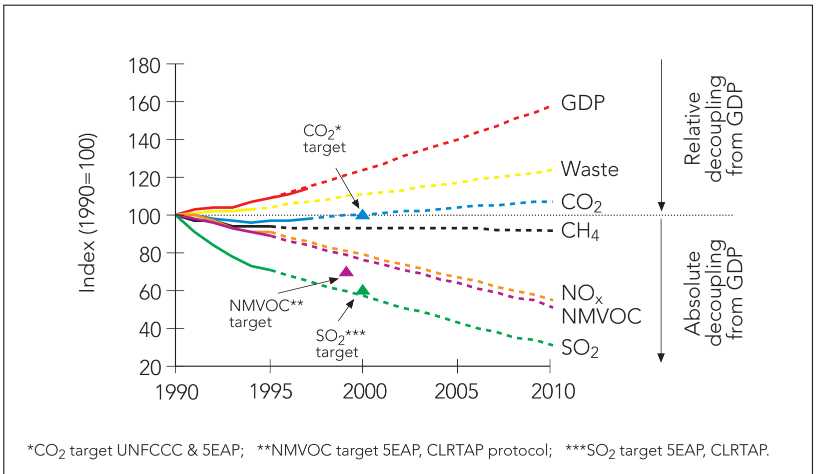
Pressures on land resources and landscapes from urban areas and transport network

house gases and stabilisation of the atmospheric concentration. For example to reach a potentially sustainable carbon dioxide (CO_2) concentration by 2100, that is stabilised at the 1990 level, would involve a reduction of global annual CO_2 emissions by 50 to 70%. Finally, acidification was only brought down to current levels after three decades of increasingly stringent legislation.

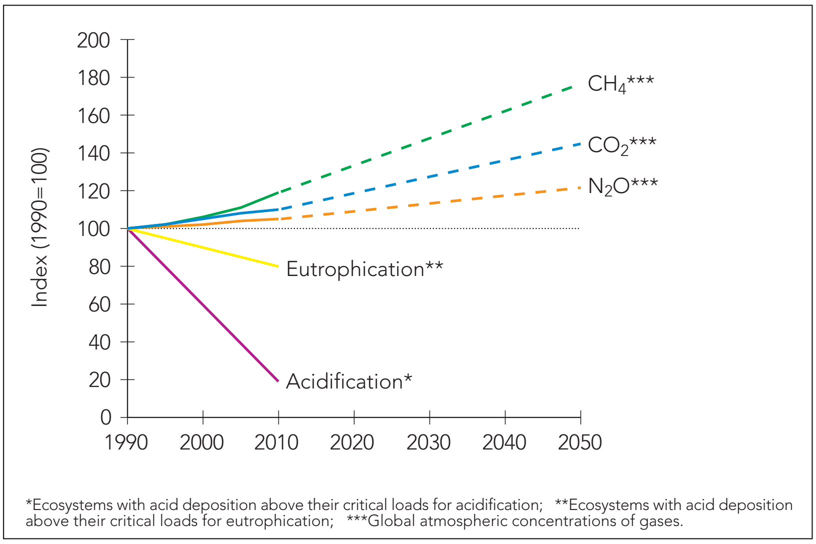
The delay between identifying problems and devising and implementing policy measures to tackle them needs to be reduced. In the past, policies have either been introduced too late, or they have not been on the scale needed to deal with issues, or they have been neutralised by negative pressures caused by the unsustainable growth in other areas (e.g. transport). Good information on environmental trends can help shorten this time lag by providing a vital link between scientific research and policy making, and enabling policy makers to anticipate future problems, and to plan to address them. The public also has responsibility in that context, both in terms of effective participation in the deci-

Box: Environmental 'hot spots' in Europe

- The good news is that the extent of areas with a very high concentration and combination of environmental pressures and impacts is decreasing. However, the spread of less intense 'hot spots' grows as more space is taken up for energy generation, transport, industry and water supply and as these activities have an impact over wider areas.
- By 2010, the environmental quality of many of the traditional industrial 'hot spots' should be greatly improved. In the Black Triangle area, for example, sulphur deposition is expected to fall sharply. But Germany and the Netherlands will still be affected by acidification, and Belgium, France, Germany, Denmark, Luxembourg, and the Netherlands by eutrophication – while the north-western part of Europe will also largely suffer most from hazardous substance emissions and deposition – cadmium, dioxins, bezno(a)pyrene, and polychlorinated biphenyl – and the Iberian Peninsula and Italy will suffer from the highest endosulphane emissions and depositions.
- Urban areas are expected to continue to suffer serious environmental pressures and impacts, for example from worsening traffic congestion and, in some areas, seasonal water shortages, as well as face the challenge of managing solid waste through incineration and recycling. And although air quality should improve, photochemical smog will probably intensify as an issue, especially in north-western Europe. In southern cities, seasonal water shortages are expected to intensify.
- Similarly, a major influx of tourists will impact on the Mediterranean areas, while agricultural adjustment could be particularly significant for other coastal areas, e.g. along the North Sea and Channel. The Alpine region faces increasing pressure from transport.



Economic developments and trends in pressures in EU (1990-2010) in relation to environmental targets
Source: Compiled from multiple sources



Selected trends in the state of the environment (1980 - 2010 -2050)
Source: Compiled from multiple sources

sion making process and through changes in behaviour and consumption patterns.

Setting clear targets, and introducing policies to meet them is crucial to achieving further environmental progress, faster. The EU has set, and will continue to fix targets for the key areas, but while it has hit and is expected to achieve some of them, it is likely to miss others, namely:

- For CO_2 the EU aims initially to stabilise emissions by 2000 at the 1990 level. The EU agreed in Kyoto to reduce **greenhouse gas** emissions, measured as CO_2 equivalents, by 8% between 1990 and 2008-2012. The baseline scenario indicates a 6% increase of total greenhouse gas emissions, while CO_2 emissions initially decreased about 1% in 1996 from 1990 level.
- The use of **stratospheric ozone-depleting substances** decreased in all countries of the EU at a more rapid rate than required to meet European targets. Although in 1996 the chlorofluorocarbon (CFC) production was a little higher than in 1995, the expectation is that future EU emissions will continue to decrease, so that future targets should be met. The Commission has proposed to phase out consumption of hydrochlorofluorocarbons (HCFCs) by 2015.
- Significant reductions in **air pollution emissions** are expected by 2010 – but not enough to meet proposed EU targets for 2010 and agreed ones for 2000. The targets are from the proposed Acidification Strategy of the Commission and the Convention on Long-Range Transboundary Air Pollution protocol of the United Nations - Economic Commission for Europe (UNECE).
- A significant gap is likely to remain on **eliminating all hazardous discharges**. Existing EU action will probably achieve new UNECE targets for reducing lead, dioxins, furans and hexachlorobenzene emissions, but not those for cadmium or mercury – polycyclic aromatic hydrocarbon emissions are expected to rise due to significant increases in road transport.
- Most cities are expected to make good progress towards **EU urban air quality** targets for sulphur dioxide (SO_2), particulate matters, benzene and benzo(a)pyrene, but less progress for

ozone and nitrogen dioxide (NO_2) concentrations.

- New initiatives – requiring a comprehensive life cycle approach emphasising preventative measures and re-use – will beneeded to stem predicted increases in most **waste streams**. Data comparability is a major problem.

- EU targets are not available for groundwater quality but only for water intended for human consumption, for which information on trends is far too limited to allow any analysis of performance. The use of pesticides is expected to decrease further, but pesticides will continue to be found in groundwater and in some cases remain a problem. Nitrate in groundwater will probably remain stable.

Performance in some areas - natural resources such as biodiversity, soil degradation, and coastal zones – is difficult to appraise since there are no quantitative targets, nor the necessary data.

One of the reasons why progress towards targets is slow is because problems are dealt with separately so that the inter-connections between environmental problems and their causes are not fully addressed. More comprehensive, or integrated, approaches to their management and assessment are therefore required. For example, the EU Acidification Strategy, under discussion, is based on a multi-pollutant/effect approach which recognises the multiple role that sulphur dioxide, nitrogen oxides, ammonia and volatile organic compounds play in causing four interconnected environmental problems: acidification, eutrophication, tropospheric ozone and climate change. An integrated approach to these different environmental impacts increases cost effectiveness and political support. Similarly, an integrated approach to climate change recognises the multiple benefits to both health and ecosystems, of improvements in fossil fuel efficiency and use of renewable energy supplies or, in general, of reducing the burning of fossil rare materials.

Progress in achieving key EU Environmental targets (Index 1990 = 100) – EU15

	1985 level	1990 level	1995 level	expected level in target year	target	progress?
Greenhouse gases (GHG) and Climate change						
basket GHG emissions	-	100	98	106	92 in 2008-2012	
CO2 emissions	96	100	97	98-102	100 in 2000	
Ozone-Depleting Substances						
CFC production	160	100	11	appr.0	0 in 1995	
HCFCs production	-	100	108	appr.0	0in2025	
Acidification						
SO_2 emissions	119	100	65	53* 29	60 in 2000 16 in 2010**	 
NO_x emissions	95	100	89	81* 55	70 in2000 45 in2010	 
non-methane volatile organic compounds (NMVOC)emissions	98	100	89	81*	70 in 1999	
Regional scale problems						
Municipal waste (per capita)	79	100	103	109	79 in 2000	

* based on Current Reduction Plans of Member States

** proposed targets which may be reviewed in the framework of the combined ozone/acidification strategy

Monitoring progress towards such '*systems integration*' in the management of environmental problems is difficult, but some indicators of progress are the EU Framework Directives for Air and Water, the Integrated Pollution Prevention and Control Directive for large industrial enterprises, and the Auto-Oil programme on air pollutants from vehicles. More comprehensive approaches towards the more efficient use of energy and materials to minimise environmental impacts (so called eco-efficiency approaches) are being developed by the World Business Council for Sustainable Development and the Organization for Economic Co-operation and Development.

Some barriers to further progress with systems integration are the lack of scientific understanding and information about the links between environmental problems, the lack of targets to measure policy performance, and the separation of the scientific disciplines and political institutions that deal with different environmental impacts.

3. Where the pressures are coming from?

The European Union environment will for the foreseeable future remain under serious pressure from a range of activities – economic, industrial, leisure and even personal – many of which are forecast to expand, and which, because they are interconnected, will have a knock-on effect on each other.

The economies of the EU Member States have been creating more material welfare for their inhabitants in the last decade. But economic growth is so large that production and consumption will in general demand more natural resources and generate more pollution than before. The end use of consumer goods and services not only requires the materials and energy incorporated in the product or services itself, but also the materials and energy used in earlier stages of the production process (the 'ecological rucksack'). Under the baseline scenario, a 45% increase in economic growth is expected to 2010. This will have environmental impacts, and it is likely to erode gains from environmental policy initiatives and increase the difficulty in achieving sustainability. As it is, materials intensity in the leading EU economies fell in the 1980s, but this trend has not continued into the 1990s.

Total primary energy supply is also showing an upward trend and the curves of the major driving forces in the economy are even steeper.

EU economies generally have recently been less *energy intensive*, but this trend still implies a growing demand for energy in absolute terms. Falling world energy prices threaten further reductions in energy intensity. The increasing use of energy is inducing more emissions of carbon dioxide, a main component of greenhouse gases. The shares of the various economic sectors in the generation of greenhouse gases develop differently through time.

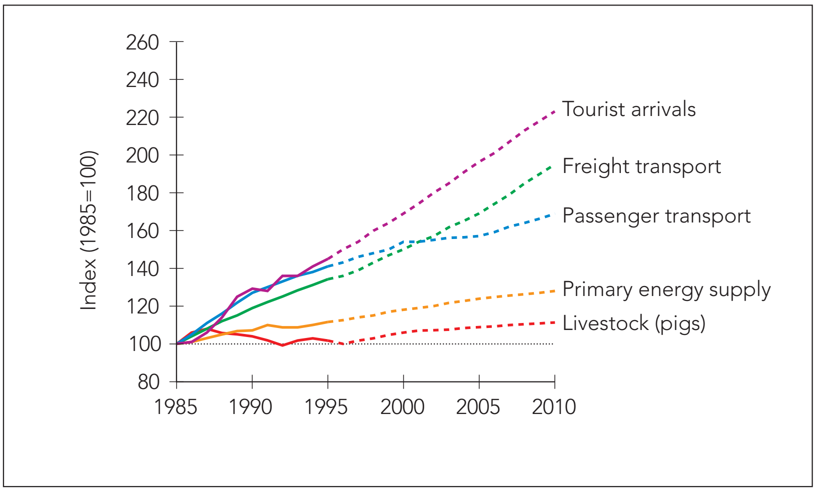
Transport and mobility is jeopardising the EU's ability to achieve many of its environmental policy targets. Big increases in both passenger and freight vehicle use are putting a strain on climate change, transboundary and urban air pollution goals. The transport infrastructure, constantly in expansion, is used beyond its capacity and congestion causes significant economic losses. In passenger transport, improvements in energy efficiency of engines is not sufficient to offset the upward pressure on energy consumption from three developments: the increased number of passenger kilometres, the tendency to use bigger cars, and a shift to car and air travelling. A similar development can be seen in freight transport, as, in spite of policy programmes to support these modes (e.g. the Trans-European Network policy), rail and inland shipping continue to loose ground to road transport.

On present forecasts, households, *industry and the services* sector will also use more energy. The chemicals, pulp and paper and building materials industries are set for major expansion, but the services sector is the fastest growing area, which will have serious implications for transportation and energy use. A shift from solid fuels and oil to natural gas is expected which represents a positive change for environmental quality. The current share of renewables is modest with about 6% and it could increase up to 8% by 2010. The EU objective aims for a 12% share by 2010; however, given the present energy market conditions, strong measures would have to be put in place if this target is to be achieved. Although further energy efficiency gains are predicted in economic sectors, the projected overall growth of sector activities will more than offset the benefits from energy technology improvements.

While the EU's population is remaining relatively stable, rising incomes and more and smaller *households* will lead to a projected 50% rise in final consumption between 1995 and 2010, and add more pressure on environmental services and natural resources. Domestic energy use has outstripped efficiency improvements because households are getting smaller hence they grow in number.

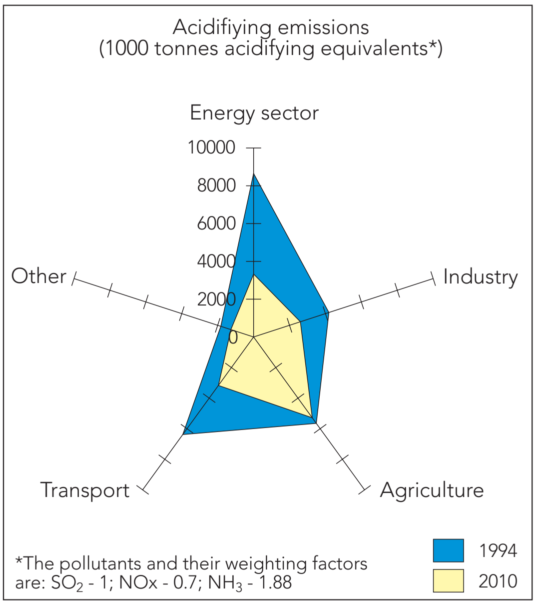
Tourism, which benefits from the increasing economic welfare, more leisure time and attractive prices (not internalising the environmental costs), is expected to grow significantly. The development of tourism activities will challenge sensitive areas such as coastal and mountain zones, and also further fuel the growth in transport.

About 40% of EU land is agricultural – much of it on or next to important sites for biodiversity. Despite reforms of the Common Agricultural Policy introducing certain environmental measures, there remains a prospect of agricultural polarisation: a combination of intensive farming and land marginalisation – both impacting on the environment. The composition of livestock is expected to shift from cattle to pigs and poultry. The use of fertilisers is on a declining trend, while the use of pesticides is fluctuating: it declined, but since 1994 has tended to rise. Future developments are unsure, but a decrease in the volume of active ingredients in pesticides is not unlikely. *Agriculture* causes acidifying emissions (ammonia) and the development in livestock will bring this sector to the very top of the contributors to acidification over the next decade, as it is hardly able to reduce the emissions, in contrast to the other sectors.



Primary energy supply and major driving forces trends in EU (1985 -2010)

Source: EEA

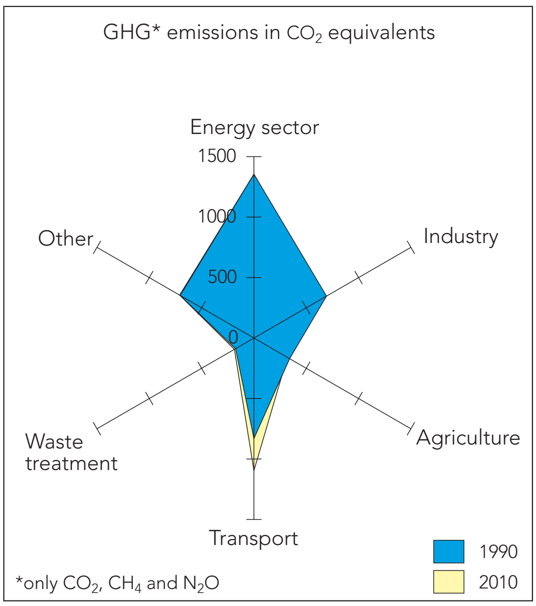


Sectoral contribution to emissions of acidifying substances in EU (1994-2010)

Source: Compiled from multiple sources

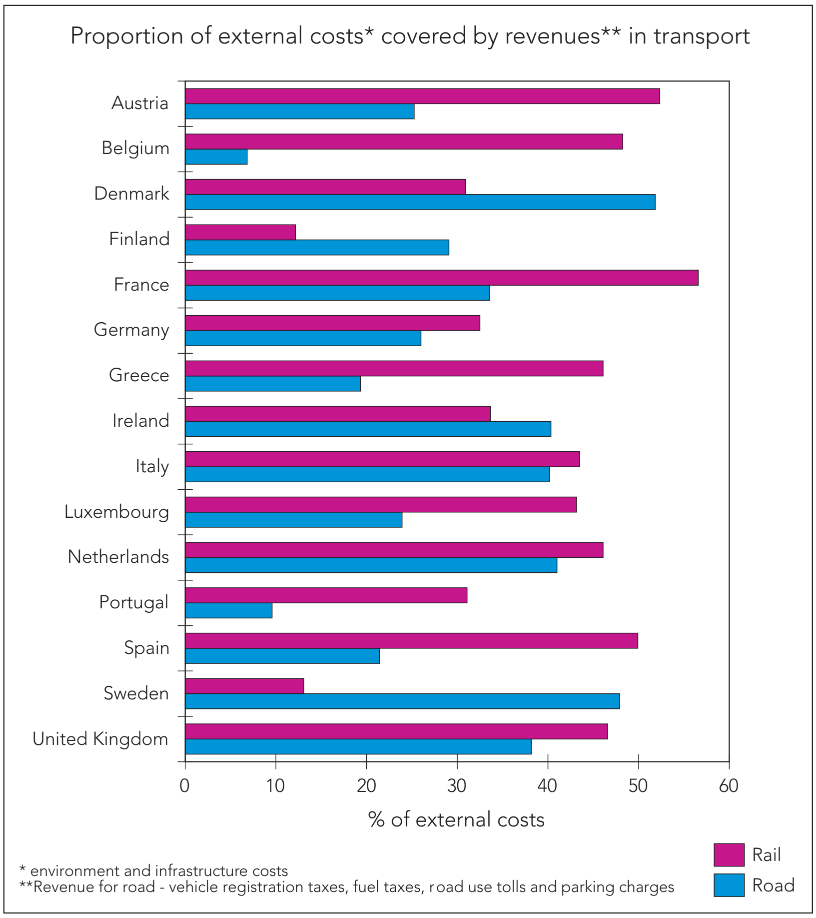
4. Are we making progress towards integration?

Progress with *sectoral integration* has been slow since its importance has been identified in the Fifth Environmental Action programme in 1992 (5EAP). However, the Cardiff European Council in June 1998 invited the Agriculture, Energy and Transport Councils to report on their strategies on environmental integration and sustainable development, and the Vienna Council in December 1998 extended this to Internal market development and Industry. That is a significant step towards the *institutional integration* required if the 'driving forces' of sectoral economic activity are to incorporate



Sectoral contribution to greenhouse gas emissions in the EU (1990-2010)

Source: Compiled from multiple sources



Transport externalities in EU countries

Source: IWW/INFRAS, ECMT

environmental considerations into their objectives and programmes.

At present, integrated strategies that include the environment in a sector's objectives remain rare, being absent from the Common Agricultural Policy treaty objectives, and absent from the EU common transport policy objectives. However, at least five countries (Austria, Denmark, the Netherlands, Sweden and the UK) have produced transport strategies that incorporate environmental objectives. The more heterogeneous industry and energy sectors are less amenable to overall integrated programmes, but climate change is now encouraging overall energy sector plans, turning the challenge of climate change into an opportunity, or 'a climate for change'.

Evaluating progress towards sectoral integration is not easy without agreement on how it is to be operationalised and monitored. In its report, 'Europe's Environment: The Second Assessment', the European Environment Agency proposed some initial sectoral integration criteria, based on the 5EAP and the United Nations Rio Declaration (on Environment and Development). They focus on the important role of prices, taxes and subsidies in encouraging particular kinds of sectoral economic activity (*market integration*), and on the use of environmental impact assessments, management systems and product policies to anticipate and minimise environmental impacts (*management integration*). Monitoring progress against these criteria has only just begun.

Some initial results on progress with the internalisation of transport *externalities* (including infrastructure costs) into prices, via taxes, in Member States are available. These are tentative conclusions which do not cover all environmental impacts of transport, but they represent an initial step in trying to achieve 'fair and efficient' market prices for transport. Without such internalisation of external costs, transport receives a significant 'subsidy' (estimated at around 4% of EU gross domestic product) which encourages mobility beyond the optimum for society, especially for freight transport, which may sometimes be cross-subsidised by private car transport. Comparable data for aviation and shipping is not available, but the absence of aviation fuel tax, and aircraft contributions to air pollution, means that air transport externalities are also far from being internalised into market prices.

Environmentally damaging *subsidies*, which are another example of failure to integrate environmental cost into market prices, are difficult to estimate. They are in general declining, though still large in agriculture, industry and the energy sectors (particularly for coal); in total they still amount to some tens of billions of euros. Tax concessions for car use and parking in some countries are another subsidy to private mobility.

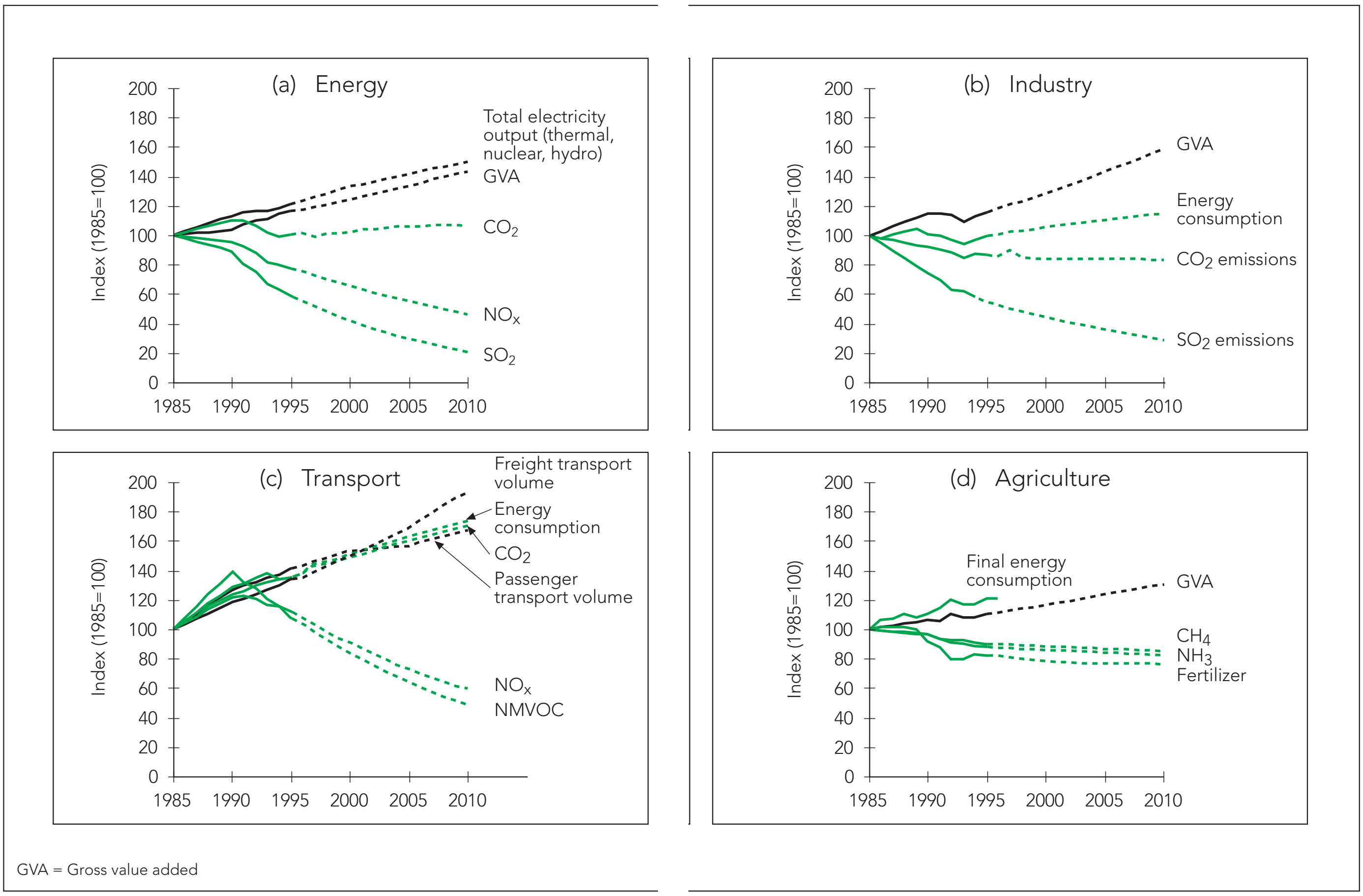
A broadening of the range of *policy instruments* has slowly occurred since 1992 with a greater use of taxes, environmental agreements and information, in addition to legislative measures such as directives. Concerning economic instruments, more environmental taxes and other economic instruments are in practice (especially in energy and transport) – less than 100 economic instruments in use in EU countries in 1987, compared to 134 in 1997. However, revenues from 'green' taxes are still less than 7% of total EU taxes (including energy taxes), and such taxes are in force mainly in Scandinavian countries, Belgium and the Netherlands, with few taxes being used in southern countries. There has been little progress in ecological tax reform, where labour taxes are reduced with revenue from environmental taxes.

There has been a more dramatic increase in the use of *environmental agreements* over the last 10 years: a survey by the European Commission found that by 1986 a total of 44 agreements recognised by Member States had been concluded in the EU, while 10 years later (by mid-1996) 304 agreements were known to be in force. However, most of these agreements do not have the monitoring and implementation procedures required to enforce and assess their environmental effectiveness.

The *use of information* has also increased but mainly in northern countries, and in the agricultural and industrial sectors where eco-labels are beginning to have an impact. Pesticides residue labelling and food quality assurance, including the organic origins of agricultural products, is becoming increasingly important in consumer choice. The possibility of choosing 'green' electricity, or locally supplied food products, is just beginning. Belgium (Flemish region), the Netherlands and Sweden have developed 'pollutant emission registers' that are consistent with the Community statistical classification of economic activities (NACE), hence allowing for cross-country analyses and linkage with economic variables. Other emission inventories (notably in Belgium, France, Germany and the UK) have been set up in response to various national and international reporting requirements.

The anticipation and reduction of environmental impacts by the prior assessment of projects and policies has made some progress, encouraged by EU activity. Most Member States and some sectors have produced guidance and other support in the use of *Environmental Impact Assessments* (EIA), which is seen as an important influence on project planning. However, most of these assessments have only lead to limited adjustments to projects, often because they were executed at rather a late stage in project design. Although the Strategic Environmental Assessment Directive is still only under discussion – several Member States (Belgium, Denmark, Finland, Italy, Netherlands and Spain) and the European Commission have developed procedures and initiatives for SEA.

Influencing supply chains through *environmental purchasing* is another means of integrating environmental considerations into management policies, and initial progress is evident in several Member States (Denmark,



Eco-efficiency on sector level

Source: Compiled from multiple sources

Finland, Germany, the Netherlands and the UK). The use of environmental management systems, encouraged by European Environmental Management and Audit Schemes (EMAS) and International Standardisation Organization (standard ISO 14000), is spreading slowly, but unevenly, with most registered EMAS sites being in Germany.

The success of the sectoral integration tools described above can be measured by the extent to which sectors decouple their economic activity from their environmental impacts, with associated increases in their '*eco-efficiency*'. At the EU level, only air polluting emissions have shown a significant decoupling from GDP since 1990. By contrast, there has been only a relatively small decoupling of carbon dioxide and waste, and these trends continue to 2010.

Within the sectors polluting emissions have declined significantly in energy, transport and industry sectors, and less so in agriculture, but energy use and carbon dioxide have either continued in step with output (transport and agriculture) or have decoupled only slightly, and there is no indication of significant eco-efficiency gains in these two critical environmental impacts up to 2010.

Eco-efficiency gains may not be sufficient to achieve sustainability as there sometimes needs to be an absolute reduction in the total load on the environment (and not just relatively less eco-impact per unit of output from eco-efficiency gains), as with greenhouse gas emissions and acidification. In addition, global environmental impacts can increase if eco-efficiency gains in the EU arise from polluting industries relocating abroad.

5. Challenge and opportunities of EU enlargement

While the 'Accession Countries' (on course for EU membership early in the next century) share many similar problems to the EU, the state of their environment also shows some differences. In the more industrial areas particularly, there is an inheritance of environmental damage, e.g. from sulphur emissions and heavy metal contamination, and water quality is poor in some areas, especially where supplies are drawn from groundwater contaminated by nitrates. There are also still potential environmental hazards associated with Soviet-era nuclear plants and military bases, for which remediation works are being undertaken.

Some Accession Countries have more environmentally sustainable economic activities, and also more extensive areas of natural habitats (the natural asset). Notwithstanding the social implications, the significant decline in gross domestic product levels in the early years of the transition process actually helped in a sense their environment – through lower waste generation, energy consumption, and use of agricultural chemicals – reducing pollution and environmental health risks. In addition, land use is not as high as in many EU countries, which is positive for biodiversity, landscape diversity and maintaining ecological processes.

However, in the transition to EU membership, there is a danger that their environment will suffer if they follow the same development path of the EU15.

When convergence with the present EU implies accelerated economic growth in the Accession Countries, their challenge is to ensure that they do not repeat the two decades of environmental neglect that occurred in western Europe - which eventually, in the 1970s, prompted a crash programme of remedial action at European and national level. It is perhaps more realistic and useful to consider that both the EU15 and the Accession Countries are in transition – transition to more sustainable development. Both have some way to go but, with different starting points, their transition paths will be different.

The Accession Countries have already started to tackle this task through the establishment of framework environmental and environmental health action plans, and the integration of EU environmental standards in national legislation. Under future convergence, appropriate policy intervention and implementation has the potential for beneficial effects in both the Accession Countries and the EU at substantially lower costs through the application of tested approaches.

In this context, a significant time-lag can be expected before full compliance is achieved with EU environmental policies and standards which themselves are evolving. In addition, environmentally damaging activities not adequately covered by EU legislation also need to be addressed in Accession Countries. This requires in particular larger consideration of the 'integration issue' (e.g. in transport, energy and agriculture). This would directly contribute to a more sustainable enlargement process, something that

Box: Developments in the environment of the Accession Countries

Central and eastern Europe Accession Countries:

- With expanding economies, **consumption and production** increases could be greater than in EU countries. In particular, private car use could increase by about 60% by 2010. The expected economic growth could well exacerbate, for example, municipal waste levels, and traffic congestion and pollution.

- With measures likely to be applied under the convergence process, **energy consumption and intensity** will probably dramatically decrease. Energy intensity in industry, especially, could improve by 35% by 2010. The energy restructuring process could result in significant declines of sulphur dioxide and carbon dioxide emissions at relatively low cost. With lower depositions, ecosystems adversely affected by acidification would probably be reduced from 44% in 1990 to 6% in 2010; ecosystems in the EU will also benefit from reduced emissions in Accession Countries; more modest gains can be expected for eutrophication. Improvements in energy efficiency and other baseline scenario assumptions would lead to a decrease in CO_2 emissions by about 8% between 1990 and 2010 for the Accession Countries.

- Currently, the **transportation systems** have less adverse implications for the environment than those in the EU. The rail network in most Accession Countries is well developed, although modernisation is required. At the same time, the road infrastructure and private transportation is less developed. This situation provides the basis for developing an efficient transportation system which is relatively harmless from an environmental perspective.

- Recent increasing yields and production occurred in **agriculture**, accompanied by lower use of pesticides and fertiliser. But the potential for increasing the use of fertilisers and the spread of manure represents an important threat to water quality. The land tenure changes already instituted in Accession Countries have significant implications for land use and increased agricultural output. Nevertheless, the opportunity exists to protect ecosystem assets through agricultural-environment integration under the proposed reforms of the Common Agricultural Policy. This could have major benefits for rural economies through the enhancement of low-impact agriculture and development of eco-tourism, while at the same time maintaining biodiversity.

- The implementation of the **urban waste water** treatment Directive in the Accession Countries could result, with high effort on sewerage development and waste water treatment with no nutrient removal, in a two-thirds reduction in organic matter load and a 40-50% reduction of nutrients input. This would potentially reduce the nitrate and phosphorus loading to both the Baltic and Black Seas by around 15-30%. However, such measures are expected to originate a very serious sludge problem, due to a drastic increase of the amounts produced. Furthermore the costs estimated for building up the necessary sewage treatment plants (excluding connections) could be of the order of 9 billion euros.

- Major reductions in the emissions of certain **hazardous substances** could be achieved with the application of EU policy within Accession Countries. Over the next decade, considerable reductions could be expected, mostly for lead, although growth in traffic would largely counter this potential improvement; also for copper and mercury. EU policy could also reduce the amount of cadmium emissions. Large increases in the emissions of all the studied pesticides are anticipated due to growth in agricultural production, while the increase in hexachlorocyclohexane (HCB) emissions stems from the expected growth in the volume of incinerated waste.

- As regards **transboundary air pollution**, sulphur dioxide and nitrogen oxide emissions are expected to be reduced by approximately 40-50%. Deposition of these pollutants will subsequently decrease but nonetheless two-thirds of ecosystems areas will still be affected by acidification and mainly eutrophication.

- **Urban air pollution**: around 90% of the population lives in cities where exposure exceeds threshold values. For all air pollutants an improvement is expected, mainly for benzene. Nevertheless, Benzo(a)pyrene, nitrogen oxides and, to a lesser extent, sulphur dioxide and particulate matters (especially PM10) will remain serious problems.

- The existing **hazardous waste** sites and nuclear plants in the area pose significant health risks and represent an environmental liability. Indeed, the severe environmental and health impacts include lower life expectancy, higher incidences of certain diseases, and greater impacts on ecosystems.

Cyprus:

- Despite its partial degradation, the quality of the environment remains quite good on the whole. However, urbanisation, which rose from about 44% in 1974 to 68% in 1992, has mostly concentrated along the coast. This increase, combined with the fact that 93% of tourist bed capacity is also located along the coast, has led to heavy pressures exacerbated by infrastructure development and, to a lesser extent, by agricultural and industrial development. Moreover, as water resources are scarce, the demands for water are causing concern, as are pressures on its quality in some areas due to effluent and use of agrochemicals. In the coastal plain aquifers, nitrate concentrations in some areas have increased. The principal groundwater quality problem is salinity due to overpumping. The annual per capita production of solid waste, estimated at 470 kg/year for residential areas and 670 kg/year for tourist areas has given rise to the generation of a variety of associated problems. In the agricultural sector, soil erosion, use of weed killers and agrochemicals and the losses of prime agricultural land to other uses, are some of the most important concerns, though the quality of the soils is good. Undoubtedly, the protection of the coastal zone and the prudent management of water resources are the two most critical and urgent issues requiring a core program of immediate – mostly corrective – tasks.

would certainly go beyond specific environmental legislation. And taking sustainable development as the reference, in particular for the sectors mentioned above, a broader compliance can be achieved.

6. Closing the information gaps

The chairman of the 'Bridging the Gap' Conference (June 1998) on new needs and perspectives for environmental information concluded that: 'At present some of the systems for monitoring and gathering information about the environment in European countries are inefficient and wasteful. They generate excessive amounts of data on subjects which do not need it; and they fail to provide timely and relevant information on other subjects where there is an urgent policy need for better focused information, and for consistent environmental assessment and reporting.'

He also recognised the need for a concerted pan-European movement:

- to streamline environmental monitoring and practices,
- to focus information gathering on key issues, and
- to develop indicators, which would need to be widely agreed, illuminating the significance of environmental change and the progress of sustainability.

The European Environment Agency (EEA) report in 1995 'Europe's Environment: The Dobris Assessment', included an overview of strengths and weaknesses in environmental and related information. There has been some progress since the 1995 review but much remains to be done to achieve the EEA mandate and the goals of the 'Bridging the Gap' Conference. Nevertheless, as shown in the present report, in 'Europe's Environment: The Second Assessment', and in the OECD (Organization for Economic Co-operation and Development) and UNECE (United Nations Economic Commission for Europe) country environmental performance reviews, more use is being made of the information currently available to highlight the state of knowledge and the remaining gaps and inconsistencies.

Public information and participation
'While surveys show a high and increasing level of environmental awareness among the general public, the public is considerably lacking in essential information' (EU Fifth Environmental Action programme).

The Directive on Freedom of Access to Environmental Information, 1990, which establishes the right of the public to access environmental information held by public authorities, has unquestionably unleashed a process of change in attitude and behaviour on the part of public authorities in many Member States in improving the flow of information to the public. However, there have been numerous complaints over the implementation of the Directive, with problems over how it is being interpreted, the wide scope for refusing access, and also slow responses and differences in charging for information. The Directive is likely to be strengthened: it is currently under review, and the EU and Member States' commitment to implement the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, and a new article in the Amsterdam Treaty establishing the right of access to documents held by EU institutions, will all aid improvement if implemented effectively.

Information to the public (via eco-labels, pollutant emission registers, environmental impact analyses and relevant indicators) is an increasingly important policy tool required to help change behaviour towards more sustainable production and consumption activities, such as demand-side management, the 'products to services' shift, and life-cycle impact reduction.

Box: Progress towards better information

- EU Directive (96/62/EC) on **ambient air quality** assessment and management and the third EU Decision (97/101/EEC) on exchange of air quality information have been adopted. The European Environment Agency (EEA) has established EuroAirNet and AIRBASE to complement and support this legislation and, in co-operation with the Commission, EEA, member countries and the EMEP Programme (under the Convention on Long Range Transboundary Air Pollution), improve the quality, consistency and timeliness of air quality data and information available at the European level. However, there has been little progress in detailed monitoring of volatile organic compounds.

- There have been improvements in the detail, comparability and timeliness of **atmospheric emission inventories** through continuing co-operation between the EEA, European Commission (EU Monitoring Mechanism for greenhouse gases), EMEP, International Panel for Climate Change (IPCC – providing technical support to UN Framework Climate Change Convention) and member countries. However, there has been little progress in direct emission measurements or in compiling at the European level emissions into water bodies on the catchment scale or releases into, or onto, land.

- Data on toxicity, ecotoxicity and environmental fate for manufactured **chemicals** is still not satisfactory but it is now recognised that new approaches focusing on persistence and bio-accumulation are required.

- There has been little progress in the quality of **waste information**; the Commission in early 1999 adopted a proposal for a regulation on waste statistics that will take some time for adoption and implementation and there has been some progress co-ordinated by the EEA and Eurostat on improving the quality and consistency of household waste statistics.

- There is an improved culture with regard to **industrial accident** reporting and sharing the lessons learnt. The European Commission accident database MARS, only for EU countries, is now complemented by SPIRS (Seveso Plants Information Retrieval Systems) which will cover the contents of the safety report of each 'Seveso plant' in the EU.

- An enormous amount of accident monitoring and environmental **radioactivity** data is now being collected across Europe which now needs to be better linked and used.

- Information about environmental impacts of **natural hazards** and interactions with human activities is not widely available.

- Information on regional **water** resources and on water abstractions has improved. An initial report presenting available information on groundwater quality and quantity has been made by the EEA. In collaboration with member countries and several Accession Countries, EEA is also developing EuroWaterNet/Waterbase to help improve data comparability and provide the information relevant to the proposed water framework Directive. However, there is still little data on small rivers and lakes, organic micropollutants and metals.

- Apart from major soil types, basic data, such as detailed European **soil** maps, are still unavailable for assessment and there has been no progress in the quality and comparability of data available at the European level. There is no European-wide monitoring network for soil, although some progress has been made, for example in monitoring of forest soils. A European inventory of contaminated sites is still lacking but requirements are being developed. Nevertheless, the importance of the soil medium and the need for European comparable data are being recognised.

- Initial assessments of methodologies and needs for **landscape** description and information have been made but comparable information at the European level is still lacking.

- There has been progress in accessibility to data on **ecosystems, habitats and species** in most countries: best data still concern vertebrates and vascular plants, but several invertebrate groups such as butterflies and lower plants are emerging. Red lists for the same species groups now exist in most countries. Forest maps are now available but need harmonisation.

- There has been progress in compiling information on flora, fauna, species and habitats for Natura 2000 (the Birds and the Habitats Directives) for the EU countries and for non-EU European countries in the related Emerald Network of the Bern Convention. Data are being used by EEA through the European Nature Information System (EUNIS) in co-operation with the Commission, the Council of Europe and international nature conservation organisations.

- On **urban environment**, there has been little progress in providing comparable information on noise. The Community Noise Strategy which will consider requirements and methodologies for such information was only established in September 1998. There are several European urban environment and **planning** initiatives but these have not yet produced much comparable information on cities across Europe.

- Information on Europe's seas remains limited but the EEA has brought together the various **marine** conventions and programmes in an Interregional Marine Forum to help improve the comparability and timeliness of information for future assessment and reporting. Information necessary for an integrated approach on European **coastal zones** and their management is still missing or poorly co-ordinated.

  There has been little progress in the collection of **geo-referenced environmental data** for spatial and territorial analysis at the European level. Consistent information on land cover for most of the EU and Accession Countries is now for the first time available. Also some progress, though limited, on specific geographical patterns or areas such as coastal strip, watersheds, natural sites. However, much more needs to be done to improve the required quality, consistency and coverage of geo-referenced environmental data for improved integrated assessments.

2.1. Meeting needs, consuming resources

1. Economic activity and the environment: links and limits.

It has been estimated that it took the whole of human history to grow to the EUR 60 billion scale of the world economy of 1900 (Speth, 1989). The world economy now grows by this amount about every two years (Goodland, 1991), and is currently at EUR 39 trillion (1998).

It is the speed and scale of this economic development which presents a threat to the integrity of the environmental support system that underpins economic activity (Box 2.1.1), and it is this which has changed most significantly over the last few decades.

Ecological services, unlike man-made technologies, are largely free, but their value can depreciate, and may disappear with over-use, as in the case of energy and materials taken from the environment, converted into useful products, then returned to the environment as waste and emissions. Such 'economic metabolism', if it exceeds the resilience of the environment, could cause shortages of both resources and ecological services.

However, managing the exploitation of the *sources* of energy and materials from nature, such as metals, minerals and forests, is much easier than managing the ecological *services* of nature, such as climate regulation, nutrient recycling, waste assimilation, and radiation protection from the ozone layer.

Shortages of materials can be overcome by improvements in efficiency, or via alternative products, such as plastics from biomass waste. Furthermore, the deposits of metals and fossil fuels are usually owned by someone, so that control over their use, via price and other means, is possible. Scarcity, and its associated price rises, stimulates invention, and man-made capital can sometimes replace natural materials from nature.

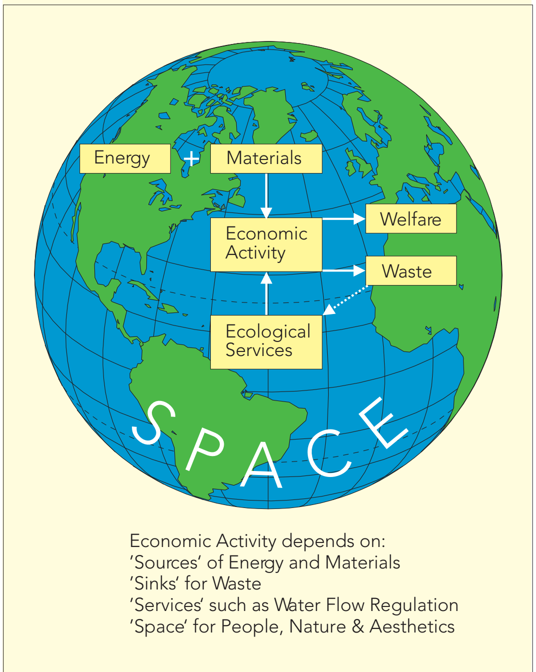
Ecological services are more difficult to deal with. It is not possible to replace the ozone layer (see Chapter 3.2) or the climate regulatory systems with man-made capital, and their efficient functioning can fail once thresholds of 'load' are passed. Such ecological services are not owned by anyone, nor do

Box 2.1.1. Economies depend on the environment

The planet is an integrated system of energy and material flows which involves the circulation of carbon, chlorine, nitrogen, sulphur, water and other key elements between the environmental compartments of air, water, soil and vegetation. The sun is the initial driving force behind such activity. This environmental system not only sustains individual life via air, food and drink but also enables us to collectively organise food, clothing and shelter in an economic sub-system through the provision of:

-Sources of energy and materials
-Sinks for waste and pollution
-Services such as water flow regulation; and
-Space for people, nature and aesthetics.

Economies and the environment: key links Figure 2.1.1



Source: EEA

These four basic 'life support' functions of the environment are essential to any economy, but whilst the products of nature such as food and drinking water are vital, the more hidden, but essential, ecological services are often ignored, or under-valued. For example, rivers and wetlands not only provide fish, water and facilities for recreation but scientific advances show that their servicing functions include holding and circulating water, producing oxygen, storing carbon dioxide, helping to regulate climate, and filtering pollution.

they usually have prices, so preserving them via market mechanisms is not so easy.

It is therefore concern about the current systems of economic activity overwhelming the *sinks* and destroying the *services* from the environment, rather than possible shortages of energy or materials, that have moved scientists, politicians and others to suggest that radical change in the way that we meet our needs is required (Box 2.1.2).

2. Natural and man-made resources: substitutes or complements?

Both the rate at which natural resources can be safely exploited, and the particular use of the resulting income stream for re-investment in replacement stocks, depends on whether it is possible to replace the functions of natural capital with those from man-made capital. If such substitution is possible, 'sustainability' can be achieved by leaving a constant stock of some combination of man-made and natural capital for future generations – this is the 'weak sustainability' view (Peskin, 1991). If substitution is not possible, as is the case with such ecological services as radiation protection from the ozone layer, or climate regulation, then natural capital must be preserved- the 'strong sustainability view' (Opschoor, 1992).

There may be cases where losses of small amounts of natural capital, such as wetlands or forests, could in theory be 'compensated' with the creation of similar resources, but despite many attempts, particularly in the USA, there have been few examples of the successful recreation of complex ecosystems such as wetlands (NRC, 1992).

There are clearly economic as well as physical limits to the replacement of free ecological services by engineered systems powered by fossil fuels. For example:

- replacing the functions of a forest requires replacements for wood products and the construction of erosion control works, air pollution control technology, water purification plants, flood control works, air conditioning plants and recreational facilities, all of which make large demands on taxes, as well as the consumption of other natural resources, with the loss of their ecological functions, such as soil (see Chapter 3.6);
- the functions of soil include food and timber production; storing twice as much carbon as the atmosphere; and

Box 2.1.2. Living beyond our means?

'The future of our planet is in the balance…The present pattern of human activity, accentuated by population growth, should make even the most optimistic about future scientific progress pause and reconsider the wisdom of ignoring these threats to our planet. Unrestrained resource consumption for energy production and other uses, especially if the developing world strives to achieve living standards based on the same level of consumption as the developed, could lead to catastrophic outcomes for the global environment.' (Royal Society/National Academy of Sciences, 1992).

Two crises are nudging humanity towards the 'outer limits' of what earth can stand.

First are the pollution and waste that exceed the planet's sink capacities to absorb and convert them. Use of fossil fuels is emitting gases that change the ecosystem – annual carbon dioxide (CO_2) emissions have quadrupled over the past 50 years. Global warming is a serious problem, threatening to play havoc with harvests, permanently flood large areas, increase the frequency of storms and droughts, accelerate the extinction of some species, spread infectious diseases – and possibly cause sudden and savage flips in the world's climates. And although material resources may not be running out, waste is mounting, both toxic and non-toxic. In industrial countries, per capita waste generation has increased almost threefold in the past 20 years.

Second is the growing deterioration of renewable resources – water, soil, forests, fish, biodiversity:

- twenty countries already suffer from water stress, having less than 1 000 cubic metres per capita a year, and water's global availability has dropped from 17 000 cubic metres per capita in 1950 to 7 000 today;

- a sixth of the world's land area – nearly 2 billion hectares – is now degraded as a result of over-grazing and poor farming practices;

- the world's forests – which bind soil and prevent erosion, regulate water supplies and help govern the climate – are shrinking. Since 1970, the wooded area per 1 000 inhabitants has fallen from 11.4 square kilometres to 7.3;

- fish stocks are declining, with about a quarter currently depleted or in danger of depletion and another 44% being fished at their biological limit.

Source: United Nations Development Programme (UNDP), 1998 providing home to the micro-organisms which are responsible for the creation of the oxygen-rich biosphere that permits life, as well as contributing to the maintenance of soil quality, the recycling of nutrients, and the breakdown of pollution (European Commission, 1997);

- it may be possible to replace, or even lose some of the millions of species in the world without too much cost, but it is very difficult to guess which species may have 'keystone ' functions that may be highly critical for ecosystem functioning, particularly under changing environmental conditions which are themselves difficult to predict (Frost *et al*, 1995). Genetic variability is therefore an insurance against the unforeseen (European Commission,1998a). A rich array of plant species, for example, ensures that when drought or other environmental stress causes some species loss, other species, with different tolerances, can compensate. Given the lack of knowledge about how ecosystems function, the present level of biodiversity may be the best proxy that scientists have for a 'safe' level of biodiversity (Baskin, 1997).

Research funded by European Commission (DG XI) is underway into the identification of critical natural capital and its management (Ekins, 1998). Adequate supplies of natural capital are also needed to maintain the value of man-made capital, e.g. saw mills without logs, or fishing boats without fish rapidly lose their value.

3. Resources: stocks, flows, accounts and impacts

Before the beginning of the Industrial Revolution, around 1750, economic activity was mainly powered by the use of flows of energy from the renewable resources of sun, wind, wood and water. After the invention of the steam engine, energy supplies moved to the exploitation of non-renewable stocks of fossil fuels, such as coal, then later oil and gas (Table 2.1.1).

For non-energy products too, there has been a similar shift towards using stocks of non-renewable resources, such as metals and minerals, rather than the flows of renewable resources, such as biomass. Non-renewable resources now account for about 70-75% of total material flows in industrialised countries compared to about 50% at the beginning of this century (Jackson, 1996; Schuster, 1997).

Main environmental re-sources: stocks and flows — Table 2.1.1.

Stocks ('Non-Renewable')	Flows ('Renewable')
Fossil fuels	*Permanently renewable:*
- recyclable - oil for plastics	Sunlight
- non-recyclable - oil for fuel	Winds
Metals	Tides
Minerals	*Conditionally renewable*
Land	Inland Water
Sea	Air
Space	Soil
	Biodiversity
	Biomass.

Source: EEA, adapted from RMNO, 1994

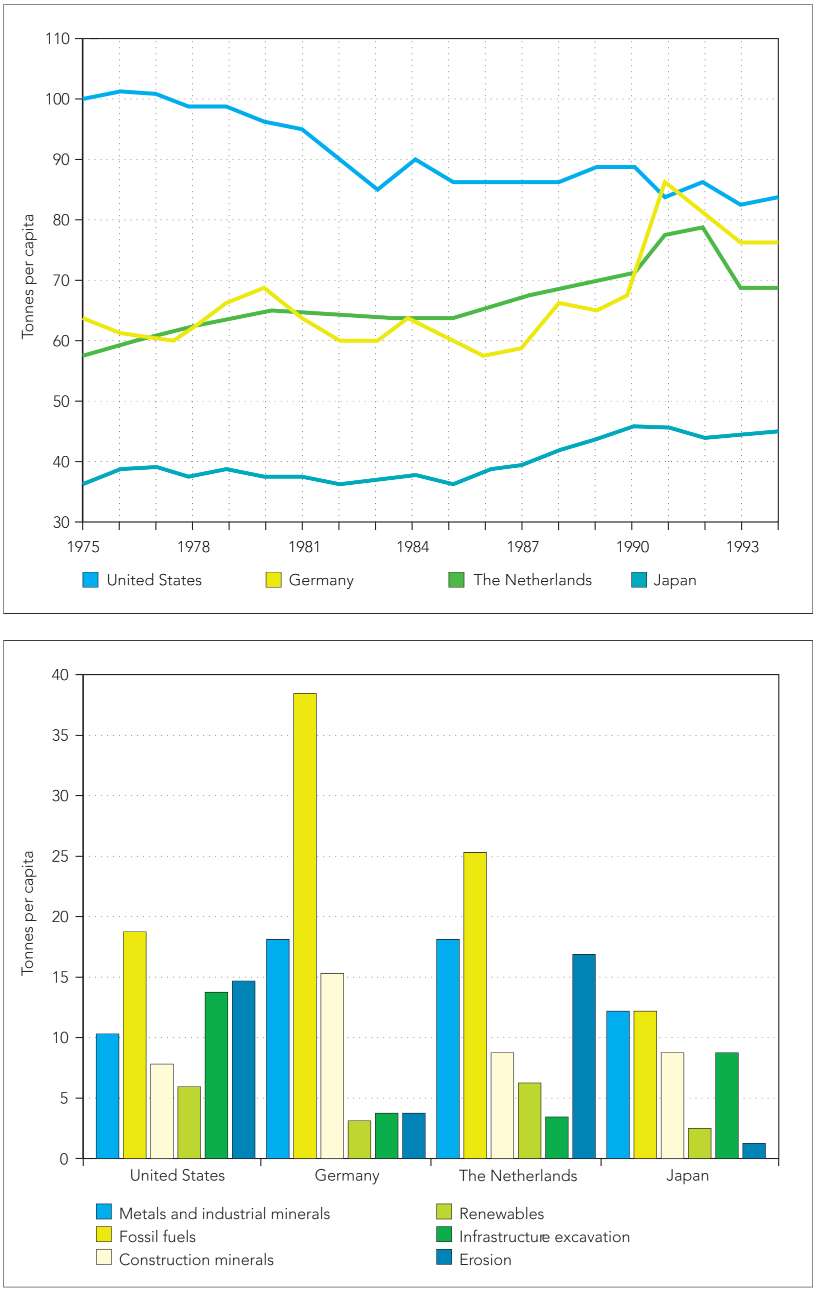
Data on total material flows in the EU is lacking, but indicative figures are available for Germany and The Netherlands, and on a comparable basis for the USA and Japan (Figure 2.1.2).

Germany, the Netherlands and the USA consume about 80 tons of materials per person per year (excluding air and water), with Japan consuming about half that. These total material requirements of current economic activity have been relatively stable over the last 20 years, despite efficiency improvements. They consist mainly of fossil fuels, mining and construction materials. Between a quarter and a half of these material flows include over-burden from mining, waste from logging etc. That do not enter normal accounting systems and which are therefore 'hidden' from the market. They are also hidden from the direct experience of the consumers, in that large amounts of materials are imported. Between one and two-thirds of these material flows are imported into Germany and the Netherlands respectively, representing part of the 'ecological footprint' of their economic activity on the rest of the world.

Stocks of non-renewable resources such as fossil fuels and metals are by definition finite but from a human perspective the stock is dynamic because the boundaries between the categories of resources that are 'known' and exploited move under changing market, technological and geological conditions (Figure 2.1.3).

How much of the stocks of such resources are used depends on whether the resource can be recycled (as with metals; and fossil fuels used as materials), or not (as with fossil

Figure 2.1.2 **Total material requirements: annual flows and main constituents**



Source: Adriaanse et al., 1997

fuels used as energy). Exploitation of resources also depends on the environmental impact of their use with available supplies sometimes being unused where environmental impacts would be unacceptably high, as with some mineral deposits.

The rate of exploitation of renewable resources must not exceed their rate of renewal if the stock is not to decline, but this principle is often ignored (Box 2.1.3).

3.1. Accounting for nature.

The market currently uses price and accounting signals which encourage the overuse of the environment. Firstly, current methods of accounting for the use of national resources via production, consumption and investment, and the associated indicator, the GNP, overestimate real growth of income because they fail to properly account for both the depletion of natural capital and for damage from pollution and associated 'defensive ' expenditures, such as the health service costs of air pollution, or the clean up of chemical spills. The consumption of natural capital is treated as income, which economists (Hicks, 1946; Repetto *et al.*, 1989) and business leaders agree is unsound. Both ecological damage to other countries (see Chapter 3.4), and the loss of global welfare from the destruction of tropical rain forests and other critical natural capital (see Chapter 3.11) need to be properly accounted for if optimal global well-being is to be achieved. However, accounting for the hidden subsidies from natural capital is not easy, particularly when the value of, say, biological diversity is more than the sum of its parts (Box 2.1.4).

In order to measure progress more accurately, several proposals to environmentally

Box 2.1.3. Fisheries: living off the capital or the interest of nature?

One way to picture the use of renewable resources is to imagine a fish biomass as being like money in a bank savings account. The money might earn 5% interest a year. If at the end of each year, 5% of the initial account were consumed, the balance of money in the account would remain the same. If more than 5% were consumed, the account would get progressively smaller and if less than 5% were consumed, the account would get bigger. Clearly, the account remains the same size only if the removal rate equals the interest rate.

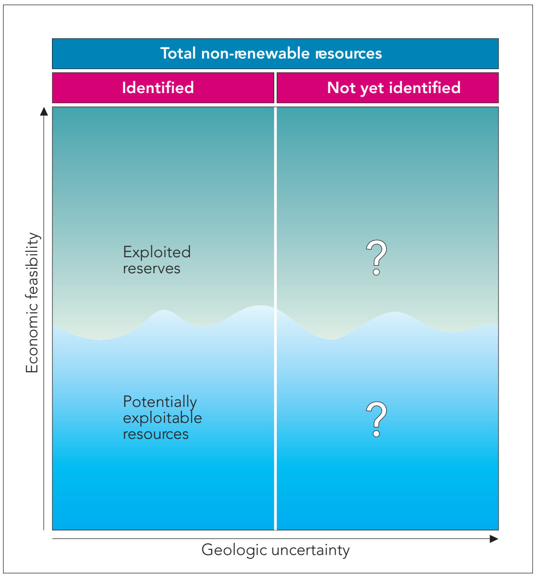
This is approximately what happens with fish populations when they are harvested. In fisheries, as in banking, it is important to distinguish between capital and interest. It is always possible to fish harder to get a higher harvest rate. However, this leads to diminished capital and hence potentially to reduced future income. Many of the world's fish stocks are being over-fished; e.g. the seven countries of the North Atlantic Salmon Conservation organisation agreed in June 1998 to a moratorium on commercial salmon fishing (EEA, 1998a).

'The bottom line is that the human species is living more off the planet's capital and less off the interest … this is bad business … many of our attempts to make progress are simply unsustainable….fundamental change is needed.' (Schmidtheiney/BCSD, 1992).

Box 2.1.4.

'How should the American oyster population of the Chesapeake Bay be valued? Is its value what it brings to market as seafood annually? Or is it the value from the current population filtering a volume of water equal to the entire bay once a year? Or is it the value before pollution and degradation, when it filtered that same enormous volume once a week? Our economies are riddled with such beneficial subsidies from nature, for which there is no current accounting. Similarly, our economies are riddled with subsidies and incentives that lead to environmental degradation.' (Lovejoy, 1995).

Stocks of non-renewable resources are not static Figure 2.1.3



Source: EEA

adjust national accounts and associated indicators have been made, such as the Index of Sustainable Economic Welfare (Jackson *et al.*, 1997; Box 2.1.5), and the 'genuine savings' indicator, but much further work is needed before environmentally-adjusted accounts and indicators are agreed and used. (Bouwer and Leipert, 1998)

Secondly, market prices do not include the full costs of environmental damage which, for transport for example, have been estimated at 4% of the EU's GNP in accidents, congestion and pollution costs. Environmental costs need to be 'internalised' into market prices, via taxes, etc. if overall welfare is to be optimised (European Commission, 1998) (see Chapter 4.1).

3.2. Impacts of human activity

In pre-industrial economic activity, the flows of carbon between the different compartments of the environment were in balance, but once the burning of fossil fuels began, the previously 'locked in' carbon was released (Figure 2.1.5).

In a relatively short space of time, this accumulated as carbon dioxide in the atmosphere, where it and other greenhouse gases contribute to global warming (see Chapter 3.1). There have been large variations in levels of greenhouse gases such as carbon dioxide and methane before now. Some of them have led to rapid changes in global temperature, such as an increase of about 7°C in the Arctic during a 50-year period some 10 700 years ago, according to

Box 2.1.5. Measuring real progress?

The Index of Sustainable Economic Welfare (ISEW) was originally pioneered for the United States (Daly and Cobb, 1989) and further developed in the UK (Jackson *et al.*, 1997). It starts with the GNP and then adjusts this figure for inequalities in the distribution of incomes using non-monetarised contributions to welfare from services provided by household labour; certain defensive expenditures against pollution; changes in the capital base, e.g. the human capital stock; and the loss of future ecological services as a result of the depletion of natural resources, the loss of habitats and the accumulation of environmental pollution.

ISEWs have been computed for the UK, Sweden and Germany, as well as the USA. They all show a similar pattern, i.e. a lower growth rate than GDP up to about the mid 1970s, then a decline, resulting in a measure of welfare in 1996 that is little higher than that in the 1950s.

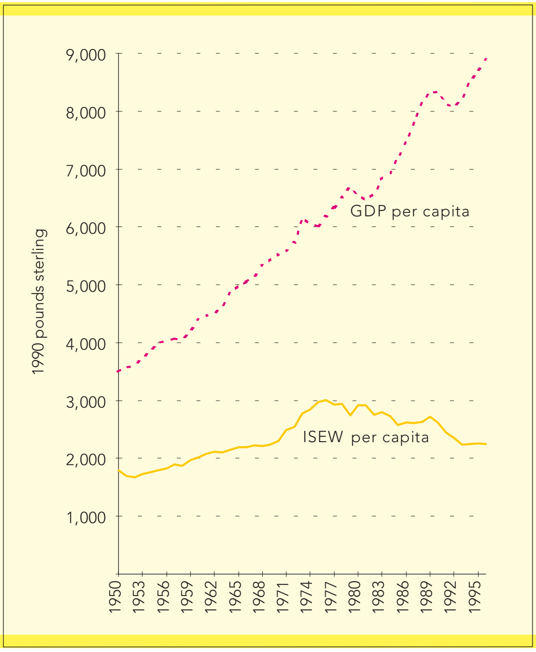
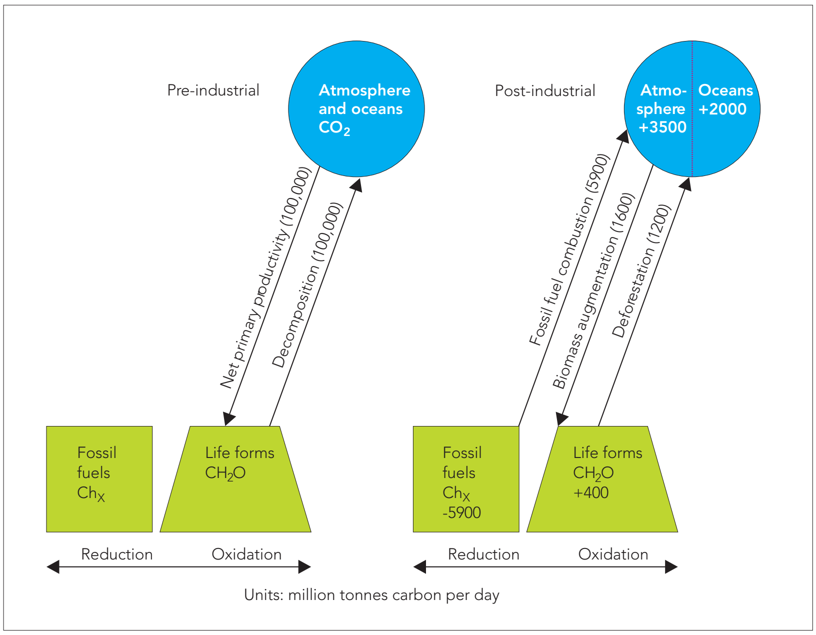


Figure 2.1.4
Development of ISEW and GDP in UK 1950-1996

Source: Jackson *et al.*, 1997

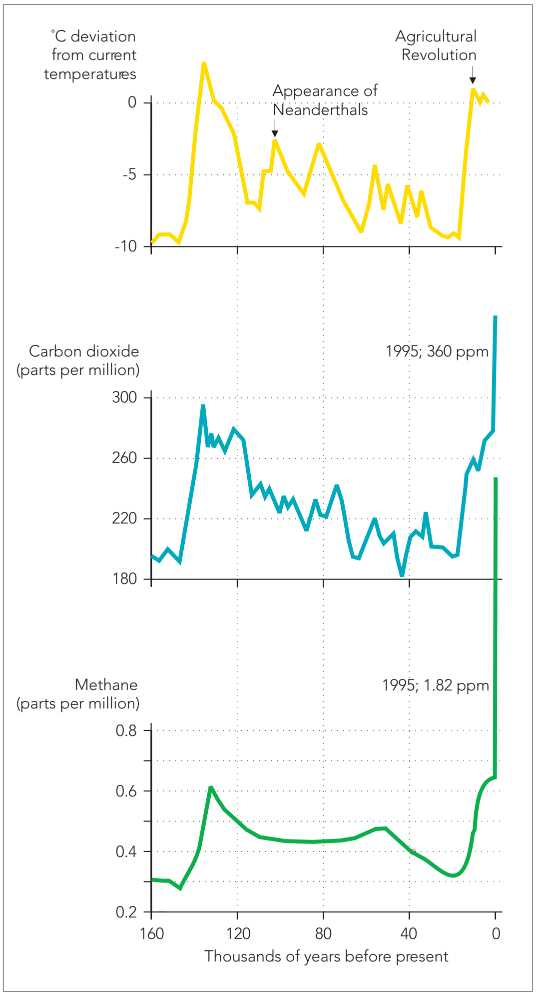
Figure 2.1.5 **Pre- and post-industrial carbon flows**



Source: Ayres, 1994

Figure 2.1.6 **Variations in some greenhouse gas concentrations and global temperature**

Source: Houghton, 1994 (updated with 1995-figures)



ice core evidence (Houghton, 1994). However, whilst it took nature about one million years to lay down the fossil fuels, their exploitation over the last 250 years has led to relatively rapid rises in carbon dioxide and methane concentrations in the atmosphere (Figure 2.1.6).

A similar change has occurred with the nitrogen cycle, with human additions of 150 million metric tons of nitrogen a year (90 from fertiliser, 40 from leguminous crops and 20 from fossil fuel combustion), providing an approximate doubling of the pre-industrial rate of nitrogen fixation (Ayres *et al.*, 1994). The speed of increase is again significant. Half of the one billion extra tons of global nitrogen added to nature from fertilisers during the period 1920-1985 accumulated during the period 1975-85 (Smil, 1991). While a more fertile world can have some benefits, the rate of increase of additional nitrogen from human activity seems to be too high for benign assimilation, leading to eutrophication, and contributing to acidification and photochemical smog. However, whilst the carbon cycle has received much attention from businesses and politicians, leading to energy efficiency gains etc., relatively little attention has so far been paid to the disturbances of the nitrogen cycle caused by fertilisers and fossil fuels.

Other human disturbances to the 'grand cycles' of nature, such as the sulphur and chlorine cycles, have led to problems of acidification and ozone layer damage (see Chapters 3.2 and 3.4). Although the human additions to natural stocks and flows can often be very small, they can be large enough to disturb the system. For example, the human-induced addition to the flow of fixed 'new' nitrogen every year is only about 1 part in 30 million of the stock of nitrogen in the atmosphere – but as nearly all of the atmosphere stock is bio-unavailable, all life depends on this trickle of fixed nitrogen, and doubling its flow may have significant impacts (Ayres, 1994).

Clearly, the use of resources to meet human needs requires a radical change in the efficiency with which they are exploited.

4. Eco-efficiency: getting more from less

Meeting needs with less use of natural and man-made resources but with more use of people has become an environmental and economic imperative (Box 2.1.6). 'Eco-

Box 2.1.6. 'Less nature, more people?'

'The serious economic and social problems the Community currently faces are the result of some fundamental inefficiencies: an 'under-use' of the quality and quantity of the labour force, combined with an 'over-use' of natural and environmental resources… The basic challenge of a new economic development model is to reverse the present negative relationship between environmental conditions and the quality of life in general, on the one hand, and economic prosperity, on the other hand.'

Source: European Commission, 1993

efficiency' aims at de-coupling resource use and pollutant release from economic activity and is becoming an object of environmental policy (OECD,1998; EEA, 1998b).

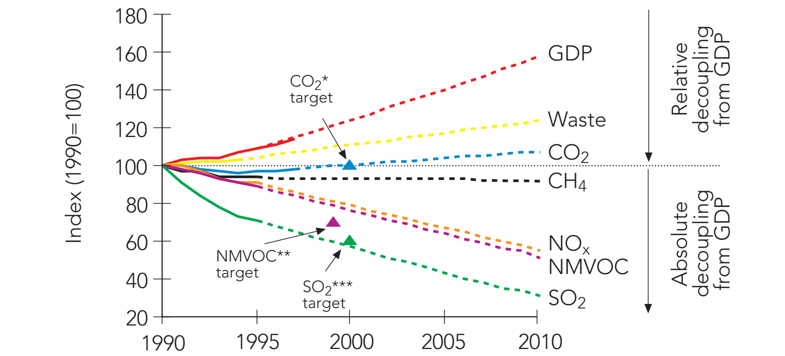
The Agenda 21 up-date (UN, 1997), in its paragraph on integration, notes the need to improve the efficiency of resource use; to consider a ten-fold improvement in resource productivity in industrialised countries; and, to promote measures favouring eco-efficiency. This will require breaking the links between use of nature, as measured by environmental indicators, and economic development, as measured by output indicators, such as GDP, or passenger-kilometres in transport for example. Both 'use of nature' and 'welfare' indicators need improving in order to better reflect reality and human needs, but some current trends in eco-efficiency can be gauged from using existing information.

Improved eco-efficiency is not a sufficient condition for sustainable development, as absolute reductions in the use of nature, and associated environmental pressures, may be necessary to get within the earth's (and human) carrying capacities, so that both relative and absolute de-linking between the use of nature and economic growth will be necessary.

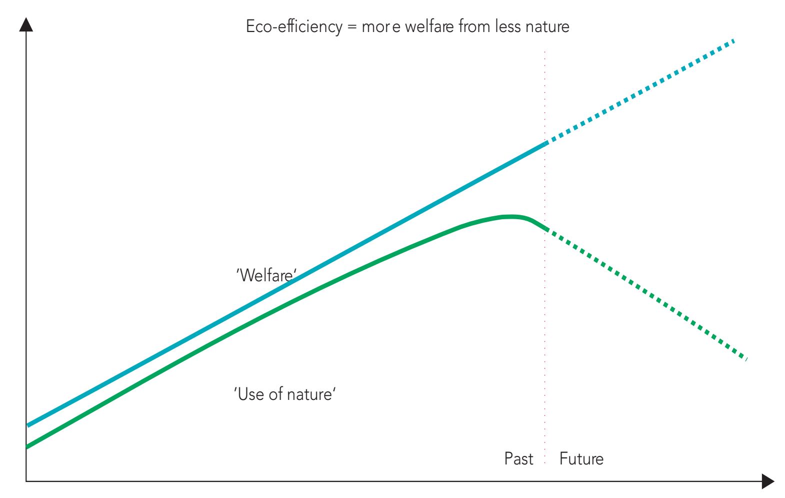
Figure 2.1.7 summarises progress with the de-linking of some environmental indicators from economic growth in the EU in the first half of the 1990s, with outlooks to 2010.

The case of Austria, which was the first country to adopt the Factor 10 target in its national environmental plan, illustrates the difference between relative eco-efficiency gains and the continued rise in the absolute use of resources from economic growth (Figure 2.1.8).

Relative and absolute de-linking: current developments and future directions Figure 2.1.7



*CO_2 target UNFCCC & 5EAP; **NMVOC target 5EAP, CLRTAP protocol; ***SO_2 target 5EAP, CLRTAP.



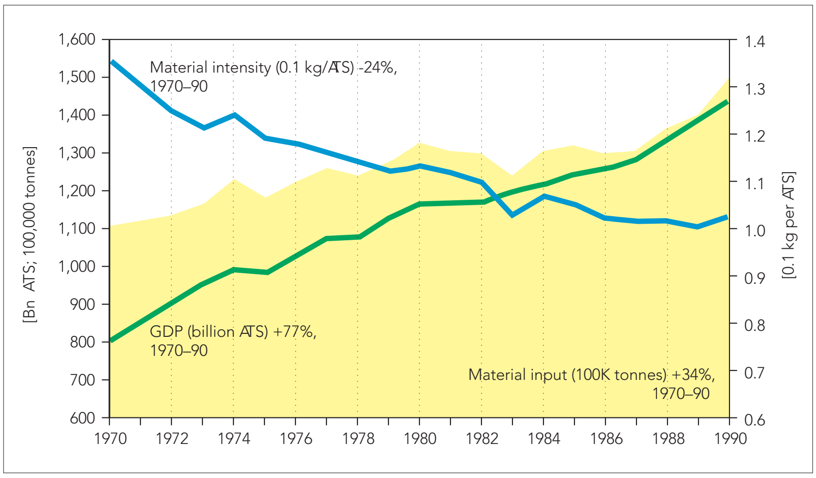
Source: EEA

There are two broad ways to enhance eco-efficiency:

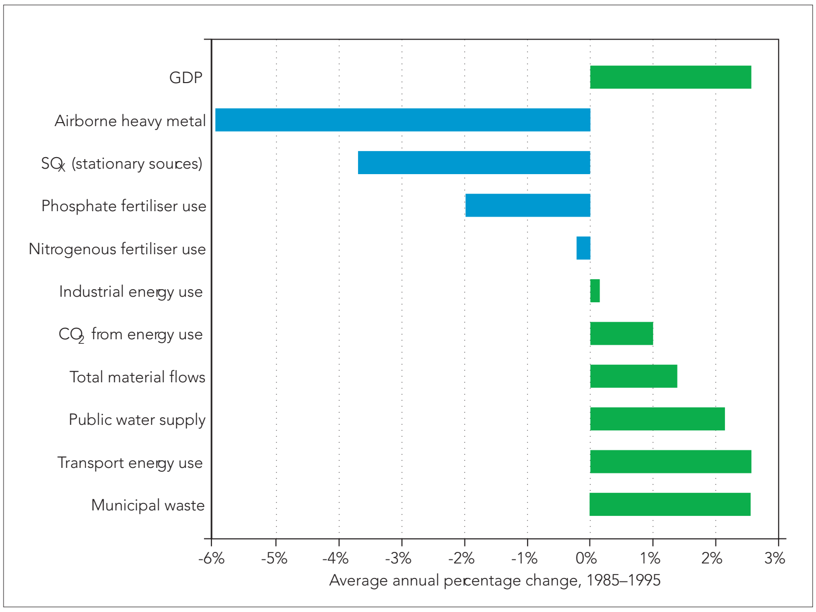
- via the more elegant and equitable use of resources, through innovation in the use of resources and labour; and
- via a focus on meeting human needs more from labour-intensive services than from capital-intensive products.

There is considerable potential for initiatives by firms and communities to improve eco-efficiency using current technologies. For example, manufacturers have found profitable ways to reduce their use of materials, energy and water per unit of production by 10-40% (OECD, 1998) and initiatives in the services sector, local governments and households achieve similar savings. Firms have also demonstrated technologies that cut the use or emission of toxic substances by 90% or more, although these technologies are not always put into place (OECD, 1998; Weizsäcker *et al.*,

Figure 2.1.8 **Eco-efficiency and material flows in Austria**



Source: Schuster,1997



Source: OECD, 1998

1997). A few firms have taken initiatives to reduce environmental impacts during and after the use of products, for example by recovering used equipment and re-using durable components (see Chapter 3.7). Initiatives that address impacts over the full life-cycle offer the greatest potential for reducing pollution and resource use economy-wide, but few firms have developed comprehensive strategies for achieving this. Business organisations such as the World Business Council for Sustainable Development (WBCSD) are encouraging reductions in the intensity of energy and materials use via the promotion of eco-efficiency (Box 2.1.7). 'Demand-side management' in the energy, water, transport and parts of the chemicals sector is beginning to shift the focus from consuming products to using services, with associated eco-efficiency and employment gains.

Industrial ecology has been slowly emerging as an approach to eco-efficiency and sustainability since the early 1970s (Erkman, 1997). It includes the promotion of regional recycling networks (or industrial ecosystems) such as the Industrial Symbiosis networks in Kalundborg, Denmark, parts of the Ruhr, Germany, and Styria, Austria, which already involve using the outputs of substantial quantities of waste from some companies as inputs for other companies. For example, of the estimated 3.8m tonnes of non-construction waste generated each year in Styria, about 1.5m is now used as production inputs to iron manufacturing, construction materials, paper and cement plants within the recycling network (Schwarz and Steininger, 1997).

Eco-industrial parks (Lowe, 1997) are being developed, mainly in the USA and Japan, where the principles of industrial symbiosis and 'zero emissions' (Pauli, 1997) are being designed into the development plans of the parks. Although there are thermo-dynamic, energy and economic limits to recycling, the current high ratio of wastes to useful products indicates that there is considerable scope for the more efficient use of resources.

The search for innovative chemical processes which facilitate less toxic and resource-intensive chemical production (Box 2.1.8) is being stimulated by 'Green chemistry' networks in Germany, Italy, the UK, Japan, and the USA (Anastas and Breen, 1997; Tundo and Breen, 1999; Royal Society of Chemistry, 1999). As the US Academy of Engineering has pointed out, 'design should not merely meet environmental regulations: environmental elegance should be part of the culture of engineering education.' (Jackson, 1996). Those companies and countries that first succeed in emulating nature's elegance in resource use will provide a great service to the environment and human society (EEA/UNEP, 1998).

In general, the focus on eco-efficiency will lead to the development of circular, rather than linear economies, where wastes become inputs rather than outputs.

The OECD has identified several ways in which governments could encourage eco-efficiency initiatives by firms and communities, such as: tax and subsidy reform; regulations; promoting 'extended producer responsibility'; and supporting the development of standard monitoring and reporting procedures.

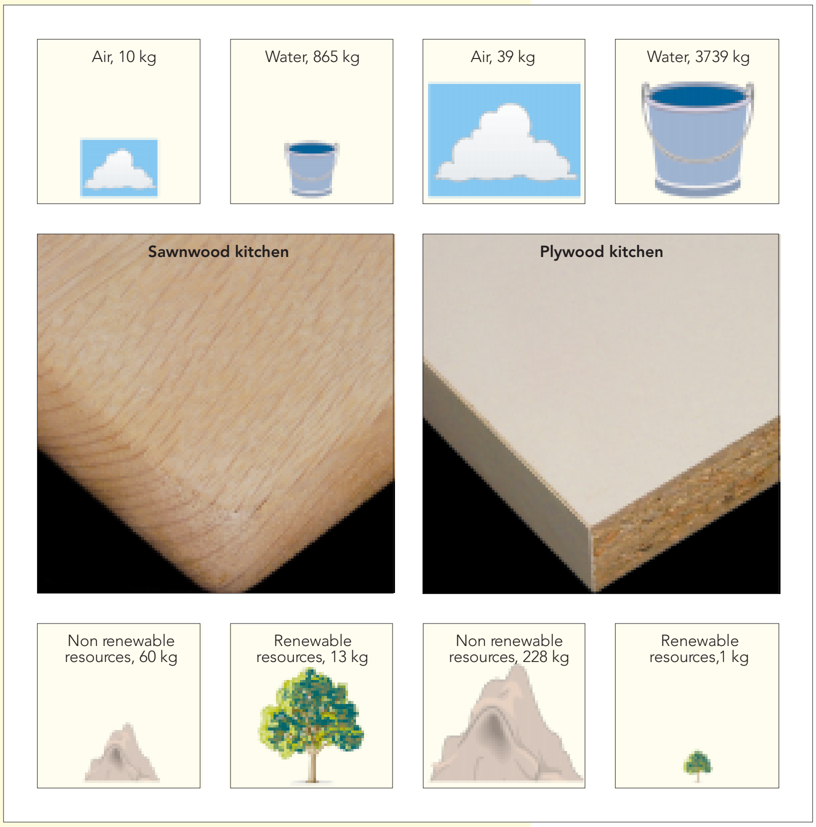
Box 2.1.7. Eco-efficiency criteria of the World Business Council for Sustainable Development

1. minimise the material intensity of goods and services;
2. minimise the energy intensity of goods and services;
3. minimise toxic dispersion;
4. enhance material recyclability;
5. maximise the use of renewable resources;
6. extend product durability;
7. increase the service intensity of goods and services.

Source: WBCSD/EPE, 1999

The materials intensity of two different types of kitchen illustrate the application of some of these criteria (Figure 2.1.9)

Materials intensities: kitchens example Figure 2.1.9



Source: Liedtke et al., 1994

5. Equity and sustainable development

'It took Britain half the resources of the planet to achieve its prosperity: how many planets will a country like India require?' (Mahatma Gandhi, when asked if, after independence, India would attain British standards of living).

It has long been recognised that the rest of the world could not achieve northern standards of living by using the same resource consuming methods. 'It will be impossible for the habits of comfort prevailing in western Europe to spread themselves over the whole world and maintain themselves for many hundred years.' (Marshall, 1920). The present global shares of resources are very unequal (Box 2.1.9) and have become more so in the last 40 years (UNDP, 1998).

Both poverty and affluence can destroy resources and damage ecological functions, but whereas both cause local and regional damage, only affluence causes widespread global damage. 'Sustainable Development'

Box 2.1.8. Green chemistry: key objectives

- Clean synthesis (e.g. new routes to important chemical intermediates including heterocycles).
- Enhanced atom utilisation (e.g. more efficient methods of bromination).
- Replacement of stoichiometric reagents (e.g. catalytic oxidations using air as the only consumable source of oxygen).
- New solvents and reaction media (e.g. use of supercritical fluids and reactions in ionic liquids).
- Water-based processes and products (e.g. organic reactions in high-temperature water).
- Replacements for hazardous reagents (e.g. the use of solid acids as replacements for traditional corrosive acids).
- Intensive processing (e.g. the use of spinning disc reactors).
- Novel separation technologies (e.g. the use of novel biphasic systems such as those involving a fluorous phase);
- Alternative feedstocks (e.g. the use of plant-derived products as raw materials for the chemical industry).
- New safer chemicals and materials (e.g. new natural product-derived pesticides).
- Waste minimisation and reduction (e.g. applying the principles of atom utilisation and the use of selective catalysts).

Source: 'Green Chemistry', Vol. 1, No. 1, Feb. 1999, University of York

Box 2.1.9 Global inequity

- Developed economies with only 20% of the world's population, consume 80% of its resources whilst sharing less of the world's increasing wealth with the 80% of the population in less 'developed' countries than 30 years ago; despite consuming large proportions of resources from developing countries, such as:

  - 45% of all meat and fish; the poorest 20% of the world's population consume 5%;

  - 58% of total energy, the poorest 20% of the world's population consume less than 4%.

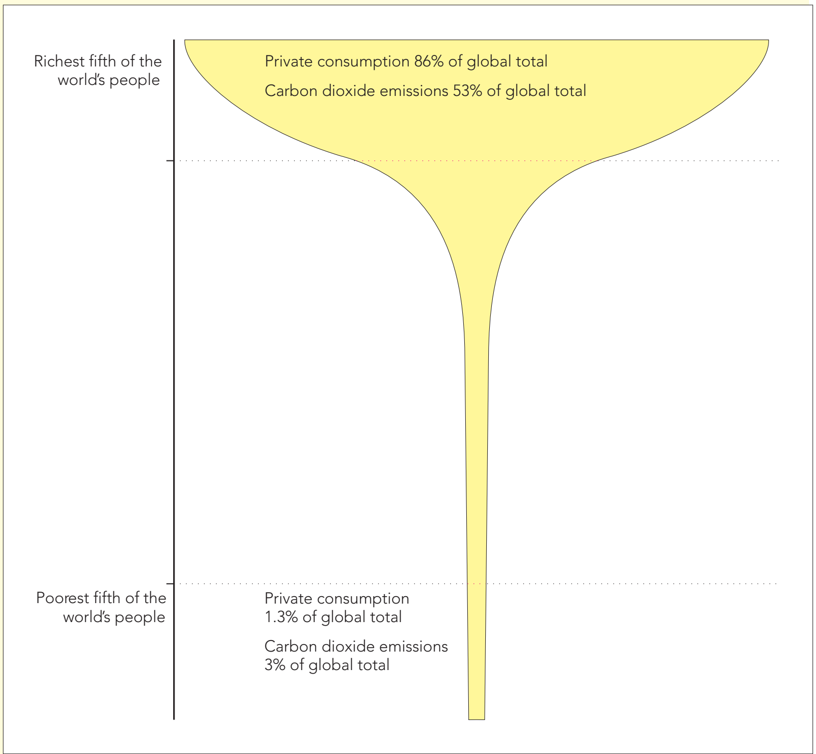
- Consumption per capita has increased steadily in industrial countries (about 2.3% annually) over the past 25 years. The average African household today consumes 20% less than it did 25 years ago. The poorest 20% of the world's people and more have been left out of the consumption explosion.
- Deforestation is concentrated in developing countries. Over the last two decades, Latin America and the Caribbean have lost 7 million hectares of tropical forest; Asia and Sub-Saharan Africa 4 million hectares each. Most of it has taken place to meet the demand for wood and paper, which has doubled and quintupled respectively since 1950. But over half the wood and nearly three-quarters of the paper is used in industrial countries.

Source: UNDP, 1998

The combined wealth of the world's richest 225 people is $1 trillion, whilst the combined annual income of the world's poorest 2.5 billion people is also $1 trillion (Worldwatch Institute, 1999).

Current global shares of consumption and carbon dioxide are shown in figure 2.1.10.

Figure 2.1.10 **Fair global shares?**



Source: EEA, based on UNEP, 1992 and 1998

therefore embraces equity and social considerations as well as economic and environmental issues.Trade issues are also important. For example, improving the overall efficiency of resource use by internalising full environmental costs into market prices can penalise the 'pioneer' countries who adopt full cost pricing first, if 'free trade' prevails. International agreements are therefore being proposed to help achieve optimal global welfare (Box 2.1.10).

Achieving well-being depends on achieving the optimal balance between the three pillars of sustainability, the economic, the social and the environmental (Box 2.1.10; Figure 2.1.11).

6. Monitoring progress towards more welfare from less nature

Monitoring progress in using less nature to meet human needs requires measures of accounting and reporting that relate *welfare* to the *use of nature*. In practice, this involves measuring the eco-intensity of production and consumption via efficiency indicators, which are one of four main types of indicators (EEA, 1999). New reporting systems, such as the Transport and Environment Reporting Mechanism (TERM) currently being developed at EU level, are trying to use a wider range of indicators to capture both eco-intensity ratios, such as energy use and pollutants per billion kilometres of output, and performance against target values, such as air quality standards.

Many firms have also developed indicators and targets for reducing their intensity of material use, energy consumption and toxic emissions per unit of production (Box 2.1.11). They monitor progress towards these targets and release the results in their annual environmental reports. Few have yet developed quantitative indicators or targets for concepts such as 'service intensity' (i.e. the quality of the service they provide to their customers), or for reducing impacts over the life-cycle of their products and services.

At the level of the economy there is a need to focus on key indicators for resource use and associated impacts: nine have been proposed by the EEA (Box 2.1.12) and similar ones are being developed by countries such as Germany, Sweden, the Netherlands and the UK. They will be further developed and described in the regular indicator reports from the EEA, Eurostat, the European Commission and Member States expected in 1999. In some cases, they will be linked to targets for the use of nature which are either linked to output, such as the 'Factor 4' eco-efficiency target, which assumes a doubling of welfare from a halving of resource use (Weizsäcker *et al.*, 1997), or the target of 'Factor 10', which aims at the absolute reduction of the global use of nature, 'over one generation' by one half, and its more equitable distribution across the world. This will involve a ten-fold reduction in absolute resource use in industrialised countries (Carnoules Declaration of the Factor 10 Club, 1997).

Some Member States have referred to overall resource-use targets, such as Germany ('Increasing raw materials productivity 2.5-fold by 2020 compared to 1990') and Austria and Sweden (Factor 10), but there is as yet little development of such targets at economic sector level (EEA, in press).

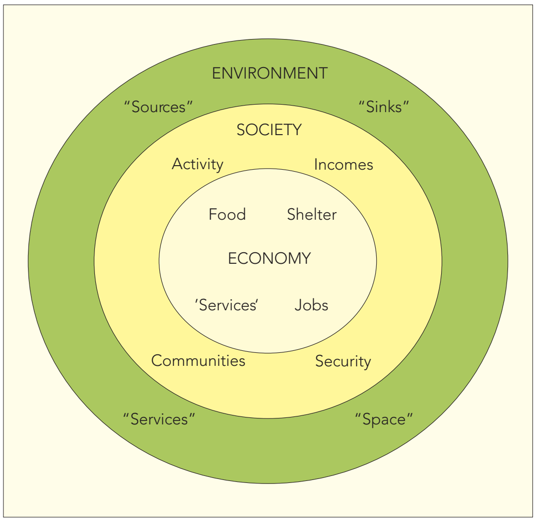
Progress towards less use of nature will require greater integration of economic and environmental activity in sectors, such as through the internalisation of external environmental costs into market prices (see Chapters 2.2 and 4.1).

Box 2.1.10. International commodity related environmental agreements?

The 'internalisation' of environmental costs into market prices can help improve economic efficiency and welfare, but this approach is not usually available to developing countries, who are usually 'price takers', with no influence on world prices for their products. Where natural capital in developing countries provides global ecological services (e.g. tropical rain forests), or when full cost pricing for traded commodities is the objective, then International Commodity Related Environmental Agreements (ICREA) have been proposed. These involve import taxes in developed countries which provide earmarked funds for developing countries to use on environmental projects. Such taxes on 'northern' consumption represent full cost pricing payments for the externalities of ecological damage and services. As the trend in commodity prices has been in favour of 'northern' consumers since 1970 (whilst interest on Third World debt payments has also risen), such moves towards 'fair and efficient pricing' of commodities could contribute to sustainability at global level.

Source: Kox and Linnemann, 1994

The three pillars of sustainability: Economy, society and environment Figure 2.1.11



Source: EEA

Box 2.1.11. Corporate reporting on eco-efficiency

The WBCSD's working group 'eco-efficiency metrics & reporting' recommends using the following ratio as a general equation to measure and report eco-efficiency:

- eco-efficiency = unit of value provided per unit of environmental burden

The following cross-comparable indicators have been considered by the WBCSD working group:

Environmental Indicators	Value Indicators
- Total Amount of Energy Use	- Mass or Number of Product
- Total Amount of Materials Use	- Number of Employees
- Greenhouse Gas Emissions	- Sales/Turnover
- Ozone Depleting Substances Emissions	- Gross Margin
- SO_2 and NO_x Emissions	- Value Added

Source: WBCSD: Executive Brief, January 1999

Box 2.1.12. Nine possible key indicators for resource use and associated impacts

Inputs (resource use):	*Outputs (impacts/ pollution)*
- material input	- emission of greenhouse gases
- energy use	- emission of acidifying substances
- land-use	- emission of ozone-depleting substances
- water consumption	- generation of (hazardous) waste
	- hazardous chemicals

References

Adriaanse, A.; Bringezu, S.; Hammond, A.; Moriguchi, Y.; Rodenburg, E.; Rogich, D.; Schütz, H., 1997. *Resource Flows: The Material Basis of Industrial Economies.* World Resources Institute. Washington D.C.

Anastas, P.T. and Breen, J.J, 1997. *Design for the environment and green chemistry: the heart and soul of industrial ecology.* In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

Ayres, R.U, Schlesinger, W.H. and Socolow, R.H., 1994. *Human Impacts on the carbon and nitrogen cycles.* In 'Industrial ecology and global change', R. Socolow, C. Andrews, F. Berkhout and V. Thomas (eds), Cambridge University Press.

Baskin, Y., 1997. *The Work of nature: How the diversity of life sustains us*, Island Press, Washington.

Brouwer, R. and Leipert, C., 1998. *The role of environmental protection expenditures in a system of integrated economic and environmental accounting, theory, practice and future prospects.* CSERGE, working paper GIC98/01 Norwich.

Daly, H. and Cobb, J., 1989. *For the Common Good - Redirecting the Economy towards Community, the Environment and Sustainable Development.* - Beacon Press, Boston.

Ekins, P., 1998. *Making sustainability operational: critical natural capital and the implications of the strong sustainability criterion*; project no PL9702076, 06XII, technical annex, Mimed, Dept. of Environmental Social Sciences, Keele University, Keele.

Erkman, S., 1997. *Industrial ecology: a historical view.* In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

European Commission, 1993. *White Paper on Growth, Competitiveness, and Employment* (COM(93)700 final), European Commission, Brussels, 5 December 1993

European Commission, 1997. *Functional Implications of Biodiversity in Soils*, Ecosystems Research Report 24, Brussels.

European Commission, 1998a. *Understanding Biodiversity.* Ecosystems Research report no 25, Brussels.

European Commission, 1998b. *Towards fair and efficient pricing of Transport.* Brussels.

EEA, 1998a. *Technical report on Fisheries situation in EU.* Prepared for the EEA by Pope, J. European Environment Agency. Copenhagen.

EEA, 1998b. *Background Paper for eco-efficiency workshop, 'Making Sustaiability Accountable'*, October 1998, Copenhagen.

EEA/UNEP, 1998. *Chemicals in Europe: Low doses, high stakes*? Copenhagen, Geneva.

EEA, 1999. *A Typology of Indicators.* (in press). Copenhagen.

EEA, (in press). *Progress with integration: a contribution to the Global Assessment of the Fifth Environmental Action Programme.* Copenhagen.

Frost, T.M. , Carpenter S.R., Ives, A.R., Kratz, T.K., 1995. *Species compensation and complementarity in ecosystem function.* In Jones C.G. and Lawton J.H. (eds), 'Linking species and ecosystems', pp 224-239. Chapman and Hall, London

Goodland, R., 1991. *The case that the world has reached its limits.* In 'Environmentally Sustainable Economic Development: building on Brundtland'. UNESCO, Paris.

Hicks, J.R., 1939. *Value and Capital.* Second edition, 1946. Oxford University Press, Oxford.

Houghton, J., 1994. *Global Warming: the Complete Briefing*, Lion Publishing, Illinois.

Hueting, R., 1980. *New scarcity and economic growth.* New York, Oxford University Press.

Jackson T., 1996. *Material Concerns: pollution, profit and quality of life.* Routledge, London.

Jackson, T.; Marks, N.; Ralls, J.; Stymne, S., 1997. *Sustainable Economic Welfare in the UK 1950-1996.* New Economics Foundation, London.

Kox H.L.M. and Linnemann, H., 1994. *International commodity-related agreements as instruments for promoting sustainable production of primary export commodities.* In 'Sustainable Resources Management and Resources Use: Policy questions and Research Needs', RMNO, The Netherlands.

Lazarus, O.S., 1991. *Save our Soils.* In 'Our Planet', vol. 2, no. 4, New York.

Liedtke C., Orbach T. and Rohn H., 1994. *Towards a Sustainable Company: Resource Management at the Kambium furniture Workshop.* Included in Conaccount conference proceedings, Wuppertal.

Lovejoy, T.E., 1995. *Will expectedly the top blow off?* Bioscience, Science and biodiversity policy Supplement: S-3-6, Washington.

Lowe, E.A., 1997. *Creating by-product resource exchanges: strategies for eco-industrial parks.* In Journal of Cleaner Production, Vol. 5 n 1-2, Oxford.

Marshall, A., 1920. *Principles of Economics.* Macmillan, London.

NRC, 1992. *Restoration of Aquatic ecosystems: Science, Technology and public Policy.* National Research Centre, National Academy Press, Washington D.C.

OECD, 1998. *Eco-efficiency.* Organisation for Economic and Co-operation Development, Paris.

Opschoor, J.B.,1992. *Economy, environment and sustainable development.* Wolters Noodrhoff Groningen.

Pauli, G., 1997. *Zero emissions: the ultimate goal of cleaner production.* In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

Peskin H.M., 1991. *Alternative environmental and resource accounting approaches*, in Robert Costanza, ed. Ecological Economics: 'The science and management of sustainability', New York, Columbia University Press.

Repetto R., Magrath W., Wells M., Beer C., Rossini F., 1989. *Wasting assets: natural resources in the national income accounts.* Washington, D.C.: World Resources Institute.

RMNO, 1994. *Sustainable Resource Management and Resource Use: Policy Questions and Research Needs.* RMNO, The Netherlands, 1994.

RS/NAS, 1992. *Population Growth, Resource Consumption and a Sustainable World.* Royal Society, London/US National Academy of Sciences, Washington, 1992.

Royal Society of Chemistry, Green Chemistry Network, Clean Technology Centre, University of York, York.

Schmidheiney/BCSO, 1992. *Changing course; a global perspective on development and the environment*, Business Council for Sustainable Development, Geneva.

Schuster M., 1997. *Translating Material Flow Analysis into Environmental Policy in Austria*. In Analysis for action : Support for Policy towards Sustainability by Material Flow Accounting, Proceedings of the Conaccount conference, Wuppertal.

Schwarz E.J. and Steininger K.W, 1997. *Implementing nature's lesson: the industrial recycling network enhancing regional development*. In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

Smil V., 1991. *Nitrogen and phosphorus*, in The Earth as transformed by human action (B.L. Turner, H.W.C. Clark, J.F. Richards, J.T. Mathews and W.B. Meyer, eds), Cambridge University Press, UK, 423-436.

Speth, J.G., 1989. *A luddite recants: technological innovation and the environment.* In The Amicus Journal (Spring). Washington.

Tundo P. and Breen J.J., 1999. *Venice: a center for green chemistry on the continent*. In Today's chemist at work, Vol.8 n° 2, American Chemical Society Publisher.

UN, 1997. *Overall review and appraisal of the implementation of Agenda 21 (Earth Summit +5)* – New York, 21-23 June 1997.

United Nations Development Programme (UNDP), 1992 and 1998. *Human Development Report 1992* and *1998*. Consumption for Human Development. New York (http://www.undp.org/hdro/98.htm).

Weizsäcker, E. v., Lovins A. B., Hunter L., 1997. *Factor Four - Doubling Wealth - Halving Resource Use*. The new report to the Club of Rome. Earthscan Publications Ltd, London.

Worldwatch Institute, 1999. 'Worldwatch', January, World Watch Institute, Washington.

WBCSD/EPE, 1999. *European eco-efficiency initiatives; a road map for business strategy and government action.* From World Business Council for Sustainable Development, Geneva, and European Partners for the Environment, Brussels

2.2. Economic developments

1. Economy and industry

Completion of the Single Market and the introduction of the European Monetary Unit (the euro) are major political events within the EU in the 1990s, which have an important economic bearing. In the process of ongoing globalisation, these are seen as vital for European economic competitiveness.

It is important to recognise the qualitative dimension of economic growth, in terms of impacts on the environment and natural resources. This was highlighted by the European Commission sponsored Task Force on the Environment and the Internal Market (Task Force, 1993), which drew attention to the danger that accelerated economic growth due to European Single Market would have negative environmental consequences, in terms of higher energy demand, international transport, waste generation, and spatial problems for the peripheral EU Member States. On the other hand, the need for harmonisation within the single market has generally resulted in adoption of legislation at EU level embodying environmental standards. The same is expected to happen in the Accession Countries.

In the Fifth Environmental Action Programme (European Commission, 1992) and its review (European Commission, 1996), households and five production sectors were identified that are major driving forces of environmental pollution and the depletion of natural resources. They include industry, agriculture, energy, transport and tourism. Industry is part of this first section. Households and tourism are dealt with in the next section, and agriculture, energy and transport are the subject of sections 3 through 5.

1.1. Historical developments

The economic development in Europe in the 1990s is typically characterised by two main trends: continuing growth in western European countries and recovery from deep recession associated with economic restructuring in the Accession Countries. Over the last three decades, Member States have experienced steady growth in GDP, albeit subject to cyclical recessions.

Developments in industry are characterised by the growth of the service sector and some decline in manufacturing, mainly in heavy industry. In Germany, for example, the share of manufacturing on total value added has decreased from one-third to one-fourth since 1970. The manufacturing industry has also been the source of many of the environmental impacts, such as air and water pollution, waste and noise, targeted by EU environmental legislation. Industrial pollution problems have mainly been dealt with by end-of-pipe measures, many times creating problems of transfer of pollution between media.

Since the 1970s, several policy measures have been proposed to deal with industrial pollution. In the beginning, these polices were primarily directed at point sources (for instance, the Large Combustion Plant Directive). More recently, non-point sources have also been addressed. An integrated, cross-media approach to pollution control is embodied in the Directive on Integrated Pollution Prevention and Control (European Community, 1996), which establishes a framework for improvements in the use of resources, such as energy and raw materials, as part of the solution to pollution and environmental problems created by industry.

1.2. Outlooks

Socio-economic and sectoral long-term outlooks are presented that are the backbone for environmental pressures, state and impact outlooks. Scenarios for the next decade have been used for population size, volumes of production and consumption (by sector), volumes of transport, etc. These scenarios, explained in the introduction to the report, are based on a consistent set of assumptions of which the most essential are shown in Box 2.2.1.

The scenarios show the potential for economic growth (44% growth of GDP in the period 1995 – 2010) in the EU under the favourable conditions as assumed (Figure 2.2.1). This would in particular lead to an increase in European transport and tourism in the services sector and in certain industrial sectors. The outlooks for the manufacturing sectors show constant growth expectations for four of the major sectors within manufacturing. Growth in the metals indus-

Box 2.2.1 Main assumption of the socio-economic scenarios

Rapid technological change in the world (industrial and agricultural production, transport and communication, environmental technology).

An increasingly open world economy (e.g. ultimately a complete removal of trade barriers is assumed and decreasing international transport and communication costs).

Favourable domestic political and economic development in particular in important countries such as China, boosting the world economy and trade.

Europe enjoys a healthy world economy. Growth is further increased by monetary unification around 2000 – 2005.

A relatively stable population size in Europe, with no shortage of labour force.

A gradual economic convergence between European Union Member States is assumed (implying that the less prosperous countries experience faster economic growth), and observed sector trends by country were further projected to the future: some specialisation of countries occurs, and the services sector (which includes transport and tourism) increases its dominance.

Sources: European Commission, 1999

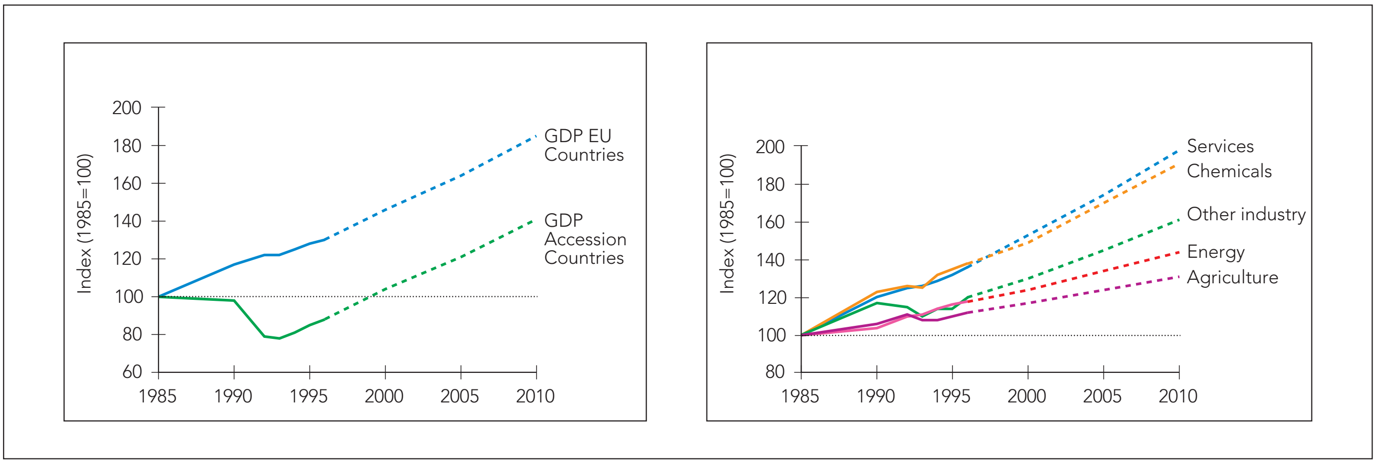
try is modest; growth in the chemicals, paper and building materials sectors amount to about 40 % in the period up to 2010. Many of these developments are based on sector-specific assumptions, and country differences may be large. However, the expected growth is general. It should be remembered that these scenarios are particularly sensitive to assumptions about long-term structural developments, and are subject to inherent uncertainty, particularly with respect to short-term fluctuations.

1.3. Accession Countries

The transition of the central and eastern European Accession Countries (AC10) from centrally planned to market economies initiated at the end of last decade and their prospective accession to the EU have far-reaching implications for the structure of their economies, and also for the existing EU. Changes are already noticeable, in particular a larger volume and a changing pattern of trade between the EU and the AC10. The AC10 used to export resource and capital-intensive goods. They have now shifted to exporting goods produced with less capital and resources and more labour. In some Accession Countries, the share of human capital or skill-intensive exports is also growing. Easier access to the western European market has tempted AC10 to copy production profiles which have been successful in the EU and to compete on the basis of lower labour costs (e.g. textiles). The example of Spain and Portugal, entering the EU in 1986, proves that developing an own profile and producing high-quality industrial manufactures such as electro-technical products, motorcars and machinery could be a successful avenue (EEA, 1999a).

The AC10 which began to develop their market economies in the early 1990s plunged into a deep recession around 1990. Most countries are now recovering. In Poland, growth rates began become positive by 1992, and GDP in real terms was slightly higher in 1996 than it was in 1989. A common characteristic is that at the point that the growth rates of these economies began to recover, the recovery was sustained. Expectations for the future are also hopeful (see Figure 2.2.1). The outlook shows a growth of 65% in the period 1995 to 2010. This is considerably stronger than in EU15 (44%). Through the period of transition and accession to the EU market, AC10 are

Figure 2.2.1 **Gross domestic product (GDP) in EU and Accession Countries, and gross value added in main economic sectors in EU, 1985-2010**



Sources: New Cronos, Eurostat; EEA, 1998; European Commission, 1999 expected to reinforce their economies and to be able to close the gap with the EU15, albeit only in the long run.

As accession to the EU is expected to bring an acceleration in economic growth, this will not go without environmental consequences. For example, after accession to the EU, Spain saw its growth of GDP rise to 27% in the period 1985 to 1993. In the same period energy consumption rose at the same rate, while increases in car ownership (+49%), road traffic (+38%) and emissions of NO_x (50%) exceeded GDP growth. Although currently stricter policies on emissions are in force in AC10 to control point source pollution, further attention will be needed in sectors such as transport.

Box 2.2.2 Energy consumption by households in the UK

A study for the UK has investigated the balance of negative and positive factors on the use of energy in households. It appeared that the energy use per household decreased by 7% in the period 1974 to 1994. Positive factors were an improvement in the energy-efficiency of the average house (building heat loss -23%) and heating system (wasted heat -17%), a negative factor was the increase of electricity consumption by 29%. The number of households grew 23% in that period, so that on balance, the overall energy consumption by households has increased by 15%.

A second study predicts that the energy consumption by households will continue to grow by 0.5% between 1990 and 2010, as a result of the further increasing number of households

Source: Boardman et al., 1997; Cambridge Econometrics, 1999

2. Population, households, consumption and tourism

During the last decade final consumption of households in the EU accounted for almost 60% of GDP. Consumer demand is determined by individual purchasing power and preferences, the numbers of consumers as well as on the way they have organised themselves. For example, a large household, according to surveys, uses resources more efficiently than single persons do.

2.1. Historical developments

In the period 1985 to 1996, the number of households in the EU grew faster than the population, as household size decreased (Eurostat, 1997); this, together with increasing per capita consumption (Figure 2.2.2), tends to increase pressures on natural resources. Improvements in efficiency of the use of natural resources are not sufficient to curb that development, as is illustrated with an example of energy use in households in the UK (Box 2.2.2).

The composition of final consumption of households has changed over the last 15 years. Whereas the proportion of expenditure on clothing and food of total consumption has significantly decreased, the share of expenditures on rent, fuel and power has increased, as has expenditure on services and transport, among which leisure activities, tourism, and communication are featured (New Cronos, Eurostat).

As the result of increased purchasing power by consumers, and also through reduction of prices and increased efficiency of transport and services in the tourism sector (WTO, 1994), the areas of leisure activities and tourism are rapidly growing. International tourism in Europe, in terms of numbers of international arrivals, rose by 60% between 1985 and 1996.

Tourist developments are characterised by several trends (see also Chapters 3.13-15). In particular, active holidays (skiing, hiking, cycling, climbing, etc.) gain popularity (WTO, 1994; Eurostat, 1995; European Commission, 1998a) and tourists tend to scatter over larger and often more sensitive areas, where their activities are more difficult to manage and control. Also certain particularly attractive areas, such as historic cities, are becoming more and more crowded with tourists, having impacts on the people who live there. Some coastal areas are overcrowded in summer and deserted in winter. Certain tourist activities are intrinsically harmful to the environment, such as golf in arid areas, requiring large amounts of water (WTO, 1994).

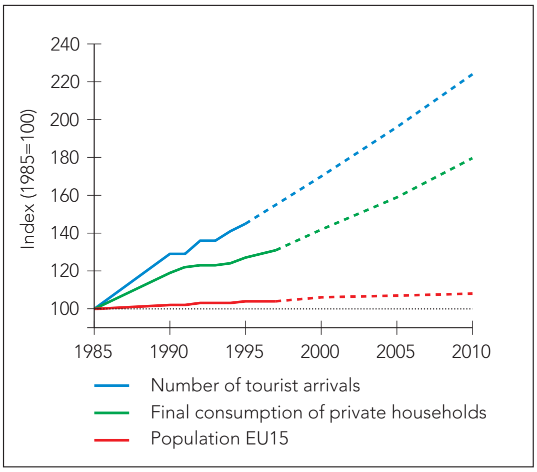
2.2. Outlooks

Figure 2.2.2 shows a considerable increase in final consumption, although projected population growth is only 4% between 1995 and 2010. The number of households is expected to increase (as average household size declines), both in the EU and even more so in the AC10. Per capita consumption is on a rising trend and some environmentally harmful activities, such as tourist trips, benefit more than proportionally. The World Tourism Organisation expects continued growth in the sector (an increase of international arrivals by about 50% between 1996 and 2010) (EEA, 1998).

The environmental impacts of steadily growing consumption depends upon the material intensity of consumption, in terms of use of materials and energy, and the ‘eco-efficiency’ of production (see Chapter 2.1).

Figure 2.2.2 **Population growth, increase in final consumption by households and tourist arrivals in EU**

Sources: New Cronos, Eurostat; Capros, 1997; EEA, 1998



Eco-efficiency depends upon the attitudes and behaviour of producers, retailers and consumers. Producers are increasingly entering into voluntary agreements aimed at the design of more efficient household appliances. In the energy sector for example, this is supported by progressive adoption of energy labels and minimum efficiency standards at EU level (SAVE) for a variety of appliances such as fridge-freezers and washing machines. Building regulations also increasingly require a better energy performance of residential housing by prescribing better insulation and double glazing. Consumers should be encouraged to be more open to energy and environmental aspects of durable consumer goods in their purchasing behaviour.

2.3. Accession Countries

Population in the AC10 declined very slightly between 1990 and 1995 (-0.6%), while the number of households (Slovenia excluded) fell by 2.6%. Hence the number of persons per household is growing, contrary to the experience in the EU. Bigger households may be the consequence of the worsened economic conditions in that period, and it is not unlikely that the trend will be reversed as incomes increase.

After the growing openness of the central and eastern European countries in the second half of the 1980s, tourism is developing quickly. The number of international arrivals showed a sharp increase of 180% in the period 1985 to 1996. This growth is stronger than in the whole of Europe in the same period. The outlook shows a continuous growth of tourism of about 60% between 1996 and 2010 which is also stronger than the predicted growth of about 50% for Europe as a whole (EEA, 1998).

3. Agriculture

The contribution of agriculture to overall economic output in the EU is modest: 2.3% of GDP and 5.3% of employment. Value added in the agricultural sector grew by 10% in the period 1985 to 1995, a much slower rate of growth than in most other sectors (New Cronos, Eurostat). The rural economy has become increasingly diversified (see Chapter 3.13). Nevertheless, agriculture is both a primary supplier of food and raw materials and a driving force exerting a major influence on the management of land and environmental quality. This is due to the high proportion of rural land devoted to farming in most of Europe, the large throughput of nutrients and chemicals, and the close link between agricultural systems, biodiversity and the visual-cultural landscape.

In many areas in the EU, agriculture is now using intensive and large-scale production methods. This has and continues to involve significant use of artificial fertiliser (mainly nitrogen and phosphate) and the application of plant protection products such as herbicides, insecticides and fungicides. Not all of these substances are taken up by the crops and certain amounts of fertilisers contribute to eutrophication of soil and water systems, whereas pesticides pollute soil, ground and surface water and air. Livestock creates eutrophication as well and contributing to acidification and producing greenhouse gases. Agriculture also contributes in some areas to soil degradation, erosion and salinisation (IEEP, 1998; Baldock *et al.*, 1996) (See Chapter 3.6).

Farmers also have a major role to play in the protection of biodiversity and landscapes. Many of the sites important for biodiversity are on, or adjacent to, agricultural land. There are sizeable areas of low intensity farmland of high nature value, including areas which merit protection under the EU Birds and Habitats' Directives (see Chapter 3.11).

While technical change has driven down costs for most agricultural products, many consumers are now expressing a preference for food produced using more traditional systems and giving greater priority to farm animal welfare. The increased popularity of organic farming products in many countries is a clear sign of new attitudes.

The agricultural sector is subject to structural changes under the Common Agricultural Policy and its subsequent reforms. These adaptations could have positive as well as negative effects for its performance with regard to environmental quality and nature conservation (European Commission, 1997a).

3.1. Historical development

For many decades, EU agriculture has become progressively more specialised and concentrated in areas with the lowest production costs. This process, driven largely by technological change and cheaper and faster transport, has been accomplished by growing intensification on the best land and in key production areas near to important markets. Higher labour costs and declining prices have also contributed to the reduced viability of farming in more marginal zones. In many marginal areas, including mountains and arid zones, production has been wound down and traditional management displaced. Afforestation, marginalisation or complete abandonment occur in some places (see Chapters 3.13 and 3.15).

Pastoral farming with cattle, sheep and occasionally other animals including goats and horses, is the main means of managing grassland in Europe and therefore of great significance to cultural landscapes and biodiversity. The maintenance of more extensive livestock farming systems is essential if stretches of grassland and other semi-natural vegetation is to continue to be grazed or kept under forms of management appropriate for species which have adapted to this environment.

However, livestock also contributes to environmental pressures. In the EU, cattle population has decreased from 98 million heads in 1984 to 85 million heads in 1996, while the pig population increased in the 1980s and has fluctuated around 118 million in the 1990s. The number of sheep grew slightly by 15% between 1985 and 1995. It has been estimated by Eurostat that about 41% of the total emissions of methane and nitrous oxide in the EU arise from the agricultural sector, mainly attributable to ruminants such as cattle, and livestock manure.

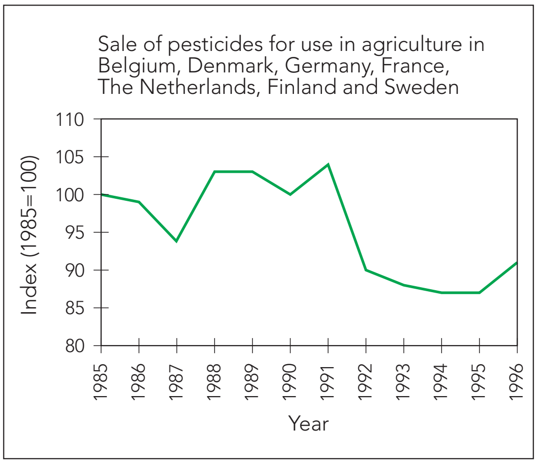
The use of inorganic fertilisers was fairly stable in the EU between 1985 and 1990, and has since declined, while there has been a gradual increase in nitrogen fertiliser usage after 1992 (See Figure 2.2.4). Total nitrogen use decreased by about 12% between 1985 and 1995. This arose from a reduction in the use of artificial fertilisers, also made possible by improvement of uptake by the crop, and an increase in the volume of manure, connected with growing numbers of livestock. The surplus of nitrogen input over uptake varies widely among EU countries. This surplus is high in certain areas of Belgium, Denmark, France, The Netherlands and the UK. It has been estimated that the supply of manure (in EU12) exceeds 170 kg N per ha – a threshold set by the Nitrate Directive for zones which are identified to be vulnerable to leaching of nitrate – in around 13% (or almost 1 million) of the farms for EU12, ranging from 63% in The Netherlands to less than 10% in France, Ireland and Italy (Brouwer *et al.*, 1997).

The use of plant protection products rose between 1985 and 1991, was lower thereafter, but tended to increase again after 1994 (use is measured in terms of the weight of active substances applied; Figure 2.2.3). However, crude measures of this kind provide little guidance about overall environmental impact, since the efficacy of many new products is increasing per kilogram of substance. The use of plant protection products partly depends on weather conditions, and the relatively dry conditions in the early 1990s were an important reason for the temporary drop in consumption.

Common Agricultural Policy and reforms

Approximately half of the EU budget goes towards financing the Common Agricultural Policy. In 1997, this amounted to over 40

Use of pesticides in selected EU Member States, 1985-1996 Figure 2.2.3



Source: New Cronos, Eurostat

billion euros. For comparison, Portugal's GDP amounted to 63 billion euros in that year. The process of reforming the CAP began in 1984 with the introduction of milk quotas and continued in 1992, in conjunction with the agricultural negotiations in the Uruguay Round/WTO. At the heart of the 1992 CAP reform was a policy of reducing price support and compensating farmers with more direct income support, such as payments per hectare of arable land. These payments make up more than half of the total CAP expenditures now. One aim was to remove the incentive for ever-increasing production levels. For the first time, all Member States were obliged to introduce agri-environmental measures providing financial support for farmers who agreed to adopt environmentally sensitive practices such as reduced inputs of fertilisers, the maintenance of extensive grassland and conversion to organic production. There was new recognition of the fact that farmers have a major role to play in the protection of biodiversity and landscapes.

Since 1992, there have been some further changes to the CAP, including reform of the fruit and vegetable regime and a new premium for more extensive beef farmers. In some, but not all cases, an environmental element has been included in these new measures in response to the overall goal of better integration between agriculture and the environment.

At the same time, a number of the existing EU environmental policy measures, such as the 1991 Nitrate Directive and the 1992 Habitats Directive, are beginning to exert a greater influence on farmland.

Links between agriculture as an important driving force and environmental pressures are diverse and complex. There is relatively little data available at a European level to provide an objective view of changing pressures on the rural environment. Although work is progressing on agri-environment indicators within the EU and the OECD (OECD, 1996) as well as at national level, they have yet to be applied in a systematic way (see Chapter 4.2). Moreover, the future for the agricultural sector is hard to predict from past trends, because of the many, partly policy-driven, structural changes. Farmers may be more exposed to economic conditions, such as market determined prices, and have more options open, including set-aside, adapted farm management and even abandonment.

Box 2.2.3 Agenda 2000

Currently, a further reform of the Common Agriculture Policy (CAP) is envisaged as part of the Agenda 2000 package adopted by the European Council in March 1999. Agenda 2000 sets out to build further on the approach in the 1992 reforms and is due to come into effect after 2000. Objectives include increased competitiveness of European agriculture on the global market, high food safety and quality, fuller integration of environmental objectives into agricultural policy and the creation of alternative jobs in rural areas. Once again, there will be a reduction in price levels, with farmers receiving direct payments in compensation. Agri-environment and rural development measures are given more prominence as a second pillar of the CAP and there is greater scope for Member States to adapt selected elements of the CAP more to their own requirements. The effect of the proposals, if agreed, will not be confined to the EU but will potentially apply to applicant countries, including several in central and eastern Europe with great agricultural potential.

3.2. Outlooks

It is possible that, as a result of the Agenda 2000 measures (see Box 2.2.3), farmers producing cereal crops will reduce their use of certain inputs, such as plant protection products and artificial fertiliser, in response to the anticipated drop in market prices. In any case, there is growing evidence that integrated crop production involving lower input use is becoming more competitive. It is generally expected that there will be further changes in the beef farming sector which has been affected by overproduction, low prices and the 'mad cow' (bovine spongiform encephalopathy (BSE)) episode which has, at least temporarily, undermined consumer confidence in many countries. Although Agenda 2000 includes proposals to assist more extensive beef farming, much of which plays an important role in the management of semi-natural grassland, there are doubts about whether this activity will remain competitive in the future. There must be a concern that polarisation between intensification and marginalisation will continue (see Chapter 3.11).

There has been a rapid growth in the number and scope of agri-environmental schemes in the EU since the current Regulation 2078/92 came into effect. By 1997, it was estimated by the European Commission that about 20% of farm holdings in the EU were participating in a voluntary agri-environment scheme and a similar proportion of the total agricultural land had been enrolled. It is expected that such schemes will continue in the future as a compulsory element in a broader rural development policy envisaged in Agenda 2000.

The baseline scenario, based on policies in force in 1997 and discounting Agenda 2000, suggests that the dairy cattle population might fall by about 16% between 1995 and 2010, while the pig population might increase by 9% and the population of laying hens rise by 6% (EEA, 1998).

Overall EU consumption of nitrogen as well as of phosphorus in fertilisers is expected to decrease further, at a very slow rate (European Fertiliser Manufacturers Association (EFMA)) (Figure 2.2.4). This projection is based on several assumptions summarised in Box 2.2.4.

As to the consumption of plant protection products, the European Crop Protection Association (ECPA) expects an overall decrease in the volume of active substances from 270 million kg in 1996 to 190 million kg in 2008, for the EU. However, the impact on the environment is uncertain. Developments in pesticide use are mainly driven by technological progress, including the advance of biotechnology, but the industry also expects policy changes, such as Agenda 2000, to have an impact. If organic agriculture were to take a larger share of the market, this would also contribute to a reduction in pesticide use.

3.3. Accession Countries

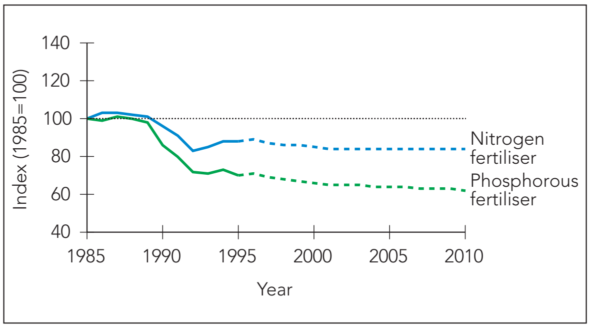
In most of the Accession Countries, privatisation of the state owned and collective farms generally has resulted in a dual farm structure. Typically, there is a large number of small family farms, subject to rapid amalgamation in some areas, which exist alongside a group of larger units comprising co-operatives, limited companies and state farms. During the economic transition period, agricultural output fell drastically. The decline in output was most pronounced in livestock production as consumers switched to cheaper staple products and export markets were lost. In most countries, cattle and sheep numbers fell to about half their former level and there was a decline of 30-35% in pig and poultry populations. Crop production fell by up to a third compared to 1989 but there has been an increase in average yields and production in most countries recently. Hence there has been a reduction in pollution from agriculture in recent years because of the lower intensity and fall in livestock numbers. The use of fertilisers and pesticides remains much below levels in the EU. Aggregate use of nitrogen fertiliser in the EU and AC10 in recent years is shown in Figure 2.2.5. But the potential for increasing the use of fertilisers and pesticides, and the spread of manure represents an important threat to water quality.

Box 2.2.4 Assumptions in fertiliser projections

The outlook assumptions:

- Farmers increasingly improve the efficiency with which they use nutrients in livestock manure. The implementation of the Nitrate Directive is expected to affect nitrogen application rates;
- A progressive change from present Common Agricultural Policy (CAP) policies to a more liberalised regime in 2006/7;
- Greater efficiency in manure storage and application;
- Set-aside reducing from 10% of the base area in 1997/8 to 8-10% in 2001/2 and being eliminated altogether by 2006/7. Potentially significant changes in cereal and sugar beet production.

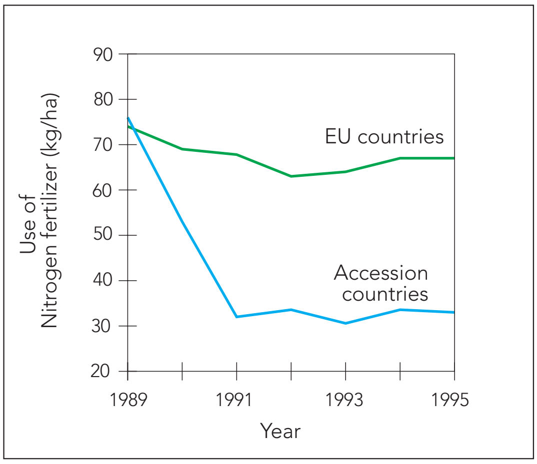
Use of fertilisers in EU, 1985-2010 Figure 2.2.4



Source: EEA, 1998

In general, prices of agricultural products are still below those in the EU but there has been a decline in AC exports to the EU, which are subject to quota and hygiene restrictions. The Common Agricultural Policy and the Agenda 2000 proposals for reform will potentially be a major force in determining the pattern of agricultural development in Accession Countries. Given the surplus in the agricultural market within the EU and the tendency to cut subsidies, it is expected that the EU's agricultural policy for Accession Countries

Use of nitrogen fertiliser (kg/ha) in Accession Countries and the EU, 1989-1995 Figure 2.2.5



Sources: EEA, 1998; EEA, 1999a

will focus on structural adjustments and rural development, rather than stimulating output.

4. Energy

Environmental impacts arise at each operating phase of the energy system (production, transmission, transformation, distribution and consumption). Among other issues, the combustion of fossil fuels generates emissions to the air (mainly greenhouse gases and acid compounds), creates waste, and the nuclear energy industry creates risks and a hazardous waste problem. There is therefore wide-spread consensus that any strategy aimed at lessening the environmental impact caused by energy use should basically rely on improved energy efficiency and the development of environmentally-friendly energy sources (e.g. renewable sources) (European Commission, 1995a).

The EU environmental policy seeks to reduce the environmental impact of particular energy sources, especially fossil fuels (European Commission, 1995a). Of particular importance are the Commission's strategy documents on acidification and tropospheric ozone, and specific measures such as the Large Combustion Plant Directive, the Directive on Integrated Pollution Prevention and Control, and measures to limit the sulphur content of heavy fuel oils. Measures specific to the transport sector are addressed in greater detail below.

4.1. Historical developments

Between 1985 and 1995, total primary energy supply in the EU increased by 11%, while GDP rose by 24% (Figure 2.2.6), indicating a modest (10%) reduction of energy intensity (defined as primary energy supply per unit of GDP). This is small when compared with the decrease of 16% achieved from 1976 to 1986 and with the EU policy objectives established in 1985 for a 20% reduction by 1995 (European Commission, 1998b). Nevertheless, the general downward trend has remained, despite the strong drop in world energy prices. This trend resulted mainly from the continuous effects of structural changes which have occurred in the EU economy (increased share of less energy-intensive economic sectors in the GDP) and from general technological improvements in the production of goods and services (e.g. in most cases, technological changes in industrial processes lead to reduced energy requirements).

The growth of final energy consumption varies between sectors (Figure 2.2.7). In transport, energy demand grew by almost 40% from 1985 to 1996 and has essentially relied on oil. Despite the new regulations on fuel quality and the ongoing development of new technology (e.g. electric cars), the impact of air emissions due to transport remains a major concern. This growth in energy consumption by transport was considerably stronger than the growth in industry (3%) and other sectors (14%) in the same period. The share of transport in final energy demand amounted to 29.6% in 1996, and ranked third shortly after industry (30.6%) and after other sectors (39.8%).

The share of different energy sources in final consumption has been subject to considerable changes. Between 1985 and 1996, natural gas and nuclear energy increased substantially at the expense of oil and coal (in spite of the integration of the former German Democratic Republic, a substantial user of solid fuels). The share of renewable energy sources was 5-6% in 1995, about the same as in 1985.

Energy consumption is influenced by economic growth, structural economic changes and social behaviour, but is also influenced by the energy policy which can improve the efficiency of energy use and give guidelines to both operators and users when they choose their sources of energy. Although the EU has a limited role to play in terms of energy policy under the Treaty of Rome, the European Union has had to adopt a common target, in particular due to the need to define the options for the Community's Climate Change Strategy (for a detailed presentation of the EU's general policy on energy and environment, see reference to document European Commission, 1997b). Guidelines and measures have been proposed (and several adopted) to enforce the improvement of energy efficiency and the development of renewable energies. In general they fall within a general trend of liberalisation of the internal energy market, which may have a diversified impact on the structure of energy supply and consumption, particularly in the context of a continuously low level of world energy prices.

A range of energy policy initiatives and framework documents has been launched recently. These are increasingly linked to the Community's Climate Change Strategy since the Kyoto Conference of December 1997 (European Commission, 1998c) (see Chapter 3.1). They include an overall framework for energy policy and more specific strategies on renewable energy, combined heat and power (CHP) and energy efficiency, which are outlined in Box 2.2.5 (Decision 96/737/ EC; European Commission 1997c).

4.2. Outlooks

The trend of decreasing energy intensity is expected to continue in the years to come. From 1995 to 2010, GDP in the EU15 is expected to grow by 44% and total primary energy supply would increase by 15%, implying a slightly better than 1% drop of energy intensity per year. The policy goal of 20% improvement (SAVE II) will then almost be met.

The share of transport in total final energy consumption is expected to increase to 32% in 2010. Since energy use by the industrial sector will only take up a slow growth path, as the balance of continued energy savings and substantially increased production volumes, the share of industry in final energy demand will remain relatively stable (29% in 2010). By then, transport will have outranked industry and become the second largest energy consumer, after other sectors (household and services). Together with services mainly, energy consumption by household will continue to grow modestly and is expected to remain the largest proportion of final energy demand, with 39% by 2010.

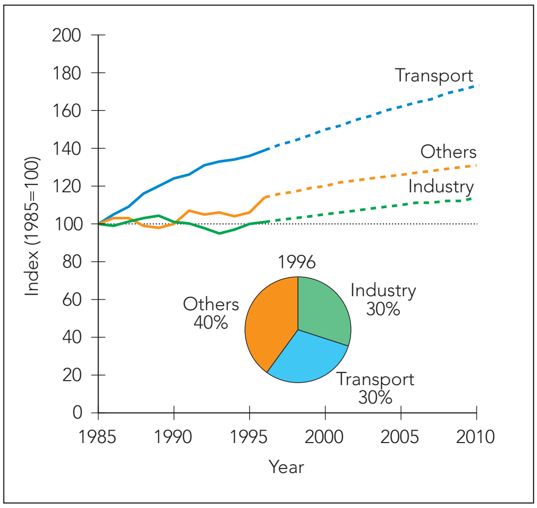
Despite the expected increase in average thermal efficiency of power generation (from 38% in 1995 to 44% in 2010), the consumption of the electricity sector will grow slightly. This is due to an increase of approximately 18% of electricity consumption, based essentially on additional thermal generation. These figures assume that the share of thermal co-generation (approximately 9% in 1995) will remain unchanged.

Up to 2010, the use of natural gas is expected to increase slowly, at the expense of solid fuels and oil. The baseline scenario comes up with a share of renewable energy sources of about 8% in 2010 which is considerably lower than the policy target. Nuclear energy is expected to maintain its share. However, policy decisions in some countries may reduce the share of nuclear energy in the long run.

4.3. Accession Countries

Total final energy consumption in most of the AC10 dropped in the 1985-1995 period, due mainly to the economic recession associated with drastic political changes.

Total Final Energy Consumption by Sectors, EU — Figure 2.2.6

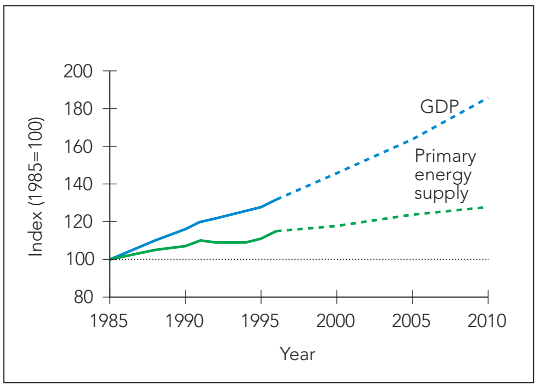


Sources: IEA; Capros, 1997

Box 2.2.5 Main policy developments in energy

- Under the umbrella of SAVE II programme, following SAVE I, the EU is implementing measures with a view to increasing energy efficiency in different sectors. The Energy Efficiency Strategy set a present target to cut back on energy intensity by 20% from 1995 to 2010.
- The Combined Heat and Power (CHP) Strategy (October 1997) set the goal of doubling the current share (9%) of electricity produced by CHP generation by 2010 which should lead to a reduction of 4% of total CO_2 emissions.
- The White Paper on renewables establishes a target of doubling energy production from renewable energy sources compared with the current level, which is supported by ALTENER II (Decision 98/352/EC).
- A new proposal for a Directive to set minimum excise duties for energy products was published in March 1997 (the proposal for an EU Carbon/ Energy Tax not having been adopted).

Primary energy supply and GDP in EU15, 1985-2010 — Figure 2.2.7



Source: IEA; Capros, 1997; New Cronos, Eurostat

Energy intensity in the AC10 is much higher than in the EU (from factor 1.5 in Slovenia, to factor 3 in Bulgaria). This is partly due to the economic structure of AC10, with a share of the industrial sector in GDP of 49% on average, but mainly due to the low efficiency of energy use – by the energy sector and by consumers.

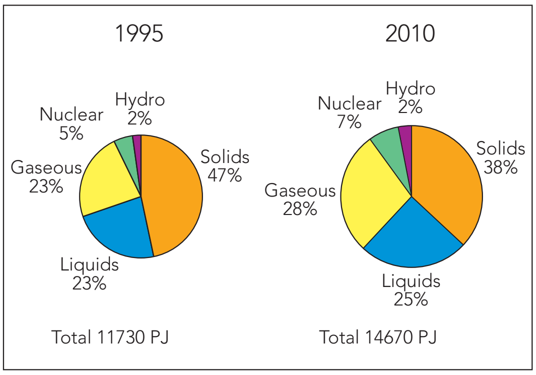
In 1990, the energy consumption structure by sector was dominated by the industry. The share of transport in final consumption amounted to less than 16%, on average. As a result of restructuring and modernisation of industrial production facilities, energy intensity in the industry could decrease dramatically up to 2010 (approximately 35%), if appropriate policies and financial instruments are in put in place (EEA, 1999b). In the same period, energy consumption in the household and services sectors (35% of the consumption in 1990) is expected to rise by at least 20% due to increased income. In the transport sector consumption is expected to grow, mainly due to increasing use of private cars (up to 56%).

Overall, total primary energy supply by energy source (Figure 2.2.8) is dominated by solid fuels (47%), followed by liquid fuels (23%) and gas (23%), in 1995. Nuclear energy (5%) and hydro-power (2%) play a modest role. Up to 2010, the increased energy consumption by the transport and household sectors will induce a switch from coal to oil and natural gas. Nuclear energy will grow slightly. But the future of nuclear power is difficult to predict, particularly due to concerns over nuclear safety.

The evolution of the energy sector in the AC10 will not be influenced only by economic growth and the general re-structuring of the economy, but also by the general policy on energy and environment. The modernisation of sectors such as energy, industry, transport and housing may be triggered by the commitments made under the Kyoto Protocol (see Chapter 3.1): the industrialised countries having anticipated an ambitious reduction target for the 2008-2012 period can invest in energy-efficiency projects in central and eastern Europe to improve the cost-effectiveness of said reduction. The transfer of technologies aimed at reducing greenhouse gas emissions between the EU Member States and Accession Countries would benefit both parties, though the rules for such procedures have yet to be agreed upon in detail. If these transfers occur, they may speed up the process of energy efficiency improvement and the switch from coal to natural gas (namely as regards the substitution of coal in heavily polluting power plants).

Figure 2.2.8 **Energy supply in the Accession Countries by fuel type, 1995 and forecast 2010**

Source: EEA, 1999b



5. Transport

Transport is of great economic importance and the source of many environmental problems. Polluting emissions from transport sources adversely affect air quality, ozone levels and acidification, and contribute to global climate change. In addition, significant energy and other resources are also consumed in vehicle production, while disposal of vehicles, tyres, batteries, etc. contributes significantly to Europe's waste streams. Moreover, transport infrastructure construction has environmental impacts, including threats to biodiversity, fragmentation of landscapes and usage of raw materials.

In the past, economic growth and lowering transport prices have raised demand for transport. Where congestion occurred, new roads, airports and other infrastructure were constructed. This again lowered transport time and cost, inducing more transport in the short term, and in the long term causing enterprises and households to choose locations which may also require more transport. This closes the vicious circle of ever expanding transport volumes. Limits are largely set by the time people want to spend on travel, and the technically achievable speed of travel (see Box 2.2.6). By far the majority of transport use is still national or even local in nature, but European liberalisation of transport services and trade have contributed, and will contribute, significantly to the overall increase. The same is also expected to happen in the Accession Countries as they converge with the market structures of EU countries.

5.1. Historical developments

Carbon dioxide (CO_2) emitted from transport sources has increased dramatically in recent decades. On the other hand, emissions of lead and nitrogen oxides (NO_x) by road traffic are decreasing because of much improved technology (e.g. lead emissions from road transport which have since 1990 decreased by more than 70% in the EU following unleaded petrol sale). In contrast, the local impacts of transport infrastructure that was constructed in the past decades on residents and biodiversity are huge, but difficult to quantify or even characterise.

In the EU, the energy consumed by transport increased by more than 40% in the period 1985-96 (IEA), due mainly to the increase in volume of transport. At the same time, there was no improvement in energy efficiency: the amount of energy used per unit of transport (passenger-kilometre or tonne-kilometre) remained the same. Although engines are more energy-efficient than 20 years ago, heavier and more powerful vehicles are used and on average less passengers or freight are transported per vehicle.

In line with the increase in use of road transport, the road network has been expanding while the railway network has either stabilised or being reduced in some countries. Motorways have been built across the continent, with large increases in total length (over 200% in the EU alone since 1970), particularly in Greece, Portugal and Spain where the total length of motorways has more than tripled in the period 1980-1996. Occupation of land by infrastructures is high in Belgium, Germany and the Netherlands, where the density of motorways exceeds 30 km per 1 000 km² of total land area (Table 2.2.1).

The total length of all roads has also increased, by 17% in the EU and 12% in the AC10 since 1970. The pattern for railways is consistent with the trends in goods transported: the railway network has shrunk by 6% in the EU, while in the AC10 it remains mostly unchanged so far.

Passenger transport

The main historical developments in EU passenger transport are presented in Box 2.2.8. This large growth of road and air passenger transport in particular was caused by increasing incomes, in combination with a decrease in real terms in transport prices, including the prices of cars and air fares.

Box 2.2.6 Travelling time in 1750 and 1998

'The traveller who landed around 1750 at Dover or Harwich after an unpredictable and often lengthy crossing (say thirty-odd hours from Holland) would be well advised to rest the night in one of the expensive, but remarkably comfortable, English inns […]. He would travel perhaps fifty miles by coach the next day, and, after another night's rest at Rochester or Chelmsford, would enter London in the middle of the next day.' (Hobsbawn, 1968).

This voyage that took almost 3 days in 1750, would not usually take more than 6 hours today. Some transport scientists claim that according to the 'law of conservation of travelling time' people have tended to spend roughly the same time on travelling since the Middle Ages. Consequently, as travel becomes faster, people will travel longer distances. However, faster travelling requires more energy. In effect, time is exchanged for energy.

Box 2.2.7 Driving a car: direct and indirect need for resources

Driving a car requires energy. Of every litre of fuel extracted from the earth's oil sources, only a small portion – 2 cl or less than a shot glass – is directly used for moving the driver from A to B. Thirty-five percent disappears unused and converted into fumes through the exhaust and 40% heats the air around the car. Six percent is lost in internal friction. So, the remaining 19% is used for movement, of which 17% moves the car, and 2% the driver.

If we manage to double car fuel efficiency, we manage to increase the portion of the fuel that is directly used to move the driver from 2 to 4%.

Source: Fussler & James, 1996

Motorway density in the EU Table 2.2.1.

Country	1970	1980	1990	1996
Austria	5,3	10,5	17,8	19,4
Belgium	14,9	36,3	50,8	51,0
Denmark	4,3	12,2	14,2	20,7
Finland	0,4	0,7	0,7	1,4
France	2,8	9,6	12,4	15,1
Germany	17,4	26,4	31,0	32,4
Greece	0,1	0,7	1,5	3,6
Ireland	0,0	0,0	0,4	1,2
Italy	13,3	20,1	21,0	21,9
Luxembourg	-	-	-	-
Netherlands	35,6	52,3	61,7	69,6
Portugal	0,7	1,4	3,5	7,8
Spain	0,8	3,9	8,9	14,6
Sweden	1,0	2,1	2,3	3,2
United Kingdom	4,4	10,6	13,2	13,8

Sources: *Eurostat*, IRF, national statistics. European Commission (DG VII, Eurostat), EU Transport in Figures, Statistical Pocket Book, April 1998

units: km per km² of country land area

1996 data: estimates for France and UK

The real prices of road transport fuels returned to previous levels after past oil crises, and aviation fuels remain exempt from taxes.

Box 2.2.8 Historical developments in EU transport sector

Passenger transport
- an increase of total passenger transport by over 50% between 1980 and 1996;
- an increase of 60% between 1980 and 1996 of car passenger-kilometres;
- the number of air passengers arriving at the major EU airports grew by more than 100% between 1980 and 1996 and the air passenger-kilometres grew more than 200% in that period;
- a growth of 10% of rail passenger traffic in the period 1980 to 1996.

Freight transport
- an increase of 75% between 1980 and 1996 of road freight transport tonne kilometres;
- an decrease of 25% between 1980 and 1996 of rail freight transport tonne kilometres;
- zero growth of the freight transport volumes by inland shipping.

Sources: ECMT national statistics, estimates; European Commission, 1998d

Freight transport
The removal of internal trade barriers in the EU and lower transport prices have caused a concentration of the production of goods in a smaller number of places, giving scale advantages which outweigh the cost of larger transport distances. Completion of the Single Market is estimated to have created an extra 20 to 30% of trade among Member States. This has also led to a speeding-up of improvement of logistic systems in the freight transport sector. Cheaper, faster and more reliable transport has also facilitated development of just-in-time delivery systems, which require faster freight movements in smaller quantities (i.e. rather by road or air than by water or rail).

The preference of transport users for reliability and flexibility has provoked a shift away from rail and inland navigation towards road transport. This trend was also supported by a structural change in the type of products to be transported. The volume of freight transport by rail in the EU reached an historic high level in 1980 but fell to about 80% of that level in 1996. Transport of goods on inland waterways is less important overall in terms of volume (7% of total EU freight transport), but is important in some countries such as the Netherlands, Germany, Luxembourg and Belgium.

In 1995, the European Commission published its action programme on the common transport policy (European Commission, 1995b), setting out proposals for the years 1995 to 2000. The Commission recently also outlined the perspectives for continuing the action programme in 2000-2004 (European Commission, 1998e). Many items in this programme are of direct or indirect relevance to the environment. Since 1995, policies have been adopted at EU level concerning the development of the Trans-European Transport Network (TEN – Box 2.2.9 and Map 2.2.1), the improvement of local passenger transport, the internalisation of external cost (European Commission, 1998f and 1995c; ECMT, 1998), the revitalisation of railways and of public transport and the development of combined transport.

Stricter standards on vehicle emissions and fuel composition will have a significant impact on some regulated pollutants. To reduce CO_2 emissions, the European Commission has recently agreed with European car manufacturers on significant reductions in new car emission rates, and a labelling scheme has been proposed (European Commission, 1998g) (see section 4 in Chapter 3.12).

Box 2.2.9 Main objectives and development of the TEN

Objectives:
- to create an intermodal transport system in which modes are combined according to their comparative advantages;
- to enhance socio-economic cohesion;
- to contribute to the achievement of the EU's environmental objectives.

Projects envisaged:
TEN Rail network:
- 2 600 km of existing new high-speed lines and 2 300 upgraded high-speed lines;
- 10 000 km of planned high-speed tracks;
- 14 000 km of lines to be upgraded to high-speed standard;
- 48 400 km of existing conventional lines;
- 1 300 km of planned conventional lines.

TEN road network:
- 47 500 km of existing TEN roads. 27 000 km of planned TEN roads of which around 54% will be upgradings and 46% will be new roads).

Inland waterway network and inland ports:
- achieve 12 000 km of navigable canals and rivers.

Airport infrastructure:
- some of the 290 strategic European airports will be refurbished for greater capacity and efficiency.

Overall foreseen investment: 400 billion euros.

5.2. Outlooks
The main assumptions in the outlooks, from the baseline scenario, are summarised in Box 2.2.10. The local effects of infrastructure building (and resources use) will however continue in the future. The number of residents at short distances from infrastructure will increase. Energy demand by transport will also continue to increase, by about 30% from the 1996 level (Figure 2.2.9).

Increase in trans-European transport network

0 500 km

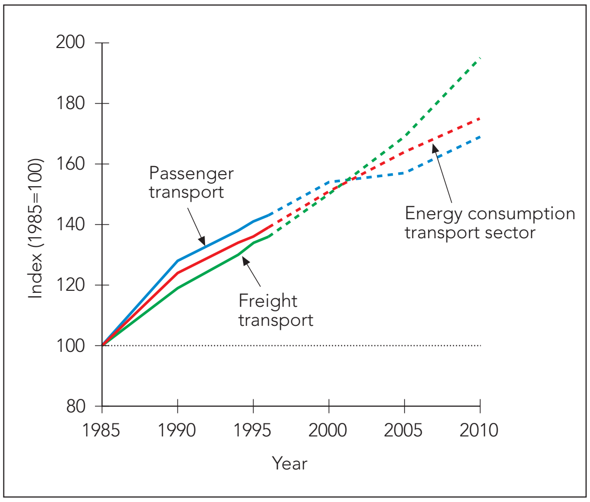
infrastructures
existing
planned

Map 2.2.1

Source: European Commission, 1998h

Figure 2.2.9 **Development of freight and passenger kilometres and energy consumption by transport, EU**

Source: European Commission, 1998d; IEA; Capros, 1997



Passenger transport
Passenger transport is expected to grow by 30% between 1995 and 2010 and the current patterns of growth favouring road and air are expected to continue. Passenger car transport will also grow by 30% between 1995 and 2010 and will maintain its share in the modal split. Passenger air travel will almost double. Rail transport is likely to increase by 30%, partly as the result of supportive policy measures, whereas bus transport will only grow by 5%. These developments are driven by the same causes as past developments (Hahn, 1997). Curbing this development and encouraging people to shift from cars to public transport could not be done without major investment in public transport systems, as is illustrated in Box 2.2.11. In addition, the construction of new motorway and rail infrastructure (including the implementation of the TEN programme) can be expected to lead to additional growth in traffic. The extension of the high speed rail (HSR) network is expected to divert travellers from air to rail, but it will also induce additional travel.

Freight transport
Total freight transport is expected to grow by around 50% between 1994 and 2010. This is mainly caused by an increase of international freight movements. Transport distances will increase, largely due to the same mechanisms as in the past. Some effects are expected, especially on longer distances, of efforts to encourage rail and combined transport (road/rail) (Figure 2.2.10). The transport outlook, from the baseline scenario, predicts that the volume of road transport will increase by 50% between 1994 and 2010. The volume of rail freight transport is expected to rise by 55% up to 2010. Although the use of inland waterways has hardly grown since 1970, an increase of about 40% from the 1994-level is expected by 2010.

5.3. Accession Countries
The transport systems in AC10 have been affected by the recession in the early 1990s. Freight transport decreased sharply after 1990 (except in the Czech and Slovak Republics). Road transport has recovered since then; in 1995 the transport volume already exceeded the 1990 level. The inland water transport sector suffered from the economic recession and lost about 40% of its volume in the period 1989–1992, and it remains relatively insignificant, despite a recovery after 1992 (Figure 2.2.11). Freight transport by rail used to be dominant throughout the 1970s and the 1980s, but was matched by road transport in 1995. In 1996, for the first time in history, the volume of road transport surpassed the

Box 2.2.10 Main assumptions for transport outlooks

The outlooks set out below take into account the main EU policies adopted or proposed by 1997 which affect transport growth. World oil price is, in this scenario, expected to increase, as well as taxes on transport fuels. Prices at the pump are projected to increase slightly.

EU policy has some effect on passenger modal split, for example through the construction of a High Speed Rail Network (EEA, 1998), and other measures to encourage public transport modes.

For freight transport, some assumptions with respect to the integration of Accession Countries markets into the EU single market. Freight modal split is assumed to be influenced by EU policies to encourage rail transport. The main freight transport policy assumptions are:

- continuing development of the TENs as scheduled by the European Commission in 1997;
- new freight rail connections (mainly part of the TENs) are foreseen where congestion of road traffic threatens economic growth;
- new road connections have been assumed where (in the total transport infrastructure network) this is needed to reduce congestion;
- other assumptions have been made concerning free access to markets, abolition of customs barriers within the EU, harmonisation of road taxes, harmonisation of fuel taxes, speed limitation, harmonisation of weight and taxes, harmonisation of VAT.

Assumptions specifically made for modal split are:

- about road taxation, fuel taxation, liberalisation of rail and inland waterways transport markets;
- influences of government policy (e.g. TENs programme) on tariffs and times.

Box 2.2.11 Relation between reduced car use and capacity of public transport in commuter traffic in The Netherlands, 1997

On a normal weekday, 5 million Dutch commuters set off for work in the morning (1997). Out of them, 2.9 million take the car, 220 000 take the train, and the same number of people goes by bus, tram and metro. At rush hour, many highways are jammed and the capacity of the public transport system is fully deployed.

The dominance of the car in commuter traffic and the large efforts that would be required to accommodate people who, e.g. for environmental reasons, would be willing to shift from car to train or bus, is illustrated by a numerical example. It shows that policy measures in support of such a shift alone, like road pricing, may not be sufficient.

Assuming that 10% of the car users will shift to the train – which will help solving quite a number of traffic jam problems – then 290 000 more people, on top of the 220 000 regular train commuters, will try to board at morning rush hour, which would require more than a doubling of the passenger railway capacity.

If the additional public transport users are spread evenly over the public transport system (which would be the case in an ideal situation only), then the railway and bus capacities would still have to grow by 40%. In many cases, commuters will be on the train as well as on the bus in one home-to-work trip, so that doubling the capacity of railway and bus systems is more than likely to be required.

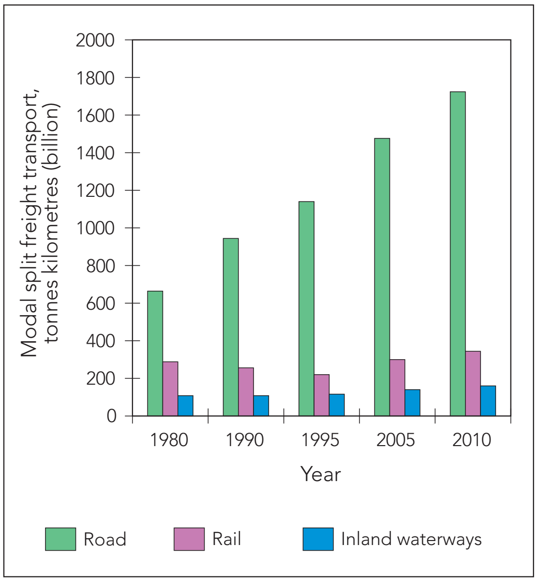
Substantially expanding the public transport system will require huge investment and lengthy political decision procedures, but it may be necessary to provide people with an alternative to private car use.

Source: Central Bureau of Statistics, Transport Sector, Heerlen, the Netherlands

volume of rail transport in terms of tonne-kilometres. The extensive existing rail infra-structure is still intact and provides options for restoring and maintaining the share of rail transport in the modal split in AC10.

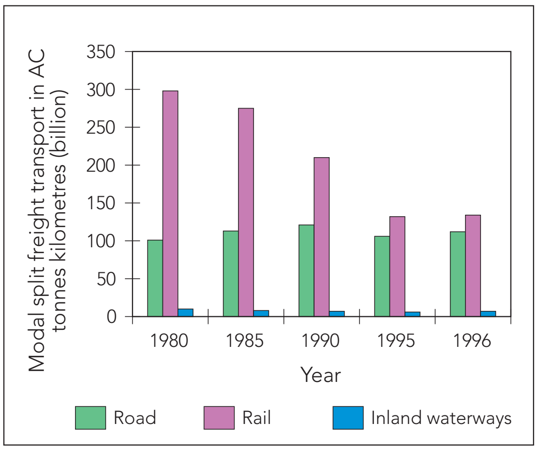
In some respects, the changes in AC10 will have positive impacts because an outdated stock of vehicles is being replaced by cleaner and more modern ones, although much of the demand for private car travel is currently being met by larger second-hand cars from western Europe. On the other hand, the same environmental pressures will arise as in the EU, and rapid growth in road transport, following substantial economic growth, will add to environmental pressures. A pan-European network of transport corridors is being considered, covering the candidate Member Countries. A further future demand can be expected following the extension of the EU. As an example, prospects for Hungary and Poland suggest that the growth of car kilometres in and between these countries and with the EU15 Member States will be even stronger than in the EU15 (EEA, 1998 and 1999a).

Modal split freight transport, EU — Figure 2.2.10



Sources: European Commission, 1998d; EEA, 1998

Modal split in freight transport, Accession Countries, 1970-1995 — Figure 2.2.11



Source: ECMT, 1996; Eurostat; UIC

References

Baldock D., Beaufoy G., Brouwer F. and Godschalk F., (1996). *Farming at the margins: abandonment or re-deployment of agricultural land in Europe.* Institute for European Environmental Policy & the Agricultural Economics Research Institute. London and the Hague.

Boardman, B. *et al.*, (1997). Cold Houses, Warm Houses and Household Energy Use: a Challenge for the Twenty-First Century; The Road to Kyoto – WWF Climate Change Conference, June 1997.

Brower, F. and P. Hellegers, (1997). Nitrogen flows at farm level across European Union: *Analysis of the effects of the CAP on the environment and assessment of existing environmental conditions in policy.* Wageningen, Wageningen Pers.

Cambridge Econometrics,1999

Capros, P. *et al.*, (1997). *Business as Usual Scenario for the EU Energy System 1995-2020* – Final Report to European Commission, DG-XVII/A2, National Technical University of Athens.

Décision du Conseil n° 96/737/EC. Save. Journal Officiel n° L335 du 24 décembre 97.

ECMT, (1996). *Infrastructure-Induced Mobility*, Report of the 105th Round Table, Paris, 7-8 November 1996.

ECMT, (1998). Efficient Transport for Europe: *Policies for the Internalisation of External Costs*, Paris, 1998.

EEA, (1998). Report on Economic Outlooks (unpub.) Report prepared by DHV for the European Environment Agency.

EEA, (1999a). (forthcoming). Environment and European Enlargement. Appraisal of future trends. Agriculture and Transport (working title). Scenarios & Prospects n 2. Technical report.

EEA, (1999b). Environment and European Enlargement. *Appraisal of future trends. Air Emissions*. Scenarios & Prospects n 1. Environmental issues n.8. European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

European Commission, (1992). *Fifth Environmental Action Plan "Towards Sustainability"*. Commission of the European Communities, Luxembourg.

European Commission, (1995a). *An energy policy for the European Union.* COM (95) 682 final.

European Commission, (1995b) Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee of the Regions - The Common Transport Policy - Action Programme 1995-2000, COM/95/302 final, Brussels, 12.07.1995

European Commission, (1995c). Towards fair and efficient pricing in transport policy - options for internalising the external cost of transport in the European Union - Green Paper, COM/95/691 final, 20.12.1995.

European Commission, (1996). *Progress Report on the implementation of the European Community Programme of policy and action in relation to sustainable development.* COM (95) 642 final.

European Community, (1996). *Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC).*

European Commission, (1997a). *Report from the Commission to the Council and the European Parliament on the application of Council Regulation (EEC) No. 2078/92 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside*. COM (97) 620. final.

European Commission, (1997b). *Communication on the energy dimension of Climate Change* (COM(97)196

European Commission, (1997c). *Energy for the future - renewable sources of energy* (White paper) COM(97)599 final.

European Commission-DG XXIII, (1998a). *Facts and Figures on The European on Holidays. Executive summary.*

European Commission, (1998b). *Communication on Energy efficiency in the European Community – towards a strategy for the rational use of energy*, COM(1998) 246.

European Commission, (1998c). *Communication on Climate Change – Towards and EU Post-Kyoto Strategy*, COM(98) 353.

European Commission, (1998d). *EU Transport in Figures. Statistical Pocketbook*. Luxembourg

European Commission, (1998e). Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee of the Regions. *The Common Transport Policy. Sustainable Mobility: Perspectives for the Future.* COM (1998) 716 Final/2, 21.12.1998)

European Commission, (1998f). *Fair payment for infrastructure use: a phased approach to a common transport infrastructure framework in the EU - White Paper* - COM (1998) 466 of 22.7.98

European Commission, (1998g). *Communication on transport and CO_2 – towards an EU approach*, COM(1998) 204.

European Commission, (1998h). Trans-European Transport Network, *1998 Report on the Implementation of the Guidelines and their Future Development*, Brussels, 28.10.1998, COM(1998)614 final

European Commission, (1999) (forthcoming). "Economic Assessment of Priorities for a European Environmental Policy Plan (working title)". Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environment, Nuclear Safety and Civil Protection).

Eurostat, (1995). CEC DG XXIII .*Tourism in Europe*. CEC, Luxembourg

Eurostat, (1997). Eurostat Yearbook 1997. Luxembourg

Fussler, C. & James, P., (1996). *Driving Eco-Innovation*. – Pitmann, London.

Hahn, W., Althoff A., Ratzenberger R., (1997). *Prognose des Personenverkehrs in Europa bis zum Jahr 2005. Studie in auftrag der Europäischen Kommission*, DGVII. Ifo Institut, München.

Hobsbawn, E.J., (1968). Industry and Empire- The Pelican Economic History of Britain (vol. 3: From 1750 to the Present Day), Penguin Books Ltd. Harmondsworth, Middlesex, England

IEEP, (1998). 'Assessment of the Environmental Impact of certain Agricultural Measures'. Report for the European Commission, Directorate-General XI (Environment, Nuclear Safety and Civil Protection). Institute for European Environmental Policy, London. Unpubl.

OECD, (1996). Agri-environmental indicators: Stocktaking report. Document submitted to the Joint Working Group Party of the Committee for Agriculture and the Environment Policy Committee, COM/AGR/CA/ENV/EPOC(96)149/REV1.

Task force on Environment and the Internal market, (1990). *"1992" - The Environmental Dimension.* Economica Verlag GmbH, Bonn.

World Tourism Organisation, (1994). *Tourism to the year 2000 and beyond*. Volume 5, Europe. Madrid.

2.3. Land use footprints

1. Land, a limited resource, under pressure

European landscapes are – in all senses – a human environment. The land provides the spatial context for, and also bears the impacts of, human activities. Each of the factors discussed previously in Chapter 2.2 (such as population change, urbanisation, industrialisation, transport and tourism, changes in world commodity prices, agriculture and forestry) may impact upon land use. Land cover is usually modified as a consequence of changes in land use, which may result from socio-economic or natural drivers or as a consequence of national or EU policies (see Box 2.3.1).

Human activity is responsible for many valued features of the European landscape, but also for growing pressures on the land (Map 2.3.1).

At its most extreme, misuse of the land can lead to environmental catastrophe, with loss of human life and economic disruption (see for example the Campania landslide Case Study, Chapter 3.8). Irreversible land changes led to major flooding incidents throughout Central, West and South Europe in 1997 and 1998, exacerbated by developments such as soil sealing (see also Chapter 3.6) and the straightening of rivers to facilitate drainage and transport. Map 2.3.2 illustrates for the major watersheds in Europe the area covered by urban fabric, road infrastructure,

Box 2.3.1 Definitions

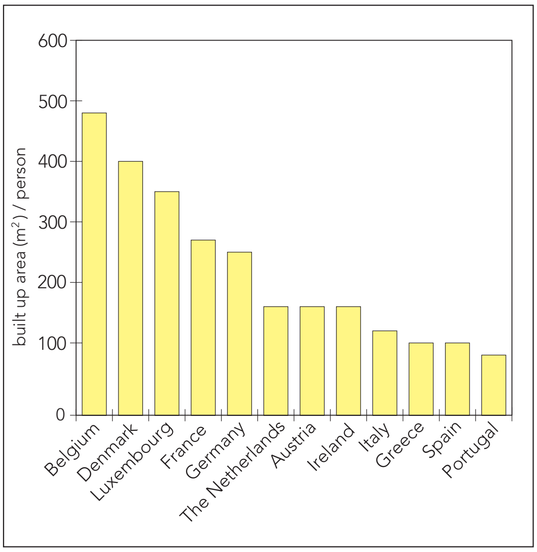
Land is defined as the surface of the solid Earth, together with superficial vegetation cover, built features and associated water surfaces, both freshwater and marine.

Land use describes the land surface from the social perspective; it is characterised by some identifiable purpose, or purposes, leading to tangible or intangible products or benefits.

Land cover is the description of the physical surface cover (e.g. grass, trees, rocks, buildings, water…).

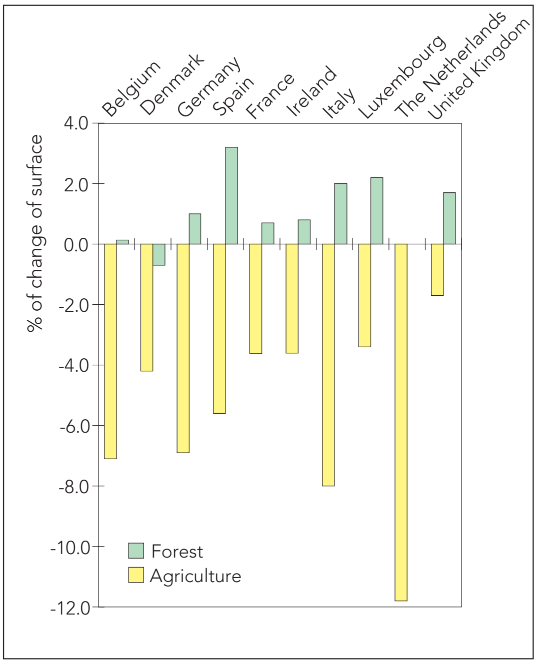
Land use and land cover are inter-dependent: changes in land use, which come about as a result of many of the socio-economic factors, impact directly on land cover.

Average of total artificialised surface (buildings, industrial and commercial areas, transport infrastructure) per inhabitant. Figure 2.3.1



Source: EEA, Eurostat

Changes in agriculture and forest land, 1970-1990 Figure 2.3.2



Source: FAO

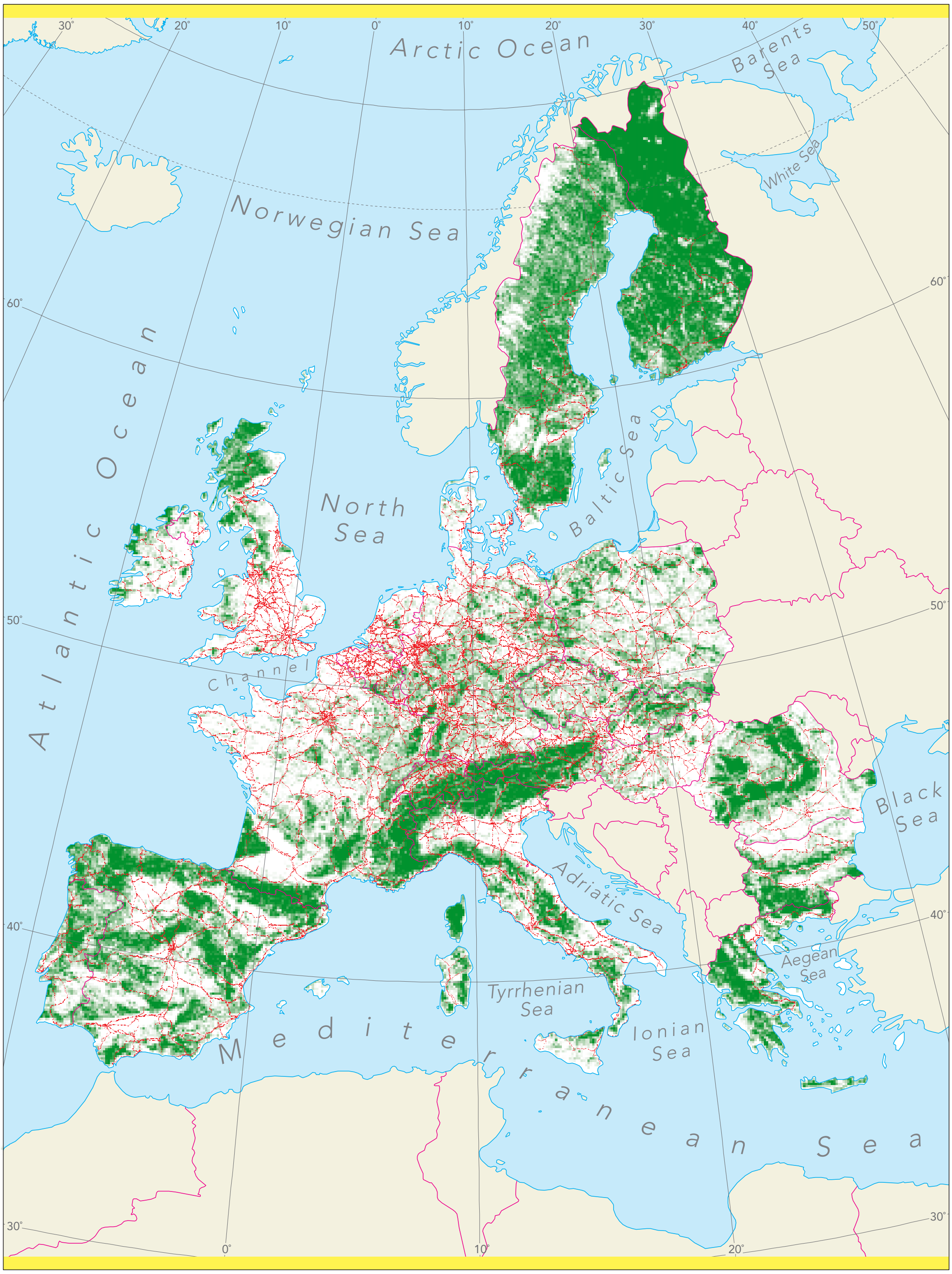
industrial and commercial sites. The major watersheds in Europe with more than 5 % of the total surface covered by built-up area are mainly located in NW Europe (e.g. Rhine, Thames, Meuse, Scheldt, Weser, Elbe).

The intensifying pressures of urban development are illustrated by figure 2.3.1, which

Pressures by urban areas and transport network

0 — 500 km

- forests and semi-natural areas
- pressure areas
- other areas



Map 3.2.1

The represented pressure areas on the map (in red) indicate the presence or risk of impact on semi-natural and natural areas (in green).

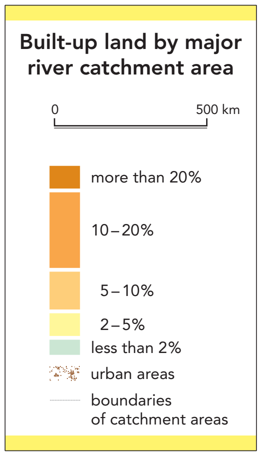
Source: EEA, Eurostat

shows that average built-up area per person tends to be higher in the more prosperous EU countries than in the peripheral regions.

2. Land and landscapes under significant changes

European landscapes have often been considered stable, timeless and changing so slowly that the effects are almost undetectable over long periods. In reality, the ability of modern society to change its surroundings has proven to be wide ranging, deep and the consequences can be rapid. Pressures arise from a combination of local pressures and driving forces that are external to the local landscape.

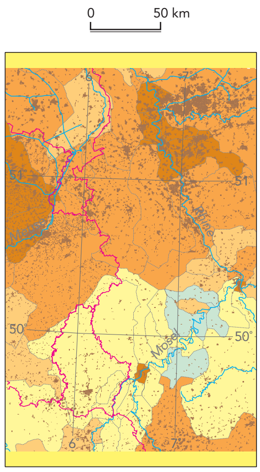
Agriculture is the main form of land use and has had a crucial role in the development of European landscapes (Figure 2.3.2). Changes in the commercial realities facing farmers can lead to damaging changes: for example, stone or earth terraces may fall into disrepair, leading to



Map 2.3.2

Source: EEA, Eurostat

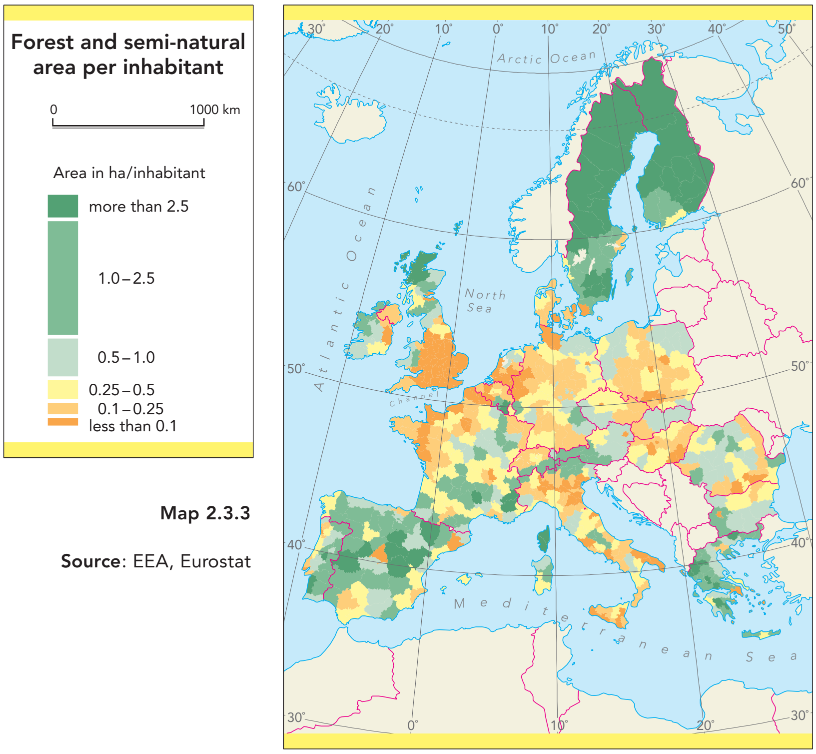
Built-up land by sub-river catchment area



erosion and even to loss of farming potential, and threats can arise to the living landscape characterised by pollarded and coppiced trees, small and irregular fields, farm woodlands and hedgerows, a diverse mosaic of land uses, and traditional rotation patterns, including ley and fallow.

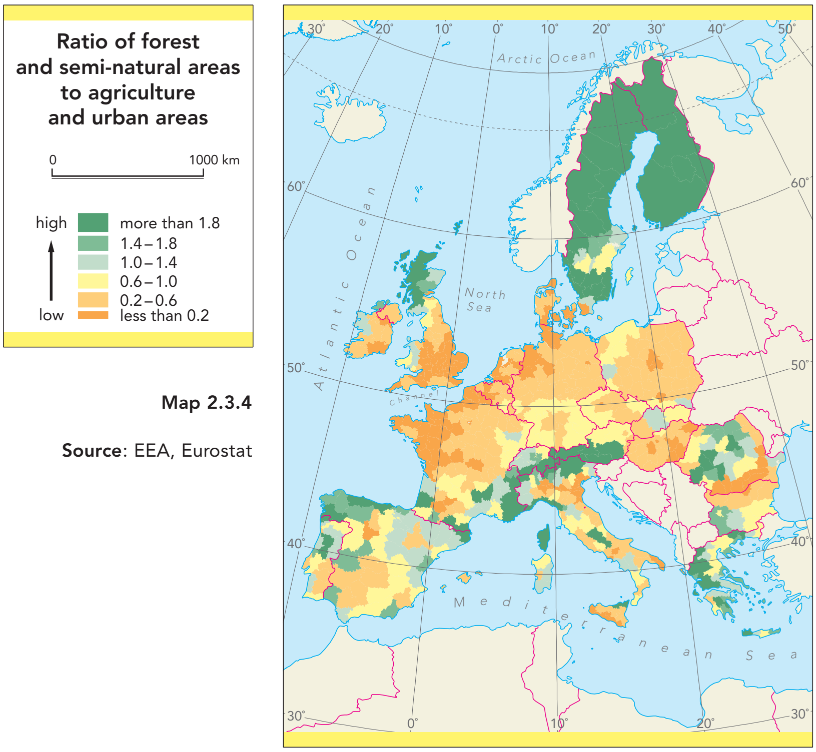
The past decades have also seen continuing trend towards urbanisation across Europe, together with increasing dispersal and sprawling of urban settlements with declining urban population densities, greater requirements for infrastructure. The consequence has been a significant growth in urban land and reduction of natural and semi-natural land. Map 2.3.3 shows the regional variation in the amount of natural and semi-natural area per inhabitant, juxtaposed to Map 2.3.4 illustrating the distribution of remaining natural and semi-natural areas in proportion to agricultural land and urban areas (see also Chapters 3.6 and 3.12).

The picture that emerges from land-cover change analysis is one of an extremely



Map 2.3.3

Source: EEA, Eurostat



Map 2.3.4

Source: EEA, Eurostat

dynamic landscape, primarily shaped by man. Interestingly, the average annual rate of land-cover changes tends to be quite small but the cumulation results in dramatic changes at local or regional scale. Map 2.3.5 shows the importance of changes in coastal areas during the past 50 years for the area of Zeebrugge at the Belgian coast. This area has experienced a yearly average change of less then 1% since 1930, resulting in a total area land change of over 50% by 1995. (For more information on changes in coastal areas, see also Chapter 3.14). Current statistical tools at European level do not yet allow us to pick up such changes in a systematic way.

Increased economic wealth and social expectations will continue to be powerful forces for change throughout Europe. Today, most of the EU countries have at least 80% of their territory given over to 'productive' uses like agriculture, forestry, urban centres, transport and industry, leaving a limited margin for further uses. Planned extensions to the motorway network will increase the total length by more than 12 000 km within the next 10 years. And a 5% increase in urban population will, according to present trends, require an equal increase in the take of urban land. Figure 2.3.3 shows projected changes in the 'productivity' of land in the EU countries between 1990 and 2010.

These challenges are being exacerbated because people are leaving new 'footprints' on the environment and the economic pressure on land is likely to be further increased by the eastward expansion of the EU. Of course, the pressure on land resources do not fall uniformly: 74% of the population of Europe is concentrated in only 15% of its land surface and zones in closest proximity to existing conurbations are, in general, those under greatest pressure from intensification of land use. However, there has been a remarkable tendency since the 1950s for a dispersal and sprawling of urban settlements, causing new hot spots to emerge (see Box 2.3.3).

3. The influence of EU Policies

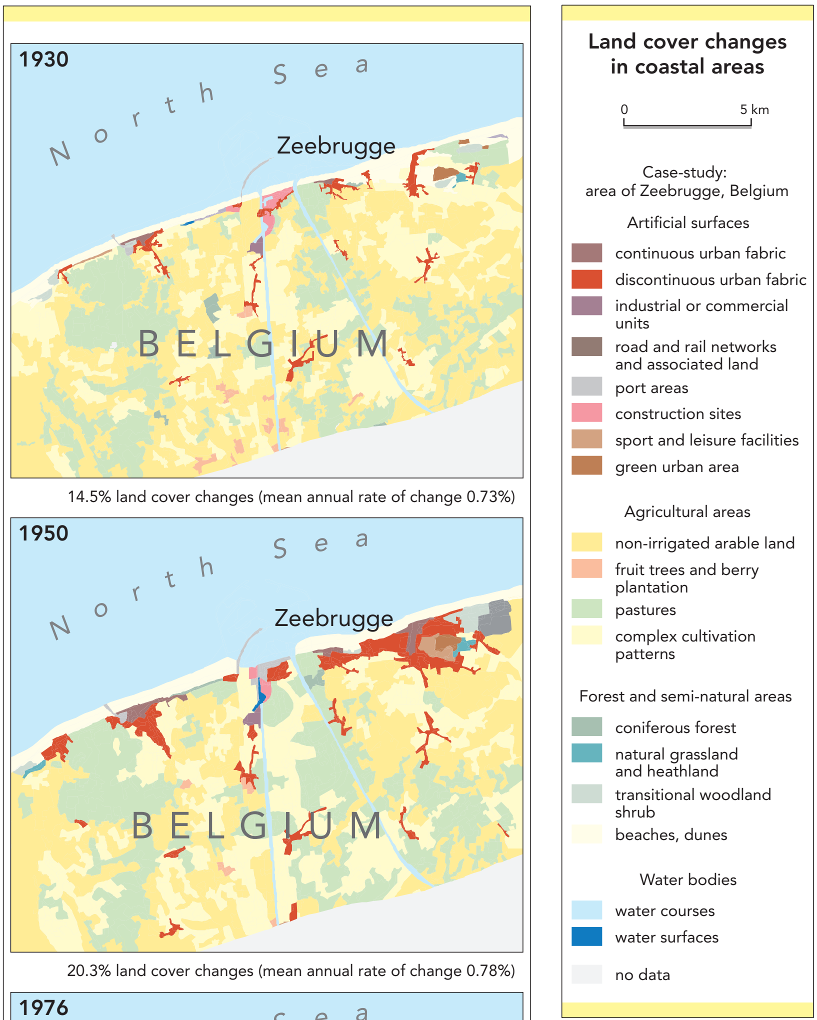
Policies explicitly relating to land-use issues, and especially physical planning, measures, have generally been the responsibility of the authorities in member states, rather than the EU which does not have an explicit competence in that area. Nevertheless, EU policies and legislation generate powerful forces for change in land use and land cover. Their potential to influence land use across Europe is extensive. There is a very real danger that inadvertent and unforeseen damage can arise from EU initiatives in areas such as regional development, transport, environmental protection, agriculture and forestry.

EU regional and rural development policies are now increasingly directed towards creating alternative opportunities that incorporate integrated environmental safeguards (see Chapter 3.13).

EU environmental protection legislation can also exert a major influence on land use. Here, the principal impacts come from Directives in the areas of Environmental Impact Assessment, water management (the new Water Framework Directive, see Chapter 3.5) and nature protection policies. Nature protection influences land use mainly through measures designed to conserve species and habitats by the designation of 'Special Protection Areas' (Birds Directive) or 'Special Areas of Conservation' (Habitats Directive). Given that nature protection networks such as Natura 2000, designated by the member states, may eventually cover as much as 10% of the land area of the EU, these legislative schemes are likely to prove an important tool for the management of European land and landscape resources (see Chapter 3.11).

4. Implications of EU enlargement

Proposals for the future enlargement of the EU, as set out in the communication 'Agenda 2000 for a stronger and wider Europe', are likely to lead to significant and often unpredictable changes in land-use patterns across the whole of the EU. Across the EU, increased East-West trade will demand expanded transport infrastructures. Trends are likely to result in loss of natural land and the degradation of land in the proximity of centres of development. Agricultural systems in the Accession Countries will be exposed to competition from more intensive practices in the West. Agriculture is the dominant form of land use, over 55% of total land area on average in the Accession countries, and an important factor in shaping the countryside. Over the period 1989-1997, the total arable land has remained relatively stable or declined slightly during transition in most Central and Eastern European Countries. Overall, this is likely to



Map 2.3.5

Source: CEO/JRC

Box 2.3.2 The European Spatial Development Perspective (ESDP) initiative

The origins of the ESDP
The European Commission has been charting the spatial development of the Community territory since 1989, with the launch of the Europe 2000 programme of studies. The ministers responsible for spatial planning decided at their informal meeting in Liège (1993) to lay the groundwork for the European Spatial Development Perspective (ESDP). Further meetings led to the adoption of the first official draft in 1997 in Noordwijk, to be finalised in May 1999. In December 1997, the ministers launched a public debate based on this document and decided to prepare a further chapter on the territorial impact of the next enlargement of the Union, as well as confirming their intention to create a European Spatial Planning Observatory Network.

ESDP and the role of Environmental and other Community policies
Four main policy areas affect the development of Community territory: the Common Agricultural Policy, regional and cohesion policy, policies linked to trans-European networks in transport and telecommunications, and environment policy. The ESDP examines both the achievements and inadequacies of these policies and draws attention to risks relating to economic and social cohesion and environmental protection. Initial conclusions highlight three main points to be addressed by an integrated vision of the whole of the European territory:

- more balance geographical distribution of production activities to correct present trends towards concentration in the most competitive areas;
- more sustainable land use to ensure appropriate choices in terms of basic infrastructure in the longer-term interest of the entire territory;
- greater sensitivity to specific territorial needs.

Some examples of some environmental objectives considered within the ESDP:

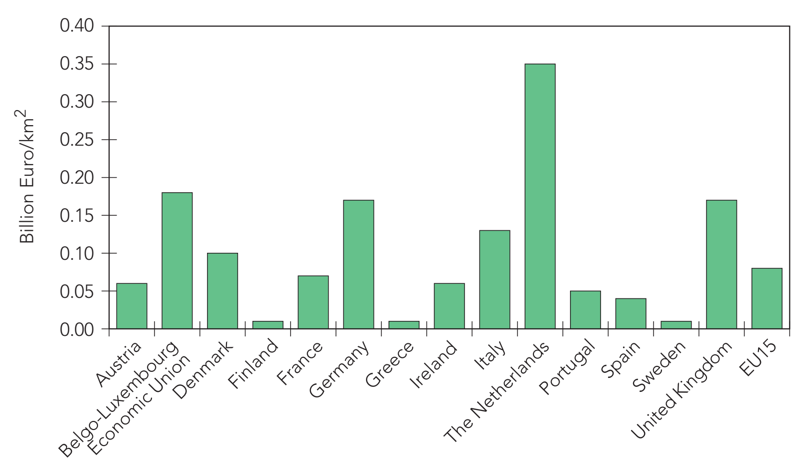
- **Better environmental protection.** The ESDP insists on the necessity of speeding up the creation of the European ecology network Natura 2000, drawing together protected sites. It proposes to ensure appropriate management of ecologically vulnerable areas or sites of exceptional biodiversity, as well as promoting policies that reconcile the maintenance of the natural heritage with the economic development of rural areas.

- **Careful management of water resources.** The ESDP recommends shared management of the major water tables and of coastal waters to preserve them from pollution, to develop mutual strategies against risk of flooding (particularly in the transnational river basins), the balancing of supply and demand for water in areas prone to drought, and the protection of wetland areas threatened with over-exploitation of water resources.

- **Better exploitation of rural landscapes.** The safeguarding of rural landscapes for their beauty, as well as cultural and historical importance, is not incompatible with economic development. The natural heritage requires careful management in line with local conditions. This is often closely linked to the maintenance of agriculture, as farmers play a central role in landscape management. Co-operation in this area will encourage the preservation and good management of rural landscapes, appropriate land-use policies and the rehabilitation of landscapes which have been degraded as a result of human activity.

There is a risk of conflicting impacts resulting from divergent policy-making in different areas of European competence. Debate on European spatial development should be focused on the potential of the ESDP to contribute greater coherence to separate Community policies.

Figure 2.3.3 **Changing intensity of land use in the EU between 1990 and 2010 illustrated by the increase of GNP per unit area of land surface (euro/km²)**



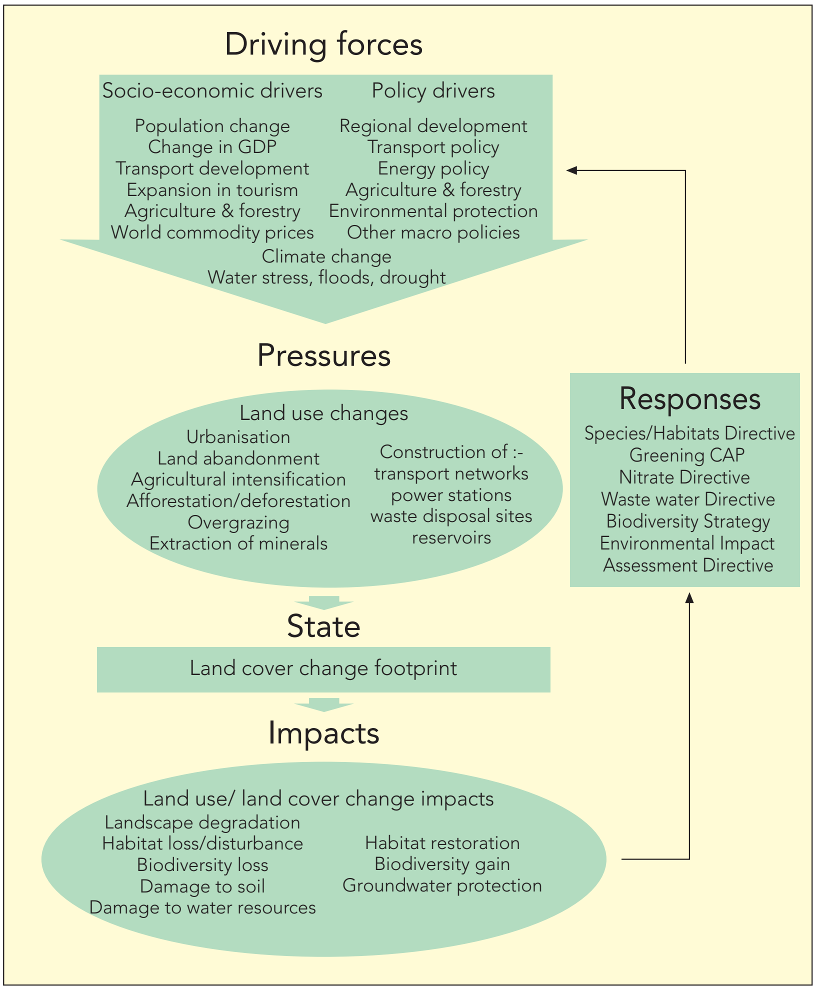
Source: Eurostat

exacerbate existing trends towards intensification in the more productive areas and decline in marginal regions.

5. A need for territorial policies

Land management and land planning are issues to be dealt with through coordination between all levels: EU, national, the regions, and locally. Managing European land resources needs therefore a share of long-term perspectives, but final success depends on regionally and locally experienced situations and actions. There is still much that remains unknown, partly because there is not yet a coordinated vision at the EU level for the future of land planning and spatial planning activities. An integrated planning approach is reflected in the European Spatial Development Perspective, now under consideration by the Member States and the EU (Box 2.3.3). The success of such initiatives will, in part, be determined by improved access to information on land resources, especially in spatially-referenced forms. Such information will be of crucial importance as a means to guide the formulation and performance analysis of spatial development policies which lies in many different, complex and interacting factors influencing processes of change (see Figure 2.3.4).

DPSIR for changes in land use and land cover Figure 2.3.4



Box 2.3.3 Environmental hot spots in Europe

About the experiment to map hotspots in Europe
A geographical analysis of the coincidence of environmental problems in Europe is dependent on the availability of suitable, accessible and scientifically robust pan-European data. Environmental problems manifest themselves at various geographical scales; the currently available geographical datasets mainly describe problems that are on a continental or even global scale. Problems that are diffuse (e.g. agricultural pollution) or that occur at a local scale (e.g. disposal of toxic waste) may be reported only at the Member State, or even local government level, or not at all. For these localised problems little harmonised European data is available. Consequently, the results shown on [Fig. HOTACC] largely reflect those environmental issues that have received greatest political attention (see also Walker & Young, 1997, and Working Group on the SEA of the TEN, 1998, for discussions on the limitations of available data). These results also reflect the challenge of complexity for policy-makers.

Defining the coincidence of environmental problems
The pressure, state or impact data mapped here address only seven **EU policy areas of concern** for which data were available: acidification and eutrophication; coastal issues; habitat loss; tropospheric ozone increases; soil degradation; ultraviolet radiation caused by stratospheric ozone depletion; and effects on freshwater resources. Additional data might reflect wider pressures and impacts. Only geo-referenced data describing environmental impacts, pressures or states that covered all of the Member States, at the sub-national scale, were used. Data that did not reflect the trans-boundary nature of environmental problems were not used. The EMEP150 grid (Hettelingh *et* al., 1991) was chosen as a base map since many of the available datasets were reported at this scale.

First, thresholds were applied to each data layer to identify environmental problems. The thresholds were defined based on one of two criteria: policy or legislative guidelines (for example, WHO air quality guidelines (WHO, 1987, as quoted in Bosch *et al.*, 1997)), or through the use of expert knowledge when such policy thresholds were not available. This resulted in policy or expert-based 'problem' maps. Based on these results, each data layer was transferred onto the EMEP150 grid by calculating the area within each cell occupied by the problem.

For each policy area the available grid layers were combined to create a map showing where one or more problems were occurring. The coincidence of

.../...

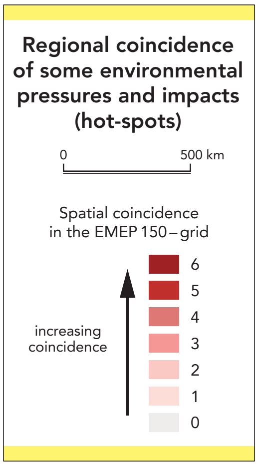
environmental problems was then defined by overlaying these different policy area layers. The result of this analysis is shown in Map 2.3.6.

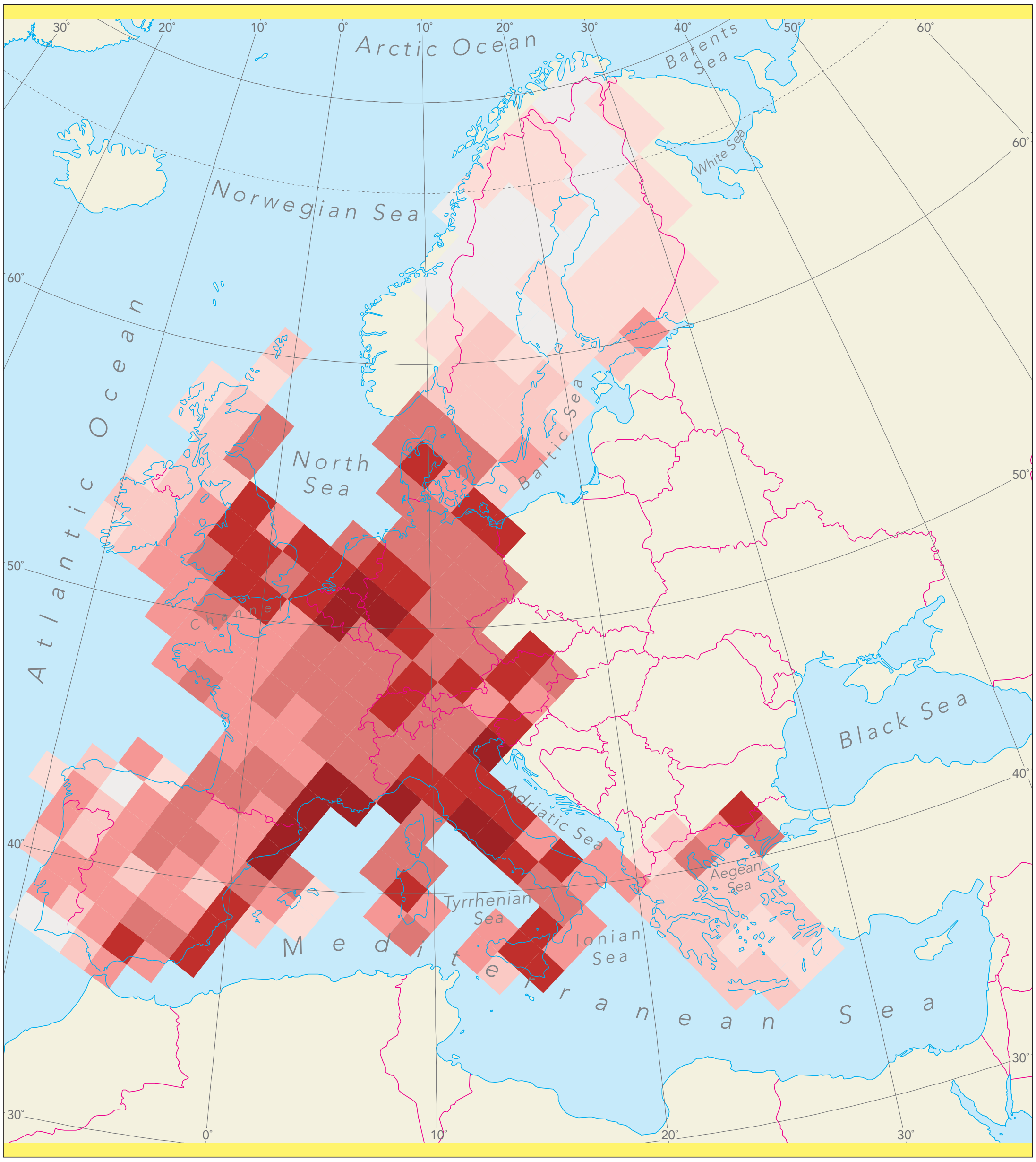
Interpretation: what the map tells us
This map shows us the extent of the urban 'footprint' across the face of Europe. If we look for the underlying driving forces and pressures (see Figure 2.3.4) we see associated problems which could not appear on the map because of data restrictions. For example, there is no 'water quality' data layer. The map also shows us where to look for areas where environmental damage may be preventable, repairable, or possibly beyond repair.

As urban population densities decrease, the actual numbers of people in spreading urban areas increases; this means that more land is taken up to supply the demand for energy, water, food production, leisure, and the transport networks which make all these things possible. So although 'traditional' hot spots (areas of high metal, PAH and sulphur deposition, for example) may be less intense and less frequent, 'new' hot spots of habitat loss and long-term soil and water deterioration appear.

The map shows us that the accumulation of problems coincides with the density of transport routes and industry in the UK, the Rhine-Ruhr corridor and in France, Germany, and Northern Italy. We see that industrial use of water, and continuing air pollution, in Germany and the Netherlands will contribute to the continuation of acidification and the loss of freshwater resources. If industrial technologies don't change then the Rhine-Ruhr corridor in particular will continue to suffer from hazardous-substance emissions and deposition: cadmium, dioxins, benz(a)pyrenes and polychlorinated biphenyls, although these substances are not mappable at this scale, at this time.

In the Mediterranean countries, where agriculture is the highest consumer of water, and in the livestock areas of France, Germany, and Benelux, we see widespread eutrophication. The Mediterranean coast, including the Athenian basin, and the Alps reflect their popularity as tourist destinations: seasonal fluctuations in demand for water and sewage treatment, and the need for permanent roads for access, are reflected in the data of habitat loss, soil degradation, and coastal problems (on the seaboard).





Map 2.3.6

Source: EEA

References

European Commission, 1997. *Agenda 2000: for a stronger wider Union/EU*, COM(97)2000.

EUROSTAT, 1996. *Environment Statistics.* EUROSTAT, Luxembourg.

Hettelingh, J.-P., Downing, R. J. & de Smet, (eds.), (1991). *Mapping critical loads for Europe: CCE technical report No. 1.* RIVM Report No. 259101001. Bilthoven, the Netherlands.

Posch, M., Hettelingh, J.-P., de Smet, P. A. M. & Downing, R. J., 1997. *Calculation and mapping of critical thresholds in Europe: Status report 1997, Coordination center for effects.* RIVM report No. 259101007. Bilthoven, the Netherlands.

Walker, P. A. & Young, M. D., 1997. *Using integrated economic and ecological information to improve government policy*. International Journal of Geographical Information Science 11 (7).

WHO, 1987. *Air quality guidelines for Europe.* WHO regional publications, European series No. 23, Copenhagen, Denmark.

Further reading

European Commission, 1995. *Communication on Cohesion Policy and the Environment.* (COM(95)509)

European Commission, 1998. *The Reform of the common Agricultural Policy*. (COM(98)157).

European Commission, 1998. *Agricultural Situation and Prospects in the Central and Eastern European Countries – Summary Report.* Working Document DGVI.

Council of the European Communities (1993). Council Regulation No 2083/93 of 20 July 1993, amending Regulation (EEC) No 4254/88 laying down provisions for implementing Regulation (EEC) No 2052/898 as regards the European Regional Development Fund.

Council of the European Union, 1994. Council Regulation (EC) No 1164/94 of 16 May 1994, establishing a Cohesion Fund.

Hille, J., 1997. *The Concept of Environmental Space: Consequences for Policies, Environmental Reporting and Assessment'.* Experts' Corner, No. 1997/2. European Environment Agency, Copenhagen.

Mortimer D., 1998. *Current Land Management and Stewardship Schemes in the EU and their implications for Land Use*, Working Paper n°1 UCL, London.Commission of the European Communities (1995). *Communication on Cohesion Policy and the Environment*. (COM(95)509).

3.1. Greenhouse gases and climate change

Main findings

Global and European annual mean air temperatures have increased by 0.3-0.6°C since 1900. 1998 was globally the warmest year on record. There is augmenting evidence that emissions of greenhouse gases (GHGs – mainly carbon dioxide (CO_2)) are causing air temperature increases resulting in climate change. Climate models estimate further increases, above 1990 levels, of about 2°C by the year 2100. It is unlikely that stable, potentially sustainable, atmospheric greenhouse gas concentrations will be realised before 2050. An immediate 50-70% reduction in global CO_2 emissions would be needed to stabilise global CO_2 concentrations at the 1990 level by 2100.

The issue of climate change is being addressed through the United Nations Framework Convention on Climate Change (UNFCCC). The EU's commitments are to stabilise CO_2 emissions by 2000 at 1990 levels and to reduce emissions of the main six greenhouse gases by 8% in 2008-2012 from 1990 levels (Kyoto Protocol).

EU CO_2 emissions decreased by 1% between 1990 and 1996, due to relatively low economic growth, increases in energy efficiency, economic restructuring of the new Länder in Germany and fuel switching from coal to natural gas in the UK. However, CO_2 emissions are projected to increase under the pre-Kyoto baseline scenario by 8% above 1990 levels by 2010 with transport sector emissions increasing by 39% while industrial sector emissions decline by 15%. The shift from solid fuels to gaseous fuels is projected to continue. Total EU GHG emissions are projected to increase 6% above 1990 levels by 2010 – clearly missing the 8% reduction target. Additional policies and measures will therefore be necessary to meet the Kyoto Protocol commitment.

In the Accession Countries CO_2 and GHG emissions are projected to decrease by 8% and 11% respectively between 1990 and 2010. This would imply a 2% increase in GHG emissions for an enlarged EU – still well short of the existing EU's 8% reduction target.

EU action thus far includes target sharing between Member States, an agreement with the car industry to reduce CO_2 emissions from new passenger cars, and energy/CO_2 taxes at national level but not – as yet – EU-wide. Consideration is being given to uses of the so-called 'Kyoto mechanisms' - emission trading, joint implementation, and the 'clean development mechanism', although the total technical reduction potential for measures with costs below 50 euro/tonne CO_2 equivalent is estimated to be more than what is needed to achieve the EU 8% reduction target. Forest carbon sinks in the EU are estimated to be only up to 1% of the 1990 EU CO_2 emissions.

1. An issue under international scrutiny

1.1. From greenhouse gases to climate change

Climate change is widely recognised as a serious potential threat to the world's environment. The problem is being addressed through the United Nations Framework Convention on Climate Change (UNFCCC), most recently at the fourth Conference of the Parties at Buenos Aires in November 1998 (UNFCCC, 1999). It has been identified by the EU as one of the key environmental themes to be tackled under the Fifth Environmental Action Programme (5EAP).

The greenhouse effect of the Earth's atmosphere is a natural phenomenon, without which the Earth's temperature would be much lower, whereby atmospheric concentrations of water vapour and carbon dioxide (CO_2) trap infrared radiation.

Over the past century there have been increases in atmospheric concentrations of anthropogenic greenhouse gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), as well as halogenated compounds such as CFCs, HFCs and PFCs. Over the same period a considerable increase, in historic terms, in global mean temperature has been observed. There is augmenting evidence that emissions of greenhouse gases from human activities are causing an enhanced greenhouse effect in the form of global warming) (IPCC, 1996; IPCC, 1997a and 1997b).

Fossil-fuel combustion resulting in CO_2 emissions is the dominant human activity (driving force) causing the enhanced greenhouse effect. Other activities that contribute to greenhouse gas emissions are agriculture and land-use changes including deforestation, certain industrial processes such as cement production, landfilling of wastes, refrigeration, foam blowing and solvent use.

Climate change resulting from the enhanced greenhouse effect is expected to have widespread consequences, causing:

- sea-level rise and possible flooding of low-lying areas;
- melting of glaciers and sea ice;
- changes in rainfall patterns with implications for floods and droughts;
- changes in the incidence of climatic extremes, especially high-temperature extremes.

These effects of climate change will have impacts on ecosystems, health, key economic sectors such as agriculture, and water resources.

There is now general recognition that policy action is needed to curb greenhouse gas emissions and that it is important to identify the extent to which consequences of climate change can be minimised by adaptation measures. Decreased emissions of greenhouse gases can have other beneficial effects (see also Chapters 3.4 and 3.11), such as:

- reduction in CO_2 emissions from fuel combustion by – for example – fuel switching to natural gas or by increased use of renewables, which also helps to reduce the emissions of other pollutants that cause acidification, troposheric ozone and reduced air quality;
- reduction in methane emissions also helps to reduce the general background levels of tropospheric ozone.

1.2. Current indications and impacts of climate change

Temperature increase

Global mean surface air temperature has increased by about 0.3-0.6°C since the late 19th century (IPCC, 1996). The year 1998 was globally the warmest year on record. In Europe similar increases in temperature have been observed, although the natural variations in regions are larger than those that occur for the global average (Figure 3.1.1).

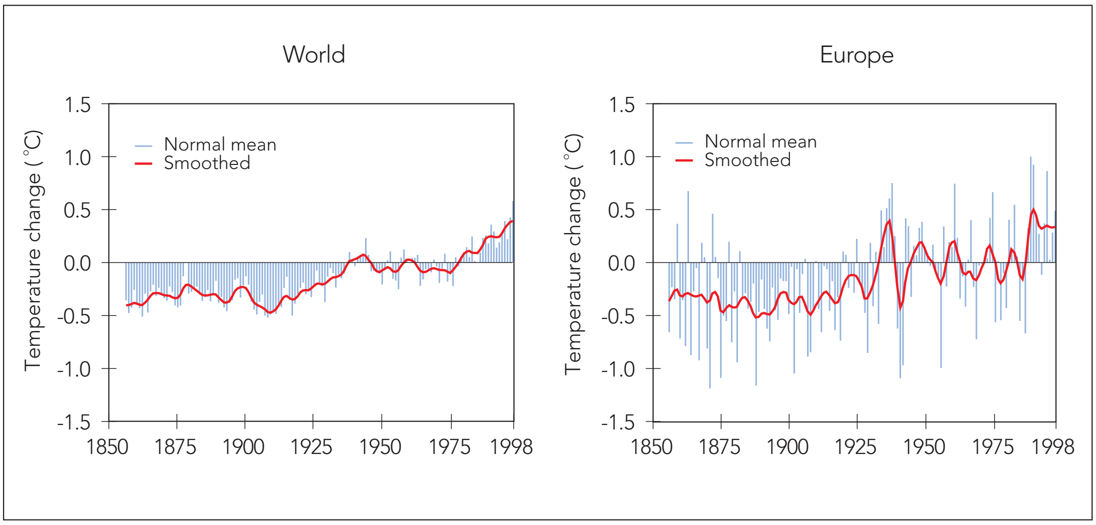
The warming effect is more prominent at higher latitudes in the northern hemisphere (Figure 3.1.2).

An observed sea level rise

Global warming causes oceans to warm and therefore expand, and increases the melting of glaciers and sea ice. Climate change can thus affect sea levels which have increased by

Figure 3.1.1 **Observed global and European annual mean temperature deviations from 1856 to 1998**

Between 1856 and 1998, the yearly deviations from the 1961-1990 global average and European temperature (in addition smoothed to show 10 yearly variations in temperature) show an increase of 0.3° C to 0.6° C. The year 1998 was globally the warmest year on record, and 1997 the warmest before that. This is partly due to the 1997/1998 El Niño/Southern Oscillation (ENSO), which was the largest on record (Hadley Centre/The Met. Office, 1998a). The ENSO phenomenon is a cycle of natural fluctuations of Pacific ocean temperatures resulting in large-scale changes in tropical rainfall and wind patterns.



Source: CRU, 1998; Hadley Centre, 1998a

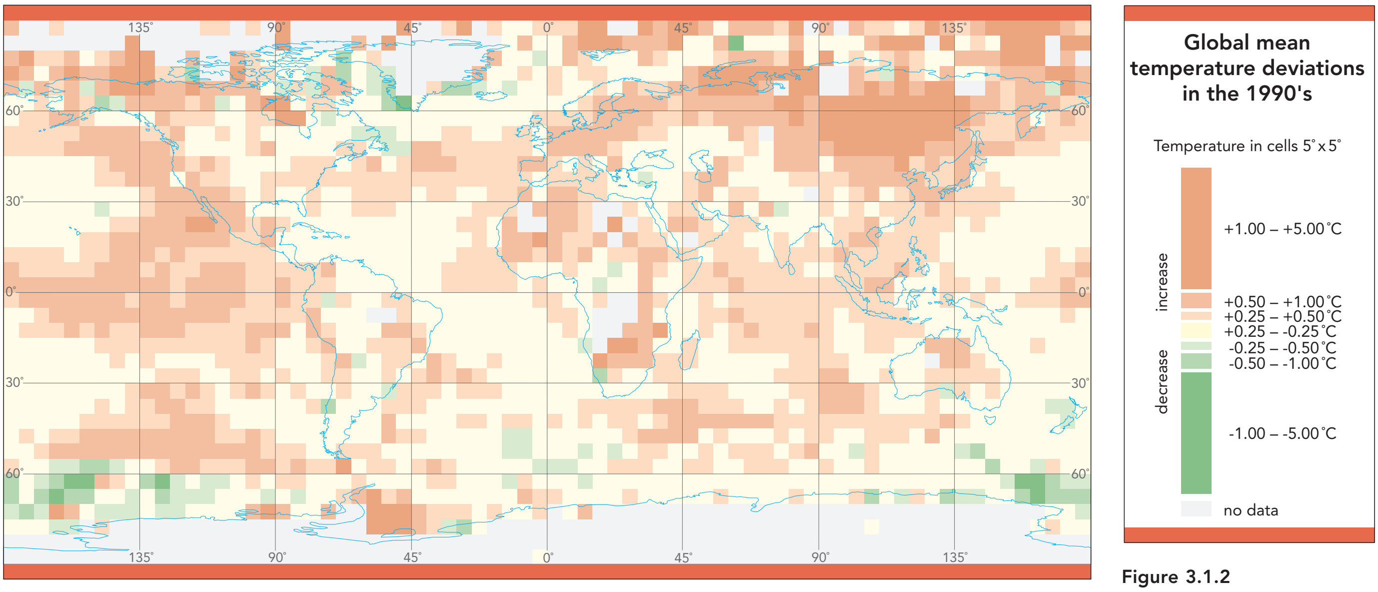


Figure 3.1.2

The mean annual temperatures in the 1990s are well above the mean annual temperatures from 1961 to1990.

Source: CRU, 1998; Hadley Centre, 1998a

10-25 cm in the past 100 years, the range reflecting differences in different parts of the world and uncertainties in the measurements. The rate of increase does not appear to be changing but it is significantly higher than that averaged over the past few thousand years (IPCC, 1996).

Greenhouse gas concentrations and global emissions increase

There has been a marked upward trend in atmospheric concentrations of CO_2, CH_4 and N_2O since pre-industrial times. The so-called 'new greenhouse gases' (the halogenated substances HFC, PFC and SF_6) entered the atmosphere only after mankind started using them in the past few decades. Table 3.1.1 shows the estimated contributions of these gases to global warming.

In addition to these gases, tropospheric ozone (O_3) may also augment global warming, by a further 16% (IPCC, 1996).

Aerosols, consisting of small particles or droplets either emitted directly (primary aerosols) or formed in the atmosphere from sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (secondary aerosols), can have a cooling effect (see also Chapter 3.4). The IPCC estimates that aerosols have offset about 50% of the total warming to date by the main greenhouse gases (IPCC, 1996). However, unlike the main greenhouse gases, aerosols have a short lifetime in the atmosphere so they cannot become distributed over the whole planet and their effect is regional and short-lived.

The total aggregate emissions in 1990 from industrialised countries reported to the UNFCCC were about 18 Gt (CO_2-equivalent) (UNFCCC, 1998) (Figure 3.1.3), although this is subject to uncertainty and the IMAGE model (see section 1.3) assumes a higher figure (21 Gt). However, between 1990 and 1995 the aggregate emission of all greenhouse gases of industrialised countries, excluding carbon removals/sinks (see Box 3.1.3 in section 5), has decreased slightly (5%), mainly due to decreases from central

Greenhouse gases: concentration changes, contribution to global warming (GW) and main sources — Table 3.1.1.

Gas	Concentration increase (%) since about 1750	Contribution to global warming (%) *	Main anthropogenic sources
CO_2	30%	64%	Fuel combustion, deforestation and land-use change, cement production
CH_4	145%	20%	Energy production and use (including biomass), animals, rice paddies, sewage, organic waste in landfills
N_2O	15%	6%	Use of fertilisers, land clearing, adipic and nitric acid production, biomass burning, combustion of fossil fuels
HFCs	not applicable		Refrigeration, air conditioners, chemical industry
PFCs	not applicable	10%**	Aluminium production
SF_6	not applicable		Electricity distribution

* To compare the impact of different gases, the global warming potential (GWP) relative to CO_2 is often used, with CO_2 having a value of 1. GWP values are strongly dependent on the time horizon considered. Examples of GWP values over a 100-year period are 21 for CH_4, 310 for N_2O and several thousand for a number of halogenated compounds (IPCC,1996). The emissions taking into account GWP values are called 'CO_2 equivalents'.

** all halogenated compounds together , including CFCs and HCFCs

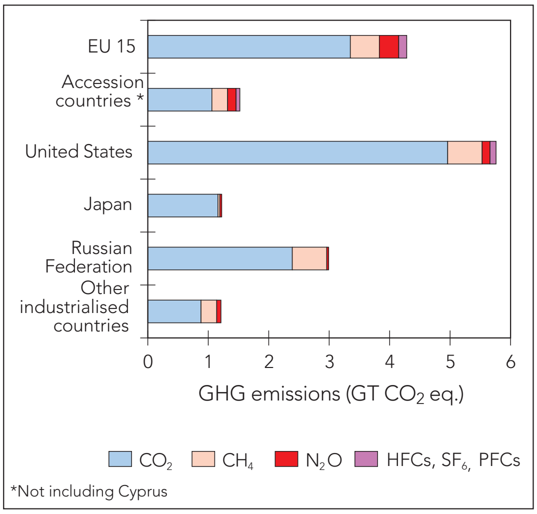
Source: IPCC, 1996

and eastern European countries, in particular from the Russian Federation (with a reduction of 30%).

Greenhouse gas emissions in the EU made up 25% of total emissions in industrialised countries in 1990 (Figure 3.1.3). Carbon dioxide contributes 80-90% of emissions in Western Europe and the US and about 70% in the other countries in the 'industrialised' category (defined by UNFCCC Annex 1). The variations are mainly due to differences in industrialisation and energy intensity and in the importance of carbon dioxide emissions or sinks from land-use change.

Figure 3.1.3 **Greenhouse gas emissions in 1990 by gas in different groups of industrialised (Annex 1) countries (excluding CO_2 sinks)**

Source: EEA, 1998; UNFCCC, 1998



1.3. Future impacts of climate change (until 2100)

Global greenhouse gas emission scenarios

The Intergovernmental Panel on Climate Change (IPCC) has assessed the possible consequences of continuing human enhancement of greenhouse gas emissions and concentrations, using a number of global socio-economic and greenhouse gas emissions scenarios, covering the period up to 2100. These scenarios range from baseline scenarios that assume low growth and a major switch to the use of non-fossil energy sources and large increases in energy efficiency. The scenarios are meant to assess the range of possible impacts on for example temperature and sea-level rise.

Integrated assessment model studies, which simulate the dynamics of the global climate system, have been undertaken for Europe with the global IMAGE model (RIVM, 1998; Alcamo *.et al.*, 1996; European Commission, 1999), using a baseline scenario that is consistent and comparable with the IPCC's mid range ('business as usual') scenario. Estimated 1990 emissions are 21 Gt (CO_2-eq.) for industrialised countries – 55% of the global total – and 16 Gt (CO_2-eq.) for developing countries. World population is projected to be 7 billion by 2010 and 10 billion by 2050. Global average GDP/capita is expected to increases by 40% between 1990 and 2010 and 140% between 1990 and 2050. Global CO_2 emissions are projected to increase from 1990 levels by about a factor of two by 2050 and a factor of three by 2100. Increases of methane and nitrous oxide emissions are less but still substantial by 2100.

Climate change impact indicators by 2050 and 2100

Global average concentrations of the three main greenhouse gases are projected to increase from 1990 to 2050: 45% for CO_2 (from 354 to 512 ppmv), 80% for CH_4 (from 1.60 to 2.84 ppmv), 22% for N_2O (from 310 to 377 ppbv) (IPCC, 1996).

IPCC (1996) findings for global temperature increase by 2100 vary over a wide range with a central estimate of a global mean temperature 2°C higher in 2100 than in 1990 (the uncertainty range is 1-3.5°C), assuming the 'baseline scenario' for global emissions. One of the climate models used in the IPCC (1996) assessment recently presented new results suggesting a global temperature increase of 3°C by 2100 (Hadley Centre, 1998b, 1998c).

According to IPCC (1996) there could be large regional variations. Climate models for Europe indicate that average increases in temperature would be similar to the estimated global increases, with greater warming in northern latitudes than in the south (Figure 3.1.4). The latest results from the Hadley Centre model show that a slowing down of the North Atlantic ocean circulation could occur due to increases of greenhouse gases, but the model still projects an increase of temperature in Europe.

IPCC (1996) and IMAGE estimates indicate that by 2050 sea levels could be almost 20 cm, and by 2100 about 50 cm (range 15-95 cm) above today's levels. There is still considerable uncertainty about these results, particularly regarding the behaviour of polar ice sheets. Sea-level rise is projected to continue after 2100 due to the inertia inherent in atmospheric-oceanic interactions.

Potential impacts from climate change on vegetation patterns and ecosystems are described in Chapters 3.11 and 3.15.

Potentially 'sustainable' targets for climate change impact indicators

The objective of Article 2 of the UNFCCC is to reach atmospheric concentrations that would prevent dangerous anthropogenic interference with the climate system but would allow sustainable economic development (IPCC, 1996).

There is no scientific consensus on sustainable target values for the main climate-change impact indicators, although various proposals have been made. The EU has adopted a provisional 'sustainable' target of a global average temperature increase of 2°C above the pre-industrial level (European Community, 1996a). The increase to 1990 has already been about 0.5°C, leaving a further allowable increase of 1.5°C from 1990 to 2100, or an average increase of 0.14°C per decade. The projected temperature increase of 2°C in 2100 above 1990 is above this provisional 'sustainable' target (IPCC, 1996).

Another provisional 'sustainable' target, consistent with the EU target and with the UNFCCC objective, has also been proposed: a 0.1°C temperature rise per decade (Krause *et al.*, 1989; Leemans, 1998). The projected rate of temperature rise (IPCC, 1996) will be more than double this provisional 'sustainable' target.

A provisional 'sustainable' target for total greenhouse concentrations that is consistent with the 'sustainable' temperature targets is currently considered to be between 450 and 500 ppmv CO_2-equivalent. Under the IPCC (1996) baseline emission scenario, the combined concentration of the three major greenhouse gases is projected to be 700 ppmv in 2050 and to continue to rise thereafter. Stable potentially 'sustainable' atmospheric concentrations of the main greenhouse gases are therefore unlikely to be realised by 2050.

A provisional 'sustainable' target of 2 cm per decade for sea-level rise has been suggested. From IPCC (1996) and the IMAGE analyses, sea-level rise will be approaching this level towards 2050. This potentially 'sustainable' target will most likely be exceeded between 2050 and 2100.

Potentially 'sustainable' greenhouse gas emissions by 2010

The issue of climate change is such that there is a need for setting long-term targets, but also for understanding the short-term implications of such targets. The concept of 'sustainable pathways' can be used to provide information on the level of short-term (2010) greenhouse gas emissions that are compatible with long term sustainable (2050 to 2100) climate goals. The analysis takes into account a range of targets for concentration of greenhouse gases, temperature increase and sea-level rise. The analysis can also show the distribution of emissions between industrialised countries and developing ('non-Annex 1') countries. Within the framework of UNFCCC, developing countries do not yet have to control their emissions (see section 2).

To stabilise the CO_2 concentration below 550 ppmv, twice the pre-industrial level, would mean that future global CO_2 emissions cannot exceed current emissions and would have to be much lower before and beyond 2100 (IPCC, 1996). To stabilise at lower CO_2 concentration levels would of course imply even lower global emissions (IPCC, 1997b). IPCC (1996, 1997b) has presented other emission pathways geared to different options for stabilisation of CO_2 and other greenhouse gas concentrations. For instance, stabilisation of the CO_2 concentration at the 1990 level (of 354 ppmv) by 2100 would involve an immediate reduction of annual CO_2 emissions by 50% to 70% and further thereafter (IPCC, 1996).

The concept of 'sustainable pathways' (IMAGE model) gives results that are consistent with IPCC (1996; 1997b). The results of the analysis are dependent on the choice of 'sustainable' climate protection targets. Here results are shown assuming the EU objective of a maximum global temperature increase of 1.5°C between 1990 and 2100, a maximum global temperature increase of 0.15°C per decade, IPCC (1996) baseline emissions for developing countries and assuming a maximum emission reduction rate for industrialised countries of 2% per year.

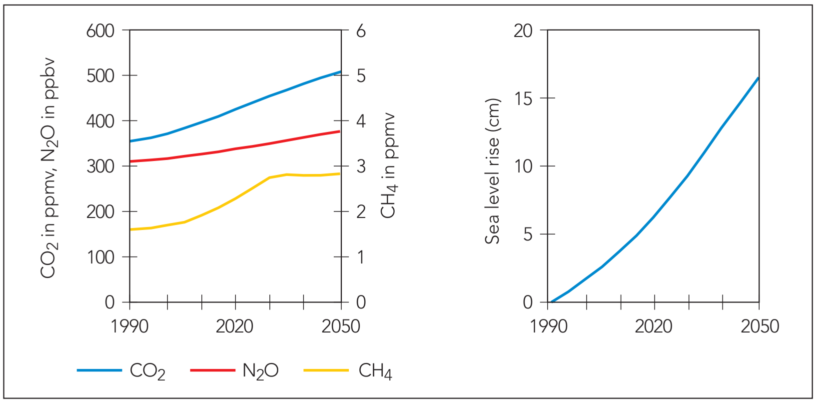
For industrialised countries this 'sustainable pathway' in 2010 implies a reduction of 35% from 1990 levels.

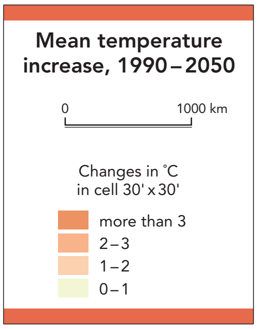
Uncertainties in climate-change scenarios

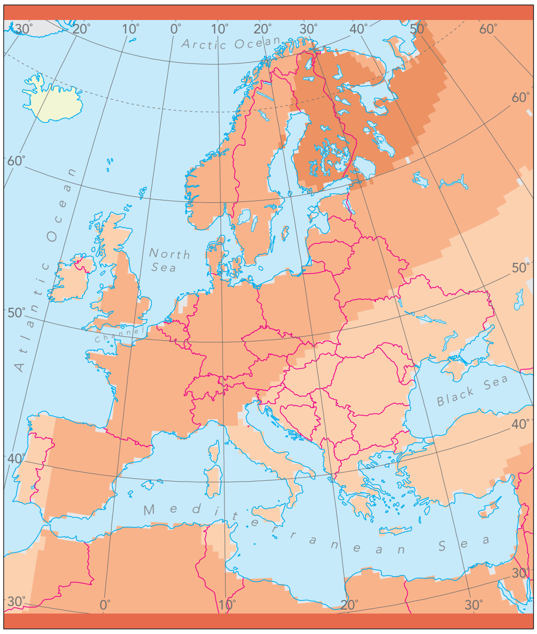
There are various sources of uncertainty in estimating future climate change by means of scenarios:

- assumptions with respect to socio-economic and sectoral developments and potential emission reductions;

Figure 3.1.4 **Temperature rise, increase of greenhouse gas concentrations and expected sea-level rise in the baseline scenario**







The IMAGE model consists of three sub-models: 'Energy-Industry', which computes the global emissions of greenhouse gases as a function of energy consumption and industrial production, 'Terrestrial Environment', which simulates the changes in global land cover and the flux from greenhouse gases from the biosphere into the atmosphere and 'Atmosphere-Ocean', which computes the average global and regional temperature and precipitation patterns.

Source: European Commission, 1999; Alcamo *et.al.*, 1996

- the process of transformation of greenhouse gas emissions into climate change;
- poorly understood or described processes in the current climate models.

European research is contributing to efforts to reduce these uncertainties, and also to improve understanding of the effects of different sources of uncertainty on the range of outcomes.

Vulnerability to climate change and damage costs
In a recent study (Eyre *et al.*, 1998) an estimate was made of the damage costs of the increasing greenhouse gas concentrations in the atmosphere (Table 3.1.2). The costs are calculated for CO_2, CH_4 and N_2O, using two different economic models and are expressed per tonne CO_2-equivalent emitted resulting in a range of 20 to 80 euros per tonne CO_2-equivalent.

The costs might be inflicted in other parts of the world and countries than where the emissions occur. The two models agree in broad outline: developing countries suffer significantly higher costs than developed regions. For industrialised countries, costs are relatively modest. In both models South and South-East Asia and Africa suffer large costs – the two regions experiencing more than half the total damage costs.

2. Current policy targets and environmental policies

2.1. Policy targets

Governments throughout the world responded to the concerns about climate change at the 1992 UN Conference on Environment and Development by adopting the Framework Convention on Climate Change (UNFCCC). More than 170 countries or groups of countries have now ratified the Convention, including the European Community and all 15 Member States and most other European countries. Developed countries (listed in Annex 1 of the Convention) made a commitment to aim to return their emissions of greenhouse gases, not controlled by the Montreal Protocol, to 1990 levels by 2000.

At the Third Conference of Parties (COP3) of UNFCCC in Kyoto in December 1997 countries listed in Annex B of the Kyoto Protocol (which is similar to the list of Annex I countries) agreed to reduce their emissions of six greenhouse gases by an overall 5% from 1990 levels by 2008-2012 (UNFCCC, 1997b), with emissions expressed in CO_2 equivalents, based on 100 year GWP (Global Warming Potential) values. These gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Each Annex B Party is allowed an assigned amount of greenhouse gas emissions not to be exceeded over the five-year commitment period 2008 – 2012, relative to its carbon dioxide equivalent emissions of all six greenhouse gases in the base year 1990 (or 1995 for HFCs, PFCs and SF_6).

By January 1999, 71 Parties, including the European Community and the US, had signed the Kyoto Protocol, and 2 Parties had ratified it. To become binding international law the Protocol has to be ratified by 55 Parties to UNFCCC and the Annex 1 Parties ratifying have to account for 55% of the 1990

CO_2 emissions (of Annex I Parties). This means that entry into force on the international level could be blocked by Parties accounting for more than 45% of the 1990 CO_2 emissions of Annex I Parties.

Under the UNFCCC the EU and each of its Member States were committed to a reduction of 8% below the 1990 level in the period 2008 to 2012. Central and eastern European countries are committed to reductions of 5-8%. Each Party is required to make demonstrable progress in achieving its commitments by 2005.

According to the Kyoto Protocol, net changes in carbon stocks due to specific types of greenhouse gas sinks, in particular forests, can be used in the national inventories to meet emission reduction commitments. This was controversial since major methodological uncertainties remain in the calculation of carbon removal by sinks (see also Section 5.)

In June 1998 a system of 'burden sharing' (also called 'target sharing') was agreed for the EU Member States (European Community, 1998a) (see Table 3.1.3).

There are three important new 'flexibility mechanisms' introduced in the Kyoto Protocol (the so-called 'Kyoto Mechanisms'):

- emissions trading among industrialised (Annex 1) countries;
- joint implementation among industrialised countries;
- cooperation between industrialised and developing countries in a 'clean development mechanism'.

Emissions trading allows Parties to the Kyoto Protocol that reduce greenhouse gas emissions below their assigned amount to sell part of their emission allowance to other Parties. A Party could also buy additional emission allowance from other Parties for the purpose of meeting its Kyoto commitment. Emissions trading is intended to improve amongst Annex B Parties (industrialised countries) the efficiency of economic resource allocation. However, some countries, for example Russia, could have large quantities of unused assigned amounts of emissions available for trading. This issue is often referred to as trading in 'hot air', since

Box 3.1.1 Vulnerability and adaptation to climate change in Europe:

Even though capabilities for adaptation in managed systems in many places in Europe are relatively well established, significant impacts of climate change still should be anticipated. Coastal systems will be affected through sea-level rise and an increase in storm-surge hazards, with areas most at risk in the EU being the coastlines of the Netherlands and Germany and some Mediterranean deltas. Major effects are likely to be felt through changes in the frequency of extreme events and precipitation, causing more droughts in some areas and more river floods elsewhere. Already occurring water stresses are likely to be enhanced in the Mediterranean region, the Alps and northern Scandinavia. Effects in agriculture could be on growing seasons and productivity as well as increases in some pests and diseases. Boreal forest and permafrost areas are projected to undergo major change. Ecosystems are especially vulnerable due to the projected rate of climate change that would change faster than the ability of plant species to migrate. Human health could be affected through increases in heat-stress mortality, tropical vector-borne diseases, urban air pollution problems, and decreases in cold-related illnesses.

Source: IPCC, 1997a

Damage costs of greenhouse gas emissions — Table 3.1.2.

Impact area	Damages included in the study			
Health impacts	expansion of the area amenable to parasitic and vector borne diseases			
Agricultural impacts	changes in area suitable for certain crops and technical changes e.g. irrigation			
Water supply impacts	changes in water resources			
Sea-level rise	losses of land and wetlands; costs of protection; migration effects			
Impacts on ecosystems	valuations based on estimates of species loss			
Hazards of extreme weather events	changes in frequency and severity of cold spells, heat waves, drought, floods, storms and tropical cyclones			
	Marginal Damage from model (euro/tonne CO_2 eq.):			
Model	FUND		Open Framework	
Discount rate	1%	3%	1%	3%
Greenhouse gas				
Carbon dioxide, CO_2	46	19	44	20
Methane, CH_4	25	17	19	18
Nitrous oxide, N_2O	55	21	84	35

Source: Eyre *et al.*, 1998

Box 3.1.2 Article 2 of the UNFCCC:

Objective

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

it could imply that no real reduction of emissions would take place. The size of this problem is uncertain, since it depends for example on the economic development of Russia.

Table 3.1.3. EU 1990 emissions and the Kyoto Protocol targets, including the EU 'burden sharing' agreement (all in CO_2-equivalents)

Country	Target (%)	Emissions 1990 (Tg CO_2 eq.)	Target 2008 – 2012 (Tg CO_2 eq.)
Austria	-13.0	78	68
Belgium	-7.0	139	129
Denmark	-21.0	72	57
Finland	0	65	65
France	0	546	546
Germany	-21.0	1 208	955
Greece	25.0	99	124
Ireland	13.0	57	64
Italy	-6.5	543	507
Luxembourg	-28.0	14	10
Netherlands	-6.0	217	204
Portugal	27.0	69	87
Spain	15.0	302	348
Sweden	4.0	66	68
United Kingdom	-12.5	790	691
EU Total	-8.0	4 264	3 922
Bulgaria	-8.0	124	114
Czech Republic	-8.0	187	173
Estonia	-8.0	49	45
Hungary	-6.0	80	76
Latvia	-8.0	37	34
Lithuania	-8.0	44	41
Poland	-6.0	591	556
Romania	-8.0	246	226
Slovakia	-8.0	72	67
Slovenia	-8.0	19	17
Croatia	-5.0	7	35
Iceland	10.0	3	3
Liechtenstein	-8.0	0	0
Norway	1.0	55	56
Switzerland	-8.0	54	49

Source: UNFCCC, 1997, 1998; European Commission, 1998f; EEA, 1999a

Joint implementation means that Annex 1 Parties may transfer or acquire from each other emission reduction units on a project basis. Private sector entities can participate in this mechanism under certain conditions.

The Clean Development Mechanism (CDM) creates the possibility that Annex I countries have reductions from projects, undertaken between 2000 and 2008-2012 (the first budget period), in non-Annex I countries credited towards their reduction targets.

At the fourth Conference of Parties (COP4, November 1998) the Buenos Aires Action Plan (UNFCCC, 1999) was adopted, that includes work to be finalised in 2000 on:

- financial mechanisms to assist the developing countries regarding adverse effects of climate change, for example through adaptation measures;
- development and transfer of technology to developing countries;
- work programme on the Kyoto Mechanisms, with a priority on the clean development mechanism;
- work related to compliance and to policies and measures.

The work programme on the Kyoto Mechanisms contains many elements, including guidelines for verification, reporting and accountability for all three mechanisms and the need for clear definitions and organisational and financial mechanisms. It also includes the need to elaborate the quantification of 'supplemental' to domestic action. This was considered a key issue by the EU. In March 1998 the EU Council proposed a quantified limit to be imposed on industrialised countries' use of greenhouse gas emissions trading and the other two Kyoto mechanisms. The proposal aims at ensuring that all Annex B Parties will take domestic measures to limit their emissions. In October 1998 the EU Council concluded that a ceiling on the use of the Kyoto Mechanisms has to be defined in 'quantitative and qualitative terms based on equitable criteria'.

2.2. Current EU policies and measures

Some EU-wide policies and measures, aimed at reducing emissions of greenhouse gases or enhancement of carbon sinks, are in place. Furthermore the Commission has presented various communications and proposals (Table 3.1.4).

The introduction of a mandatory EU-wide energy and CO_2 tax has been proposed by

Main EU actions, policies and measures for reducing greenhouse gas emissions Table 3.1.4.

Type	Policies and measures (and proposals)	Description and objectives
General	Monitoring mechanism for CO_2 and other greenhouse gas emissions (Decision 93/ 389/EEC)	Monitor progress towards the target of stabilisation of Community CO_2 emissions in 2000 on 1990 levels.
	Proposal for amending the Monitoring Mechanism, COM(98) 108	To include other greenhouse gases and report after 2000 and bring in line with Kyoto Protocol.
	Strategy paper for reducing methane emissions, COM(96) 557	Overview of potential measures (methane).
	Climate Change – the EU approach to Kyoto, COM(97) 481	Overview of potential measures, before the UNFCCC Kyoto Protocol agreement.
	Communication on Climate Change – Towards an EU Post-Kyoto Strategy, COM(98) 353	Overview of potential measures, after the UNFCCC Kyoto protocol agreement.
	Council conclusions on targets for Member States on GHG emission reductions CO_2 (June 1998)	New 'burden/target' sharing of Member States in line with the UNFCCC Kyoto Protocol.
Energy efficiency/ energy technologies	New proposal for a EU wide energy products tax COM(97)30	No agreement. Various Member States have implemented an energy/CO_2 tax.
	The energy dimension of climate change, COM(97)196	Overview of implications for the energy sector of reducing GHG emissions.
	Energy efficiency in the European Community – towards a strategy for the rational use of energy, COM(1998) 246	Overview of possible measures/policies to improve energy efficiency.
	JOULE/THERMIE programme 1995/1998 (Decision 94/ 806/EEC)	Promotion of R&D of environmentally friendly and efficient energy technologies and renewable energy.
	ALTENER I programme (1993/1997); proposal for ALTENER II (1998/1999), COM (97) 87	Promotion of renewable energy sources.
	SAVE I (1991/1995) and SAVE II (1996/2000) programmes (Decision 96/737/EC)	Overview of measures to improve energy efficiency.
Industry	Directive 96/61/EC concerning Integrated Pollution Prevention and Control (IPPC)	Requires improvement of energy efficiency in industrial (IPPC) installations.
	Directive on Large Combustion Plants (88/609/EEC) and proposal for revision (1998)	Proposal for revision requires the operator to investigate feasibility of combined heat and power (CHP).
Transport	Communication on implementing the Community strategy to reduce CO_2 emissions from cars: an environmental agreement with the European automobile industry, COM(1998) 495	EU target of reduction of CO_2 emissions from new passenger cars to 120 g/km by 2005 or 2010 at the latest. Industry commitment to reduce to 140 g/km by 2008.
	Trans European Networks (TEN) for transport	Europe wide expansion of transport infrastructure (road, rail, water). Potential modal shift away from road transport.
Waste	Proposal for a Directive on the landfill of waste	Reduction of methane emissions, requirement for operators to install a control system for landfill gas.
Agriculture and forestry	Reform of the Common Agriculture Policy (CAP)	Indirect reduction of methane emissions due to reduction of number of cattle, and of nitrous oxide emissions due to reduced amount of fertilisers.
	Regulation instituting a Community aid scheme for forestry measures in agriculture (Regulation EEC/2080/92)	Afforestation of agricultural land and thereby also enhancement of carbon sinks.
Households	Directives for energy labelling of house-hold refrigerators, freezers, washing machines, dishwashers, lamps.	Labelling of energy consumption for information
	Directives on energy efficiency requirements of hot water boilers, household refrigerators, freezers. Agreements with manufacturers and importers of washing machines, televisions, video.	Minimum standards for energy efficiency.

Sources: European Commission, 1996a, 1996b, 1997a, 1997b, 1997c, 1998a, 1998b, 1998c, 1998d, 1998e, 1998 f; European Community, 1996a, 1998b; EEA , 1999a; UBA, 1998 the European Commission but no agreement has been reached. In 1997, the European Commission presented a proposal for a comprehensive energy products tax, to extend the scope of the existing EU-wide excise system to cover natural gas, coal and electricity as well. Various Member States have already implemented an energy/CO_2 tax: Austria, Denmark, Finland, Sweden and the Netherlands (see Chapter 4.1).

To monitor progress towards the target of stabilisation of EU CO_2 emissions at 1990 levels by the year 2000, the Council adopted in 1993 a monitoring mechanism for CO_2 and other greenhouse gas emissions (European Community, 1993). The European Commission prepared two reports (European Commission, 1996a) and the EEA prepared a draft report with an overview of national programmes to reduce greenhouse gas emissions (EEA, 1999a). In 1998 the Commission presented a proposal for revision of the monitoring mechanism to reflect the agreement reached at Kyoto (European Commission, 1998a).

The Communication 'the EU Approach to Kyoto' (European Commission, 1997b) showed that a 15% reduction in CO_2 emissions would be technically feasible and the costburden would not be insupportable. A more recent Communication (European Commission, 1998f) contains an analysis of the Kyoto Protocol and the implications for the EU and also indicated potential EU policies and measures. Based on the UNFCCC Buenos Aires Action Plan and strategies of the Member States, the Commission will prepare a more complete strategy in 1999.

The European Commission has identified the potential for energy efficiency improvements until 2010 (European Commission, 1998b). For energy in the EU (production and supply), the programmes ALTENER, SAVE and JOULE-THERMIE feature prominently in the policy response to climate change, although their actual impact on GHG emission reductions is quite difficult to assess.

The Integrated Pollution Prevention and Control (IPPC) Directive for industry includes energy efficiency as a criterion for the determination of best available technology (BAT) and could therefore contribute to reduction of CO_2 emissions.

For transport, the European Commission reached an agreement with the car industry in July 1998 to reduce CO_2 emissions from new passenger cars by 25% (to 140 g/km) between 1995 and 2008 (European Commission, 1998d). The Commission's target is to improve fuel efficiency of passenger cars so that emissions are reduced to 120 g/km, and it has proposed a scheme for energy labelling of new passenger cars to help achieving this target.

The revised proposal for a Directive on the landfill of waste aims at reducing landfill methane emissions. Member States would need to fit all new and existing landfills which receive biodegradable waste with a landfill gas control mechanism, where possible using the gas collected for energy production and the directive sets binding targets for the reduction of the amounts of municipal organic waste (see also Chapter 3.7).

In agriculture, the 1992 reforms of the Common Agricultural Policy (see also Chapter 2.1) could indirectly lead to a reduction of methane emissions, caused by reduced numbers of cattle and a reduction of nitrous oxide emissions due to reduced amounts of mineral fertilisers applied. Increased non-food biomass production on set-aside land could help to substitute fossil fuel with biofuel. In the forestry sector, financial support will be provided by the EU for afforestation of agricultural land.

With respect to household consumption, several Directives have been adopted on energy-efficiency requirements for appliances and various agreements with manufacturers and importers on minimum energy standards have been reached.

2.3. Member States' current policies and measures

In addition to initiatives at EU level, the Members States have implemented various national policies and measures (see Table 3.1.5). Although the impact of these measures on the EU total greenhouse emissions is difficult to assess, some estimates are provided in section 4.

3. Sources and trends of greenhouse gas emissions

3.1. Main sources of greenhouse gas emissions in Europe

The energy sector (mainly power and heat generation) is the main contributor to EU CO_2 emissions (32%), followed by transport (24%) and industry (23%) (Figure 3.1.5). In central and eastern Europe transport makes a relatively smaller, and energy supply and

National EU Member States' policies and measures for reducing greenhouse gas emissions — Table 3.1.5.

	Energy general	Power generation	Industry	Transport	Residential	Others
Austria	Energy/CO_2 tax implemented	promotion of combined heat and power (CHP) plants and renewable energy			tightening of energy-relevant regulations for buildings	
Belgium		promotion of CHP and renewable energy		improvement of public transport, promotion of combined rail and road transport	improved energy efficiency	
Denmark	Energy/CO_2 tax implemented for households, similar tax for the industry sector	promotion of CHP and electricity production from biomass; construction of new gas-fired (replacing coal) power plants after 2000. Large scale use of wind energy for electricity		promoting public transport, financial support for purchase of clean vehicles.		
Finland	Energy/CO_2 tax implemented	efficiency improvements, promotion of CHP, electricity production from biomass	promotion of energy saving through voluntary agreements			forestry: measures to enhance carbon sequestration
France		demand-side management		more energy-efficient transport	increasing energy efficiency in buildings	forestry: increasing forest carbon sequestration
Germany		voluntary commitment on improved energy efficiency, legislation on the sale of electricity generated from renewables to the grid	voluntary measures, improving energy efficiency	energy-efficient transportation policy		new Länder: emission reductions by replacement of lignite by other fuels, moderni-sation of industrial installations, improvement of energy efficiency (industry, resi-dential sector)
Greece		introduction of natural gas, development of CHP, large scale exploitation of solar energy	introduction of natural gas	metro in Athens and Thessaloniki	introduction of natural gas	forestry: Control of forest resources, re-afforestation programme.
Ireland		energy efficiency improvements, fuel switching to natural gas, promotion of CHP, increasing the use of renewables	energy efficiency improvements	investment programme for roads and rail networks	energy efficiency improvements	forestry: afforestation programme.
Italy		efficiency improvement, increasing use of renewables	increased use of natural gas	traffic control and rationalisation of urban mobility	increased use of natural gas, increasing energy efficiency in buildings	
Luxem-bourg				promotion of public transport, rail transport and waterways	promotion of CHP	

.../...

	Energy general	Power generation	Industry	Transport	Residential	Others
Netherlands	Energy/CO_2 tax implemented	increase of CHP, increasing renewable energy and partial fuel switch to wood; providing adequate payments for energy generated from renewable sources	voluntary agreements on energy efficiency	shift to more efficient cars, improvement public transport	energy performance standards, promote energy-efficient products, appliances and heat insulation	waste treatment: 5 million tonnes of waste for energy purposes by 2000
Portugal		introduction of natural gas, increased use of renewables, technological improvements		alternative fuels and infrastructural improvements		
Spain			energy conservation, fuel switching, promotion of natural gas and CHP	subsidising public transport, investment in rail infrastructure	energy conservation, fuel switching, promotion of natural gas and CHP	
Sweden	Energy/CO_2 tax implemented	promote renewable energy (bio-fuels, wind power and solar energy), increase efficiency		tax on petrol		forestry: switch to sustainable practices
United Kingdom		switch from coal to natural gas continuing, improvements in the produc-tivity of the nuclear plants, increase CHP, promote renewable sources of energy	voluntary agreements regarding energy savings, promotion of energy efficiency	increase road fuel duties, fuel efficiency improvement of vehicles	stricter regulations for energy efficiency for new buildings	

industry a larger contribution than in the EU. The main sources of CH_4 emissions in EU are agriculture (42%), in particular from ruminants (enteric fermentation and manure management), waste treatment and disposal (36%) and others, mainly coal mining and leakage from natural-gas distribution networks (17%). Estimates for methane are more uncertain than for CO_2 emissions since the major agricultural sources and emissions from waste treatment are less well quantified.

The main sources of N_2O emissions in EU are from fertilised agricultural land (46%), industry (26%), in particular adipic acid and nitric acid manufacture, the transport sector (7%) and the energy sector (7%). Emissions from transport are due to the introduction of three-way catalysts in cars, which reduce emissions of nitrogen oxides, carbon monoxide and hydrocarbons, but as a side-effect increase the emissions of nitrous oxides. As for methane, the data is more uncertain, mainly because the major agricultural sources are less well quantified. In central and eastern Europe the share of agriculture is larger, and that of industry and transport smaller.

3.2. Current trends in EU Member States

Carbon dioxide, methane, nitrous oxide

EU CO_2 emissions decreased by 1% between 1990 and 1996, although the trend varies considerably between Member States (Tables 3.1.6 and 3.1.7). The decrease for the EU as a whole depends strongly on the reductions in Germany and the UK. Germany has the largest national CO_2 emission in the EU, with a contribution of approximately 30% to EU emissions in 1995. Between 1990 and 1996 the largest absolute emission reduction took place in Germany, mainly caused by the economic restructuring of the new Länder. The substantial reduction in emissions in the UK was mainly caused by fuel switching from coal to natural gas.

CO_2 emission trends can be compared with economic development in these years. Between 1960 and 1990, GDP growth for each five-year period varied in EU Member States between 8% and 28%. In the period 1990-1996, GDP growth in the EU was about 9% (almost 6% between 1990 and 1995). With the exception of the second oil crisis in the early 1980s, the five-year average GDP growth in the period 1960 to 1990 was about 16%. This indicates that the reduction of CO_2 emissions between 1990 and 1996 is partly related to the relatively low GDP growth in this period and is partly due to an increase in energy efficiency and the effects of policies and measures to reduce GHG emissions (see Table 3.1.7).

EU nitrous oxide emissions decreased 5% in 1996 from 1990 levels, although this trend varies considerably between the Member States. Although the trend and its causes are more uncertain than for CO_2 the largest reductions appear to be due to falling production levels for adipic and nitric acid in industry and a reduction in the consumption of inorganic nitrogenous fertilisers in agriculture. These reductions were partially offset by an increase in transport emissions as the number of cars with catalytic converters increased (AEA, 1998a).

EU methane emissions fell by 7% between 1990 and 1995, with some variation between Member States. As for nitrous oxides the trend and its causes are more uncertain than for CO_2 emissions. The largest emission reduction appears to be due to the decline of deep mining in the UK (and to some extent in Germany) and the replacement of the old gas distribution pipework. Agricultural emissions also fell, due mainly to a reduction in the number of dairy cows (AEA, 1998b).

Halogenated gases
Emission estimates of the three groups of halogenated gases HFCs, PFCs and SF_6 have only recently been prepared, but not yet by all Member States. For the EU, 1995 will probably be the base year under the Kyoto Protocol for reduction in emissions of these gases.

Total estimated EU emissions in 1995 of the halogenated gases HFC's, PFC's and SF_6 are about 58 Mt CO_2-equivalents, which is 1-2% of total EU emissions of CO_2, CH_4 and N_2O in 1990 (in CO_2-equivalent). The largest contribution comes from HFCs (64%) followed by SF_6 (25%) (Table 3.1.8).

At present HFCs are mainly emitted as a by-product during the production of HCFC-22. The most important source of SF_6 is electricity distribution (use in switches) and of PFCs industrial production processes in the primary aluminium and the electronics industry.

Greenhouse gas emissions by sector in EU and Accession Countries Figure 3.1.5

Source: EEA, ETC/AE, 1998

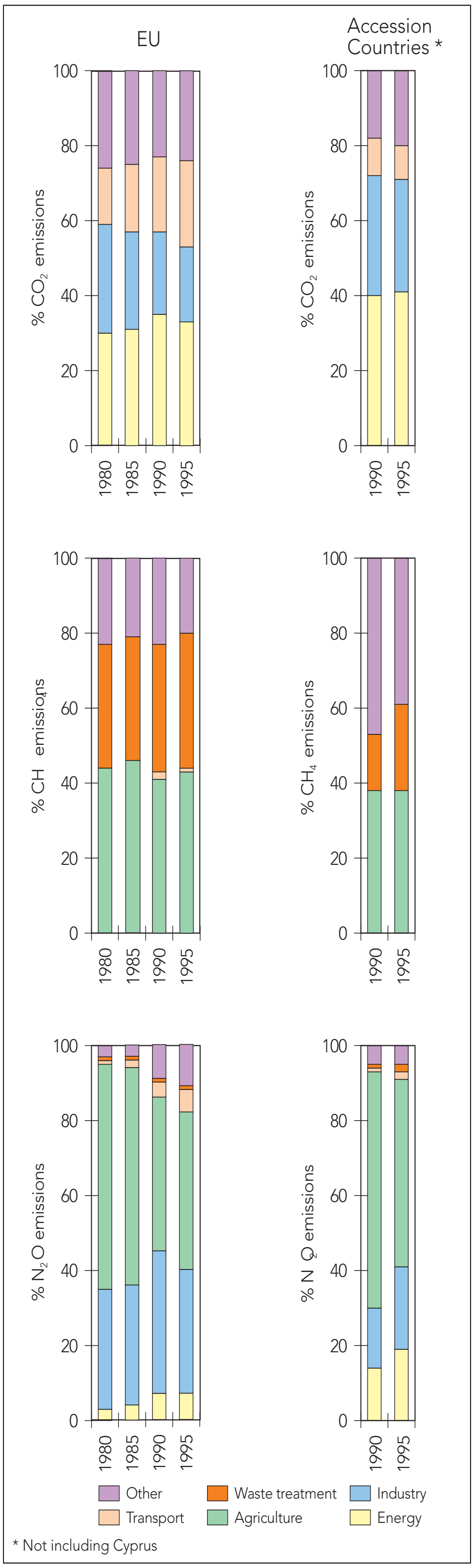


Table 3.1.6. Greenhouse gas emissions and removals/sinks in 1996 (CO_2, CH_4, N_2O) – EU

	CO_2 (in million tonnes)		CH_4 (in 1 000 tonnes)	N_2O (in 1 000 tonnes)
MEMBER STATE	Emissions	Removals/Sinks		
Austria	62	14	580	13
Belgium	129	2	591	35
Denmark	60	1	430	33
Finland	66	14	270	18
France	399	60	2844	174
Germany	910	30	4788	210
Greece	92	-	457	29
Ireland	35	6	800	26
Italy	448	36	2516	162
Luxembourg	7	0	24	1
Netherlands	185	2	1179	72
Portugal	51	1	834	14
Spain	248	29	2370	90
Sweden	63	32	297	10
United Kingdom	593	19	3712	189
EU15	3 347	247	21 692	1 076

Estimates for 1996 were not available for Austria, Denmark, France, Italy, Portugal and Spain. For these countries 1994 or 1995 estimates have been used for a preliminary EU15 1996 estimate. The CO_2 estimates are not corrected for temperature or electricity trade. Some Member States use corrected CO_2 estimates to better reflect national circumstances.

Source: EEA, 1999a

Table 3.1.7. CO_2 emissions and GDP growth in EU: percentage change 1990-1996

Source: EEA, 1999a

MEMBER STATE	CO_2	GDP
Austria	0.2	11.9
Belgium	10.7	7.8
Denmark	13.9	8.7
Finland	12.0	-3.4
France	1.7	4.8
Germany	-10.3	9.5
Greece	7.8	7.2
Ireland	13.3	35.7
Italy	1.4	6.8
Luxembourg	- 46.6	15.1
Netherlands	14.6	9.5
Portugal	7.9	8.9
Spain	2.2	7.8
Sweden	14.3	4.7
United Kingdom	- 3.5	6.5
EU15	- 0.7	9.0

4. Progress and outlook (2000 and 2010)

4.1 Progress towards EU target of CO_2 stabilisation by 2000

If national projections of CO_2 emissions for 2000 are aggregated for the EU, the result is a 2% reduction compared with the 1990 level (Table 3.1.9), with a decrease in six Member States.

However, these projections are subject to uncertainties related to socio-economic developments and the success of the implementation of policies and measures, and also have methodological differences.

The European Commission has made its own projections, based on a consistent methodology for the EU and derived from the Commission's pre-Kyoto 'baseline' energy scenario (which assumes no additional policy action for CO_2 abatement).

The projections for the year 2000 show EU energy-related CO_2 emissions 2% above 1990 levels; transport is the fastest-growing sector with emissions increasing to 22% above the 1990 level in 2000.

The combination of these two assessments (national estimates and pre-Kyoto EU energy scenario) suggests that EU CO_2 emissions in 2000 could be in the range of 2% above or below 1990 levels.

4.2. Baseline scenario for 2010 (reaching the Kyoto target for EU?)

The EU is also committed (under the Kyoto Protocol) to an 8% reduction by 2008-2012 (from 1990 levels) in emissions of the six main greenhouse gases.

EU total greenhouse gas emissions under the baseline scenario are projected to increase by about 6% in 2010 from 1990 levels (Figure 3.1.6).

Because the Kyoto targets for the EU and other UNFCCC Parties are expressed in CO_2-equivalents, as a sum of all six greenhouse gases, it is essential to combine the information on the emissions in 1990 and 2010 (baseline) for all six gases. Thus it is possible to assess the emission reductions required, on top of the assumptions on policies and measures in the baseline scenario, for achieving the Kyoto target for the EU (Figure 3.1.6).

The Kyoto target of -8% requires a reduction of about 600 Mt CO_2-equivalent from the projected baseline scenario emissions in 2010 (from 4 490 to 3 890 Mt CO_2-equivalent, while the 1990 emissions were 4 227 Mt CO_2-equivalent).

Carbon dioxide
The projected EU CO_2 emissions for 2010 based on the pre-Kyoto baseline scenario are about 8% above the 1990 level (Figure 3.1.7).

This baseline scenario for 2010 is based on the assumption of no additional EU policy action for CO_2 abatement. The pre-Kyoto scenario relates only to fuel-related CO_2 emissions (about 95% of total CO_2 emissions). (For the main assumptions in this scenario, see Chapters 1.1. and 2.2.).

Transport is the fastest-growing sector with emissions projected to increase by 22% (in 2000) and 39% (in 2010) above the 1990 level (Figure 3.1.8). In contrast, industrial CO_2 emissions are projected to decrease by 15% between 1990 and 2010, while CO_2 emissions from the domestic/tertiary sector are projected to remain stable. This is mainly due to expected increased market penetration of electrical and heating equipment – in effect CO_2 emissions are exported to the power generation sector. Nevertheless, CO_2 emissions in the power- and heat-producing sector are projected to remain at the 1990 level until 2010, although some increase can be expected after 2010, due to changes in the power-generation structure (such as retirement of nuclear power plants at the end of their lifetime).

Among the Member States, only Germany is projected to have CO_2 emissions in 2010 below the 1990 level. In both 1995 and 2010, about half of the CO_2 emissions are related to combustion of liquid fuels. An important shift however is occurring away from solid fuels to gaseous fuels. This explains the relatively small increase (+8%) in aggregate CO_2 emissions, compared to the larger increase in total energy consumption between 1995 and 2010 and demonstrates a partial de-coupling between CO_2 emissions and energy consumption.

Methane and nitrous oxide
Various recent studies for the Commission have provided EU baseline scenario emission estimates for methane and nitrous oxides for 2010 (AEA, 1998a, 1998b; Ecofys, 1998a, 1998b; Coherence, 1998). The results are comparable but have some different assumptions on the extent to which measures for

Main emission sources of HFCs, PFCs and SF_6 in EU in 1995 Table 3.1.8.

Emission estimates (Million tonnes (Mt) CO_2-equivalents)

HFCs	PFCs	SF_6
37 Mt	**7 Mt**	**14 Mt**
HFC production/handling	Primary aluminium production	Electricity distribution
HCFC-22 production	Semiconductor manufacturing	Magnesium production
Refrigeration		Semiconductor manufacturing
Mobile air conditioners		Noise-insulating windows
Foam blowing		Tyres
Solvent use		
Aerosols, Fire extinguishers		

Source: Ecofys, 1998a

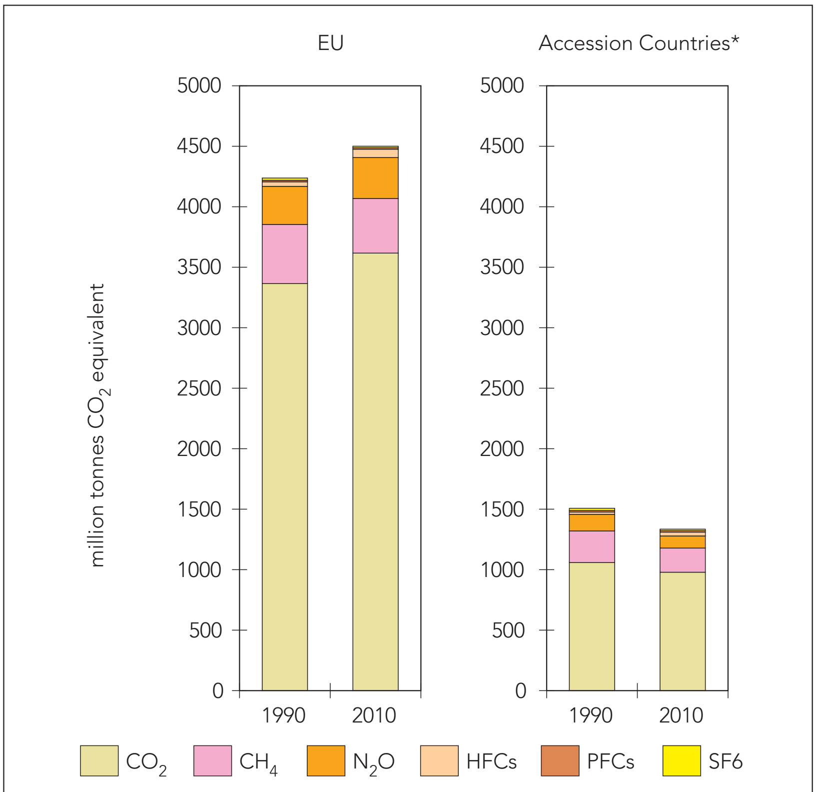
CO_2 emissions in EU Member States, reported (1990) and projected (2000) Table 3.1.9.

	Inventory 1990	Projections 2000
	(million tonnes CO_2) (Mt)	
MEMBER STATE	**1990 (base year)**	**2000 with measuress**
Austria	62	57
Belgium	116	125
Denmark	52	54
Finland	59	60
France	392	377
Germany	1 014	894
Greece	85	98
Ireland	31	35
Italy	442	446
Luxembourg	13	7
Netherlands	161	189
Portugal	47	50
Spain	226	258
Sweden	55	60
United Kingdom	615	578
EU15	3 372	3 290

The column 'with measures' represents the expected emissions in 2000, taking into account the policies and measures that were already adopted by the Member States and for which an estimation of reduction potential was available from national programmes (1997/1998).

Source: EEA 1999

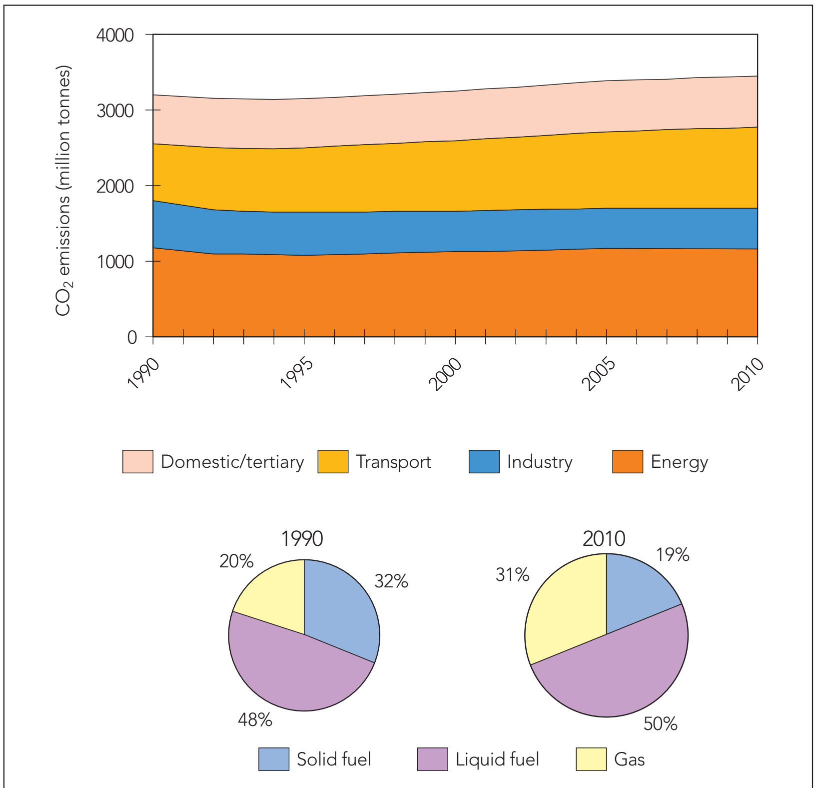
Figure 3.1.6 **Greenhouse gas emissions in EU and AC10 by 2010 – baseline scenario**



*not including Cyprus

Source: European Commission, 1999; Ecofys, 1998a, 1998b; AEA, 1998a, 1998b, UNFCCC, 1998, EEA, 1999a; EEA, 1999 b.

Figure 3.1.7 **EU15 energy-related baseline CO_2 emission projections by sector and by fuel**



Source: European Commission, 1999; Capros, 1998, European Commission, 1997a

the industry sector (N_2O emissions) and the agricultural sector (CH_4 and N_2O emissions) are included in the scenario.

Methane emissions in the EU are projected to decrease by 8% between 1990 and 2010 (Coherence, 1998) mainly due to large emission decreases from coal mining, as coal production is projected to fall, and from agriculture as cattle numbers are projected to fall. Reductions from the waste sector, for example through measures to collect and remove methane emissions from new landfills, are not included in this baseline scenario (see also section 5).

EU nitrous oxide emissions are projected to increase by 9% between 1990 and 2010 (Ecofys, 1998b), mainly due to increases in emissions from passenger-car catalytic converters. No reductions are assumed from the industrial sector (production of adipic and nitric acid) and only minor reductions from agriculture.

Halogenated gases
For the halogenated gases an indicative baseline scenario emission projection (based on the limited information available) has been prepared for the Commission (Ecofys, 1998a; March Consulting Group, 1998). In 2010, total fluorocarbon emissions are projected to be about 82 Mt CO_2-equivalent, an increase of about 40% compared with 1995 emissions of 58 Mt. The share of HFCs is expected to rise to 79%, while the shares of SF_6 and PFC's would decrease to 15% and 6% respectively by 2010.

Emission reductions by 2010 for an enlarged EU
The analysis given above focuses on the EU. For other countries in Europe much less data is available. This section, however, presents a preliminary analysis of the emissions by 2010 of an enlarged EU, meaning EU15 and the 10 central and eastern European Accession Countries (AC10). These emissions could be compared to the current Kyoto targets for the EU and Accession Countries, although this would only be indicative since agreed targets for a potentially enlarged EU do not exist.

For AC10 information is available from a study performed by IIASA for EEA (EEA, 1999b), using the official energy projections for 2010 provided by these countries.

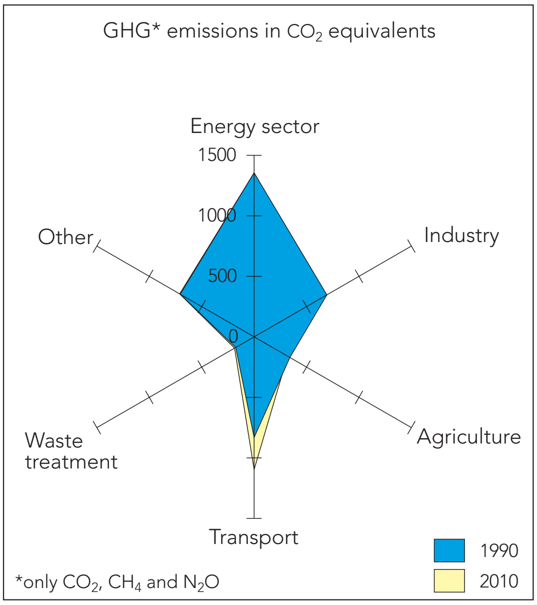
There have been significant falls in greenhouse gas emissions in Eastern Europe since 1990. CO_2 emissions in AC10 fell by 20%

between 1990 and 1995. By 2010, GDP is expected to be 31% higher than in 1990, while energy consumption would rise by only 4% (UNECE, 1996). In addition, there is likely to be a switch to fuels that emit lower amounts of greenhouse gases (EEA, 1999b). The baseline scenario suggests an 8% decrease in CO_2 emissions for the AC10 by 2010.

For AC10 information on baseline emission projections for methane, nitrous oxide and the fluorocarbons is very limited. Nevertheless, some indicative estimates for 2010 for have been prepared by EEA/ETC-AE (see Figure 3.1.6), according to which the total greenhouse gas emissions for the AC10 are projected to decrease by 11% in 2010 from 1990 levels. Combined with the projected 6% increase for EU greenhouse gas emissions, this would probably result in a 2% increase in emissions of a potentially enlarged EU during the same period.

It is clear that under the assumptions of the baseline scenario, an EU25 target for 2012 emissions between 6% and 8% below 1990 levels would not be achievable.

Sectoral contribution to greenhouse gases in the EU (1990-2010) Figure 3.1.8



Source: EEA

Box 3.1.3 Carbon sinks of forests

According to Article 3.3. of the UNFCCC Kyoto Protocol, Parties can use the net changes in greenhouse gas emissions from sources and removals by sinks to meet their commitments, but only those resulting from direct human-induced land-use change and forestry activities and limited to afforestation, reforestation, and deforestation since 1990. Afforestation and reforestation can increase the stock of carbon and therefore act as a net sink. On the other hand deforestation leads to additional net emissions of CO_2. Further work to clarify the definitions, to remove major uncertainties and to agree methodologies and appropriate modalities will be addressed in future. The IPCC will produce a special report on the issue of carbon sinks in 2000.

Additional land-use and land-use change activities that could be used to contribute to the fulfilment of the Kyoto target may be specified under Article 3.4 of the Kyoto Protocol. UNFCCC negotiations on this issue will start after 2000.

The European Forest Institute prepared for EEA (EFI, 1998) a preliminary analysis of the issue of forest carbon sinks in Europe, related to the Kyoto Protocol. The more comprehensive EUROFLUX project (Martin *et. al.*, 1998) provides similar results, while taking into account all important carbon fluxes. It provides long-term carbon dioxide and water vapor fluxes of European forests. The main conclusions of the EFIstudy are:

- for Europe the land-use change and forestry carbon balance (usually sinks) reported by the countries to UNFCCC using the IPCC Guidelines, is comparable to a uniform estimate from FAO statistics (a carbon sink of 50-70 million tonne (Mt) C per year for EU15);
- there are large differences in the national methods used;
- the forest carbon sink according to the Kyoto Protocol can be estimated in different ways, because the definition of afforestation is not clear. Using FAO definitions the carbon balance for EU15 is estimated to be a sink of 10 Mt C per year, while using the IPCC definitions this is only 1 Mt C per year;
- the forest carbon sinks are relatively small compared with the EU15 CO_2 emissions (of 3 372 Mt or 920 Mt C), depending on the definitions between 0.1% and 1%. This shows that to reach the EU Kyoto commitment for 2008-2012 carbon sequestration can form only a small part of the required policies and measures, although the potential for carbon sequestration can vary considerably between countries.

Furthermore it should be noted that the accounting approach for carbon sinks in the Kyoto Protocol can lead to incentives with negative impacts on biodiversity conservation and soil protection (WBGU, 1998).

Table 3.1.10. **Possible potential for greenhouse emission reduction and costs in the EU**

Sector/measures	Emission reduction (Mt CO_2 eq.)	Average cost (euro/tonne CO_2-equiv.) Low (1)	0-50
CO_2			
Transport, increased passenger-car fuel efficiency	145	X	
Industry (increased energy efficiency)	66		X
Tertiary/domestic (increased	33		X
energy efficiency)			
Power generation			
fossil-fuel switching	86		X
CHP	31		X
renewables (biomass, other)	79		X
EU total CO_2	440	below 50	
CH_4			
Agriculture (improved manure management)	34	X	
	20		X
Waste (landfill gas	23		X
recovery/flaring)	60		X
Energy (reduction	4	X	
gas leakage)	11		X
EU total CH_4	150	below 50	
N_2O			
Agriculture (reduce fertiliser application)	24	X	
Waste	1	X	
Industry (BAT installed in adipic and nitric acid production)	86		X
Energy (combustion)	8	X	
EU total N_2O	120	below 50	
Halogenated gases:			
HFC (HFC manufacturing, reduce leakage or use substitutes)	48		X
PFC	4		X
SF_6	7		X
EU total halogenated gases	60	below 50	
EU total all greenhouse gases	770	below 50	

(1) low means approximately zero costs or cost savings that offset the costs of the measure

Source: Capros, 1998; Coherence, 1998; Ecofys, 1998a, 1998b; AEA, 1998a, 1998b; March Consulting Group, 1998

5. Possible future responses in the European Union

According to the initial analysis, as described above, the effort required to meet the EU reduction objective under the Kyoto Protocol is estimated to be around 600 Mtonnes of CO_2-equivalent.

An important element in an EU climate change policy will be the cost-effectiveness of policies and measures. This means a combination of measures for the six gases that will have the least cost for all sectors together. It should be noted that apart from cost-effectiveness other criteria for selection and implementation of measures are also important, such as political acceptability, fairness (for example between sectors), social barriers and industrial competitiveness.

Use of all abatement measures with a cost below 50 euros/tonne CO_2-equivalent would give a total technical reduction potential of 770 Mt CO_2-equivalent for the six greenhouse gases from (Table 3.1.10), which includes 440Mt from measures targeted at CO_2. This is more than the reduction required for achieving the Kyoto emission reduction target of 600 Mt CO_2-equivalent. It should be noted that there are quite large ranges in cost estimates from the various studies, so the cost estimates should only be regarded as indicative. Some of the measures presented here are already being planned or implemented in various Member States.

The Commission and Member States will undertake further assessments of policies and measures at both EU and national levels in conjunction with the Kyoto Protocol Flexible Mechanisms. The EU Strategy on Climate Change, expected in 1999, will make an important contribution to this process.

References

AEA, 1998b. *Options to reduce methane emissions*, draft report prepared for the Commission (DGXI), September 1998.

AEA, 1998a. *Options to reduce nitrous oxide emissions*, draft report prepared for the Commission (DGXI), September 1998.

Alcamo, J., Kreileman, G.J.J., Bollen, J.C., van den Born, G.J., Gerlagh, R., Krol, M.S., Toet, A.M.C. and de Vries, H.J.M., 1996. *Baseline scenarios of global environmental change*. Global Environ. Change, 6: 261-303.

Capros, 1998. Note on the costs for the EU of meeting the Kyoto target, preliminary analysis, NTUA, Athens, April 1998.

COHERENCE, 1998. *Economic evaluation of quantitative objectives for climate change. Contribution of non- CO_2 greenhouse gases to the EU Kyoto target: evaluation of the reduction potential and costs,* draft report prepared for the Commission, October 1998.

CRU, 1998. Web site (www.cru.uea.ac.uk/cru/data/temperat.htm), Climate Research Unit University of East Anglia, UK.

Ecofys, 1998a. *Reduction of the emissions of HFCs, PFCs and SF6 in the EU*, draft report prepared for the European Commission, October 1998.

Ecofys, 1998b. *Emission reduction potential and costs for methane and nitrous oxide emissions in the EU*, draft report prepared for the European Commission, June 1998.

EEA 1999a. *Overview of national programmes to reduce greenhouse gas emissions.* Prepared by the European Topic Centre on Air Emissions for the European Environment Agency, Copenhagen. Draft February 1999.

EEA, 1999b. *Environment and European Enlargement. Appraisal of future trends. Air Emissions.* Environmental issues n.8. European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EFI, 1998. *Case study on CO_2 sinks of forests*, European Forest Institute report for the European Environment Agency, draft, October 1998.

European Commission, 1996a. Report from the Commission under Council Decision 93/389/EEC. *Second evaluation of national programmes under the monitoring mechanism of Community CO_2 and other greenhouse gas emissions. Progress towards the Community CO_2 stabilisation target.* COM (96) 91 final.

European Commission, 1996b. *Strategy paper for reducing methane emissions*, COM(96) 557.

European Commission, 1997a. *Communication on the energy dimension of climate change.* COM(97) 196.

European Commission, 1997b. *Communication on Climate Change – the EU approach to Kyoto*, COM(97) 481.

European Commission, 1997c. *Communication on the nuclear industries in the European Union*, COM(97) 401.

European Commission, 1998a. *Proposal for a Council Decision amending Decision 93/389/EEC for a monitoring mechanism of Community CO2 and other greenhouse gas emissions*, COM(98) 108.

European Commission, 1998b. *Communication on Energy efficiency in the European Community – towards a strategy for the rational use of energy*, COM(1998) 246.

European Commission, 1998c. *Communication on transport and CO_2 – towards an EU approach*, COM(1998) 204.

European Commission, 1998d. *Communication on implementing the Community strategy to reduce CO_2 emissions from cars: an environmental agreement with the European automobile industry* COM(1998) 495.

European Commission, 1998e. *Communication on Climate Change – Towards and EU Post-Kyoto Strategy*, COM(98) 353.

European Commission, 1998f. *Second Communication from the European Community under the UN Framework Convention on Climate Change*, Draft, May 1998.

European Commission, 1999 (forthcoming). *Economic Assessment of Priorities for a European Environmental Policy Plan (working title).* Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environment, Nuclear Safety and Civil Protection).

European Community, 1993. *Council Decision (93/389/EEC) of 24 June 1993 for a monitoring mechanism of Community CO_2 and other greenhouse gas emissions.*

European Community, 1996a. *Council conclusions on climate change*, June 1996.

European Community, 1996b. *Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC).*

European Community, 1998a. *Council conclusions of climate change*. June 1998.

European Community, 1998b. *Community strategy on climate change and negotiations with industry on carbon dioxide emissions from motor vehicles*, EU Environment Council conclusions, 23 March 1998.

Eurostat, 1998. *Carbon dioxide emissions from fossil fuels 1985-1996*, Commission of the European Communities, Eurostat.

Eyre, Downing, Hoekstra, Rennings and Tol, 1998. *ExternE Global Warming; subtask Global Warming Damages.*

Hadley Centre, 1998a. Website (http://www.meto.govt.uk/sec5/), Hadley Centre for Climate Prediction and Research The Met. Office, UK.

Hadley Centre and The Met. Office, 1998b. *Climate Change and its impacts*, The Met. Office and DETR, UK, November 1998.

Hadley Centre, CRU and The Met. Office, 1998c. *Climate Change Scenarios for the United Kingdom.* UK Climate Impacts Progamme, Technical Report No. 1, UK, September 1998.

IPCC, 1996. *Second Assessment Climate Change 1995, Report of the Intergovernmental Panel on Climate Change. 'The Science of Climate Change', Contribution of Working Group I. 'Impacts, Adaptations and Mitigation of Climate Change', Contribution of Working Group 2. 'Economic and Social Dimensions of Climate Change', Contribution of Working Group 3,* WMO, UNEP. Cambridge University Press.

IPCC, 1997a. *The Regional Impacts of Climate Change, An Assessment of Vulnerability,* R.T. Watson, M.C. Zinyowera, R.H. Moss. Cambridge, Cambridge University Press.

IPCC, 1997b. *Stabilisation of atmospheric greenhouse gases: physical, biological and socio-economic implications*, IPCC Technical paper 3, WMO, UNEP.

Krause, F., Bach, W. and Koomey, J., 1989. *Energy Policy in the Greenhouse, Volume 1: From Warming Fate to Warming Limit.* Benchmarks for a Global Climate Convention. International Project for Sustainable Energy Paths. El Cerrito, California.

Leemans, R. and Hootsman, R., 1998, *Ecosystem vulnerability and climate protection goals*, Report no. 481508004, RIVM, the Netherlands.

March Consulting Group, 1998. *Opportunities to minimise emissions of hydrofluorocarbons from the EU*, draft report prepared for the Commission (DGIII), UK, September 1998.

Martin, P.H., *et. al.*, 1998. *A New Estimate of the Carbon Sink Strength of EU Forests integrating Flux Measurements, Field Surveys, and Space Observations*, *AMBIO*, 27 (7), 582–584.

RIVM, 1998. *IMAGE 2.1 An Integrated Assessment Model for Global Environmental Change* and *'Global Change Scenarios from IMAGE 2.1'* (CDROM), RIVM, The Netherlands.

UBA Germany, 1998. *Analyses of the implementation of a Protocol to the UNFCCC: impacts of activities and regulations of the EU on the emissions of greenhouse gases*, Report by Ecologic for UBA Germany, June 1998.

UNECE, 1996. *Energy Balances for Countries in Transition 1993, 1994-2010 and Energy Prospects in CIS-Countries.*

UNFCCC, 1997. *Kyoto protocol to the United Nations Framework Convention on Climate Change.* FCCC/CP/1997/L.7/Add.1, December 1997.

UNFCCC, 1998. *Second compilation and synthesis of second national communications from Annex I Parties*, 6 October 1998, FCCC/CP/1998/11/Add.1 and Add.2 and *Summary compilation of annual greenhouse gas emissions inventory data from Annex 1 Parties,* 31 October 1998, FCCC/CP/1998/INF.9, UNFCCC secretariat.

UNFCCC, 1999. *Report of the Conference of Parties on its fourth session, held at Buenos Aires 2-14 November 1998, part 2: Action taken by the conference of Parties*, FCCC/CP/1998/16/Add.1.

WBGU, 1998. *The accounting of biological sources under the Kyoto Protocol – a step forward or backwards for global environmental protection*, German Advisory Council on Global Change Special Report, 1998.

3.2. Ozone-depleting substances

Main findings

International regulations have led to significant reductions in production, usage and emissions of ozone-depleting substances (ODSs), despite smuggling and illegal production, although large amounts of CFCs and halons are still in use; there is now a challenge to assist developing countries in meeting their commitments to phase out ODSs.

The total potential chlorine concentration in the lower atmosphere has decreased since its maximum in 1994, mainly due to the rapid phase-out of methyl chloroform, although the atmospheric concentration of halons is still increasing contrary to earlier expectations.

Increased levels of UV radiation will continue, with damaging effects for humans and ecosystems; full recovery of the ozone layer is unlikely before 2050.

There is some limited scope for additional measures to speed up ozone-layer recovery, mainly by eliminating global halon emissions.

1. Depletion of the ozone layer

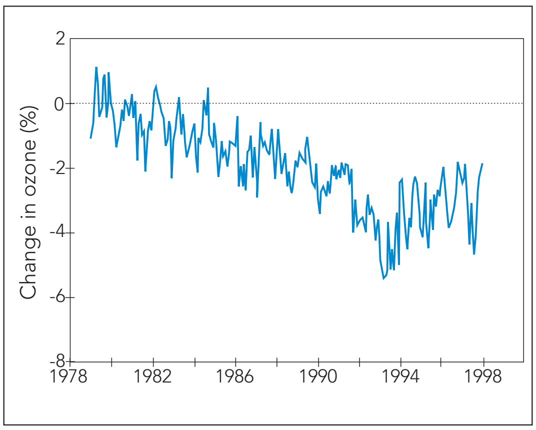
1.1. Total ozone decreased since 1980

Depletion of the stratospheric ozone layer, leading to increases in UV-B radiation, was initally a matter of scientific observation, but subsequently became the focus of pioneering initiatives for global environmental cooperation, as realisation grew of the dangers to human health and eco-systems (see EEA, 1998; Box 3.2.1; for an overview of current scientific understanding of ozone depletion, see European Commission, 1997, and WMO, 1999).

Damage to the ozone layer started in approximately 1980, and was initially observed in the polar regions. Satellite measurements show several years with very low total ozone values in the 1990s, but the rate of decline has slowed in recent years (Figure 3.2.1). The largest decreases in total ozone of 60-70% – known as the ozone hole – occur every year in spring over Antarctica (September-November); in 1998 the decrease in ozone in the Antarctic started earlier than usual (in mid-August) and reached a record size covering an area of 27 million km², the size of Europe. Since the beginning of the 1990s a similar phenomenon has been observed in the Arctic, with decreases of 30-40% in the ozone layer in spring (February – March) (Figure 3.2.2), although there is considerable year-to-year variability in the Arctic stratosphere. Very low ozone values occurred over the Arctic in the spring of 1993, 1996 and 1997. Higher values were recorded in March 1998, although these were still significantly lower than the values in 1980.

Ozone depletion is also seen, albeit to a lesser extent, in midlatitudes (25-60°). Between 1979 and 1991 there were downward trends in column ozone of 4.0%, 1.8% and 3.8% per decade, respectively, for northern midlatitudes in winter/spring; northern midlatitudes in summer/fall; and southern midlatitudes year round. The lowest values occurred in 1992 and 1993 exacerbated by the eruption of Mt. Pinatubo in the Philippines in June 1991. Since 1991 the linear trend observed during the 1980s has not continued, but rather total column

Percentage change in total ozone averaged over 60°S to 60°N — Figure 3.2.1



Note: Effects associated with the seasonal cycle (1 year), solar cycle (12 years) and the quasi-biennial oscillation (2 years) have been filtered out. The decrease in 1992-1993 is caused by the eruption of Mt. Pinatubo in 1991.

Source: WMO, 1999

Box 3.2.1. Background

Formation and destruction of the ozone layer
The stratospheric ozone layer is a diluted veil of ozone gas that stretches from about 10-40 km above the ground. The stratosphere contains approximately 90% of the ozone in the atmosphere, with the remaining 10% in the troposphere. Ozone is produced in the upper part of the stratosphere by short-wave radiation from the sun, while radiation with somewhat longer wavelengths and chemical reactions can dissociate it again, creating a dynamic balance between production and loss of ozone. Most of the ozone in the stratosphere is produced above the tropics where the sunlight is the most intense. Large scale circulation transports the ozone towards the poles causing a maximum in total ozone (the amount of ozone in a column that reaches from the ground to the top of the atmosphere) in the spring and a minimum in the late autumn.

Man-made chemicals are the cause of ozone depletion
Man-made ozone depletion is caused by chlorine and bromine, but not all compounds with chlorine and bromine affect the ozone layer to the same extent. A large number of compounds react with other gases in the troposphere and the halogen atoms are removed by rain and do not reach the stratosphere. The longer the atmospheric lifetime of a compound the more of it can enter the stratosphere. The chlorine and bromine compounds that cause significant depletion of the ozone layer are CFCs, carbon tetrachloride (CCl_4), methyl chloroform (CH_3CCl_3), HCFCs, HBFCs and halons, all of which are completely of anthropogenic origin. They are used as coolant, aerosol propellant, cleaning agent, fire extinguisher, and in the production of foam insulation. The ozone layer can also be depleted by methyl chloride (CH_3Cl) which comes mainly from the oceans and methyl bromide (CH_3Br) which comes from natural and anthropogenic sources. Other substances such as nitrous oxide and and water vapour also participate in the process of ozone destruction.

The use of CFCs and halons, in particular, has led to an increase in the concentration of chlorine and bromine in the stratosphere. These compounds are chemically very stable and are not degraded in the troposphere. In the stratosphere they are dissociated by the short-wave radiation from the sun and release chlorine and bromine, which then take part in chemical chain reactions. A single chlorine or bromine atom can destroy many thousands of ozone molecules before being removed from the stratosphere. The natural balance between production and loss of ozone is therefore shifted towards a lower concentration of ozone.

Polar ozone depletion
The large depletion of stratospheric ozone in polar regions is caused by the combination of man-made chlorine and bromine compounds, extremely low temperatures and solar radiation. Reactions on the surface of polar stratospheric cloud (PSC) particles, which form at low temperatures, start a series of chemical reactions which cause a large destruction of ozone molecules in polar spring.

Other effects which can affect ozone depletion
Large volcanic eruptions, as from Mt. Pinatubo in 1991, can cause an extra depletion of ozone for several years.

Climate change may cause an increase in temperature in the troposphere and a decrease in the stratosphere. This may delay the recovery of the ozone layer in the Arctic and Antarctic, due to an increase in clouds in the stratosphere.

The greenhouse gases methane and nitrous oxide may affect stratospheric ozone by chemical interactions. This may have a positive or negative effect.

The impact of aircraft on the observed ozone depletion is unknown. The effect of a possible future fleet of supersonic aircraft flying in the stratosphere on the ozone layer could be slightly negative or positive, but should not exceed a few percent (Brasseur *et al.*, 1998).

Source: EEA, 1998; European Commission, 1997; Brasseur et al., 1998; WMO, 1999

ozone has been almost constant at all midlatitudes in both hemispheres since the recovery from the Mt. Pinatubo eruption. The observed total column ozone losses from 1979 to the period 1994-1997 are about 5.4%, 2.8% and 5.0%, respectively, for northern midlatitudes in winter/spring; northern midlatitudes in summer/fall; and southern midlatitudes year round. There are also considerable regional differences in ozone changes at midlatitudes. The largest midlatitude depletion occurs over Siberia in spring and Europe in winter and spring, while North America shows relatively smaller trends in winter and spring. In summer and autumn no significant trends are observed at midlatitudes. No trend in total ozone is seen over the tropics (EEA, 1998; WMO, 1999).

Ozone depletion shows a large year-to-year variability, due to instabilities in the air circulation in the Arctic stratosphere. The 1980 graph in Figure 3.3.2 shows a pattern typical of a non-depleted ozone layer. A similar depletion of stratospheric ozone is seen in the Antarctic since the beginning of the 1980s.

1.2. Ozone depletion is caused by man-made chemicals

The ozone layer has been damaged by the use of certain chemicals; if the damage is to be reversed, these uses must cease or substitutes developed. Anthropogenic emissions of chlorine and bromine compounds are the main cause of ozone depletion at midlatitudes and in polar regions (see Box 3.2.1). The impact of a substance on the ozone layer is determined by its ozone depletion potential and by its total emission to the

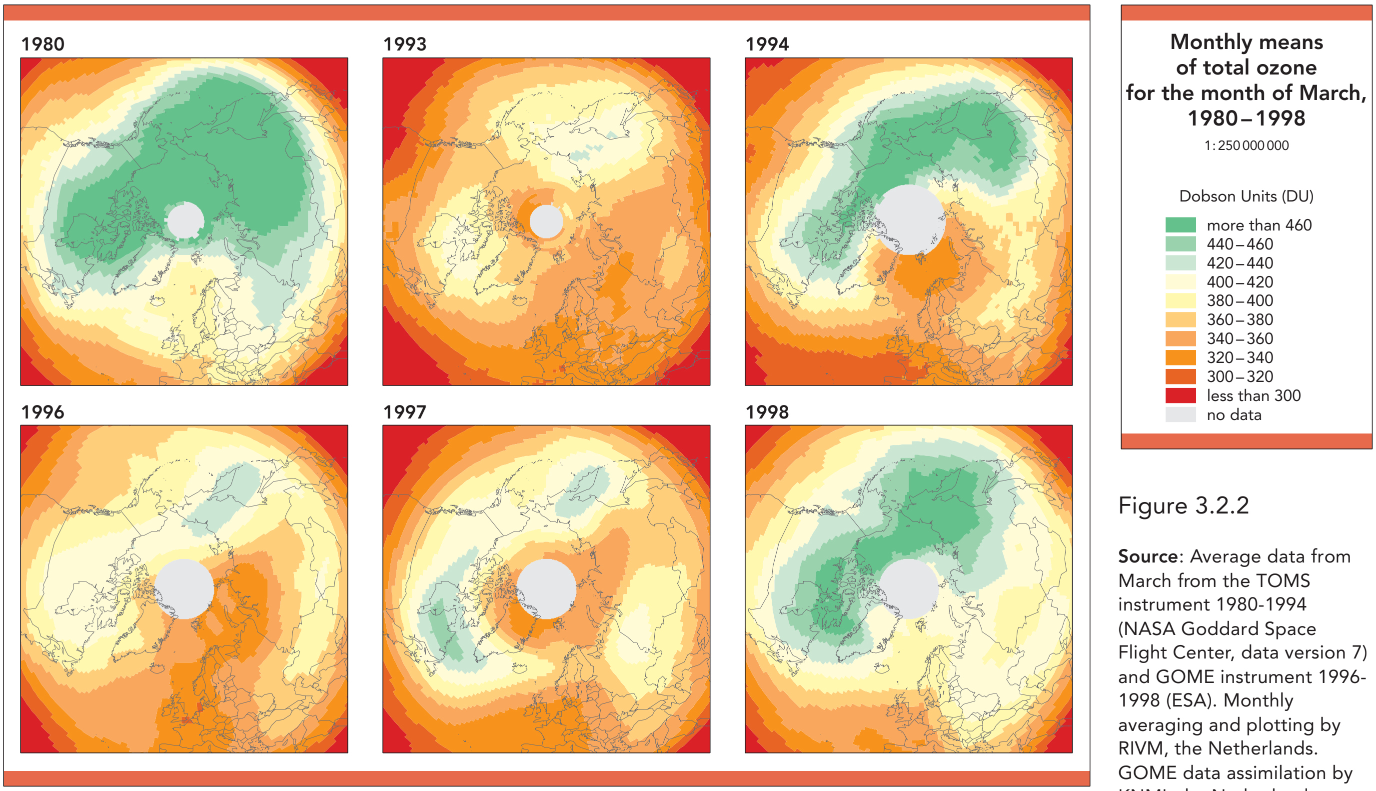


Figure 3.2.2

Source: Average data from March from the TOMS instrument 1980-1994 (NASA Goddard Space Flight Center, data version 7) and GOME instrument 1996-1998 (ESA). Monthly averaging and plotting by RIVM, the Netherlands. GOME data assimilation by KNMI, the Netherlands (Eskes *et al.*, 1999)

atmosphere. By far the largest contribution to ozone depletion comes from CFCs (WMO, 1999). In 1995 CFCs made up about 41% of the total effective chlorine+bromine in the stratosphere (natural and anthropogenic emissions). The next largest anthropogenic contributions come from carbon tetrachloride (11%) and methyl chloroform (11%). Other substances contribute less – halons about 9%, anthropogenic emissions of methyl bromide about 3%. Natural (non anthropogenic) emissions of methyl chloride and methyl bromide both contribute about 12%. HCFCs, used partly as substitutes for CFCs have a smaller effect (only about 1%), since they are largely dissociated and removed in the troposphere and only a fraction reaches the stratosphere. It should be noted, however, that CFC and its alternatives (HCFCs, HFCs) are greenhouse gases (see Chapter 3.1). The relative importance of the ODSs is expressed by their Ozone Depletion Potential (ODP). The ODP gives the impact (relative to CFC-11) of an emission of 1 kg of the substance on the depletion of stratospheric ozone (Table 3.2.1).

1.3. Progress with production and consumption of ozone-depleting substances (ODSs)

Global cooperation to protect the ozone layer has had considerable success in limiting production and consumption of damaging substances (see Section 3 below). Global production and emission of ODSs has

Ozone depletion potentials (ODPs) Table 3.2.1.

Compound	ODP	Compound	ODP
CFC-11	1.0	HCFC-123	0.012 (2)
CFC-12	0.82	HCFC-124	0.026 (2)
CFC-113	0.90	HCFC-141b	0.086 (2)
CFC-114	0.85	HCFC-142b	0.043 (2)
CFC-115	0.40	HCFC-225ca	0.017
Halon 1301	12	HCFC-225cb	0.017
Halon 1211	5.1	Methyl bromide (CH_3Br)	0.37
Halon 2402	6.0 (1)	Methyl chloride (CH_3Cl)	0.02 (3)
Carbon tetrachloride (CCl_4)	1.20	CH_2ClBr	0.15 (3,4)
Methyl chloroform (CH_3CCl_3)	0.12	$CH_2BrCH_2CH_3$	0.026 (3,4)
HCFC-22	0.034	HFCs	<0.0005 (3)

The ODP is defined as the integrated change in total ozone per unit mass emission of a specific compound, relative to the integrated change in total ozone per unit mass emission of CFC-11. The HCFCs are partly used as alternatives for CFC; they have a lower ODP but are regulated by the Montreal Protocol. HFCs are also used as alternatives; their ODP is very small and they are not regulated by the Montreal Protocol.

Source: The latest scientific values from WMO (1999). The values differ slightly from the approved values used for regulatory purpose in the Montreal Protocol. 1) UNEP, Handbook for the Montreal Protocol (1996). 2) Value corresponding with the mostly used isomer. 3) Not regulated in the Montreal Protocol (WMO, 1999). 4) Wuebbles et al., 1998.

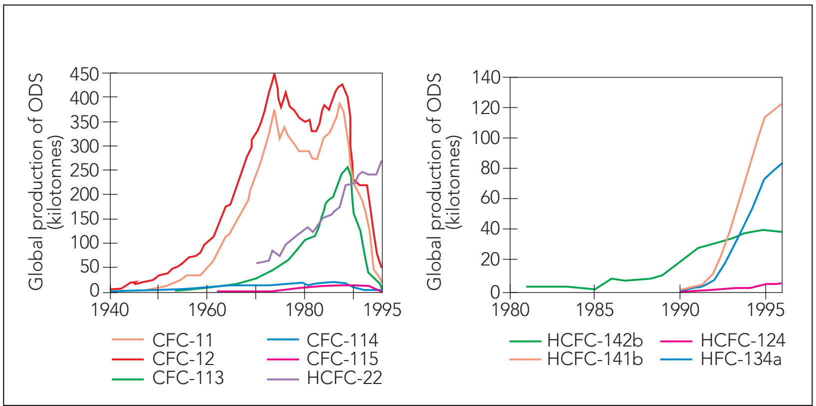
decreased sharply since the end of the 1980s as a direct result of international measures (Figure 3.2.3). Production and consumption in the European countries also show a strong decrease (Table 3.2.2 and Figure 3.2.4). (The following definitions are used in the Montreal Protocol (see below): Production = Amount produced minus what is destroyed, minus what is used entirely as feedstock; Consumption = Production plus import minus export. It is therefore possible to report a negative production or consumption.)

Production of CFCs in the major developed countries had declined by 1996 to about 7% of its maximum level at the end of the 1980s as a result of the international regulations. HCFCs and HFCs, which are partly used as alternatives to CFCs, show an increase in production. HCFC-22 was already used in the 1970s in refrigeration and is used only partly as a substitute for CFCs. During the 1990s the production of ODSs decreased at a more rapid rate than that required under the Montreal Protocol. Production shown here is based on data from chemical companies in mostly western countries. The production in developing countries was much smaller in the past few decades but has increased in recent years relative to developed countries.

Emissions of ODSs lag behind their production by months, or years, depending on their use. In between emission and production the ODS is contained in the equipment in which it is used, the so-called bank. Large amounts of halons and also CFCs are still contained in existing equipment such as fire extinguishers, refrigerators and foams. If not recovered and destroyed these ODSs will, in time, be released to the atmosphere.

Consumption of CFCs has decreased significantly in all European countries, and particularly in western Europe. Total consumption in the EU in 1986 was seven times higher than in the Accession Countries, but by 1996 the difference was approximately a factor of two higher in EU15. Consumption of halons and methyl chloroform also decreased in all countries. However, HCFC

Figure 3.2.3 **Large reductions in global production of CFCs; strong increase in HCFCs**



Source: AFEAS, 1998

Table 3.2.2. **Production of ozone-depleting substances in the EU is largely decreased (ktonnes)**

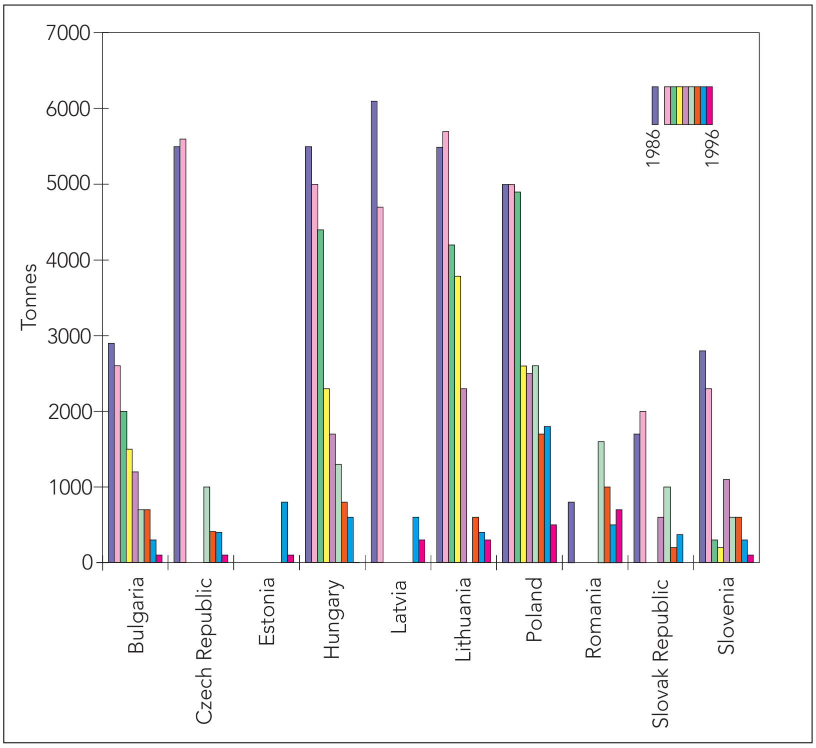
Source: European Commission, DGXI. Data before 1995 from the EU12 countries only

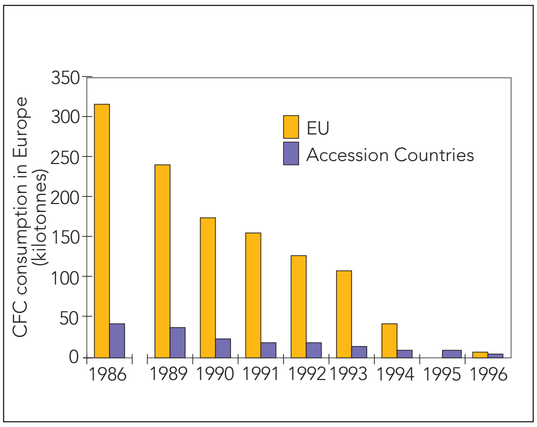
Year	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	HCFC-22	Halons	CCl_4	CH_3CCl_3
1986	203.9	167.5	56.1	8.8	6.3	n.a.	13.78	n.a.	n.a.
1989	165.1	124.1	68.0	6.3	8.9	61.2	14.15	57.96	208.8
1990	116.9	93.0	62.4	4.2	7.9	69.2	11.63	29.34	214.7
1991	115.8	78.1	54.5	3.7	7.3	63.5	10.68	13.41	182.5
1992	101.1	78.8	39.8	2.4	8.4	76.0	6.81	11.42	182.4
1993	81.7	79.3	24.7	3.6	9.4	75.2	3.48	3.74	108.0
1994	28.8	41.7	10.6	1.8	7.5	86.7	0.00	2.50	83.6
1995	8.9	21.0	0.2	0.3	0.2	95.9	0.00	4.28	n.a.
1996	12.1	19.6	0.5	0.1	0.7	102.0	0.00	0.42	n.a.

Since 1994 halons are no longer produced in the EU as a direct consequence of the Montreal Protocol and its Amendments and Adjustments. The obligation of the Montreal Protocol was to phase out production of CFCs in 1996. The tighter EU regulations require a phase-out in 1995. From 1995 onwards a limited production of CFCs is allowed for essential uses as approved by the parties to the Montreal Protocol, and for use in developing countries.

n.a. no data available or no legal basis for data collection.

Consumption of CFCs in Europe decreases — Figure 3.2.4





Note: The consumption of all 15 countries now forming the EU is included in the EU15 figure. The CFC consumption is ODP-weighted.

Source: UNEP, 1997a, 1998b

consumption, which is often used as a replacement for other ODSs, shows an increase in most countries.

1.4. Positive indications with remaining uncertainties

Measurements from ground-level monitoring networks show that the tropospheric concentration of major ozone-depleting substances (CFC-11, methyl chloroform and carbon tetrachloride) reached their maximum a few years ago and are now decreasing (Figure 3.2.5) (Midgley *et al.*, 1998; Simmonds *et al.*, 1998a). The concentration of CFC-12 is still increasing but the rate of increase has declined. The concentration of halons (the major anthropogenic bromine compounds used as fire extinguishers) is still increasing (Butler *et al.*, 1998). Whilst the production of halons was phased out in developed countries in 1994, the continuing increase in concentration is probably caused by emissions from halons in existing applications, mostly in developed countries and from newly produced halons in developing countries (SORG, 1996; WMO, 1999).

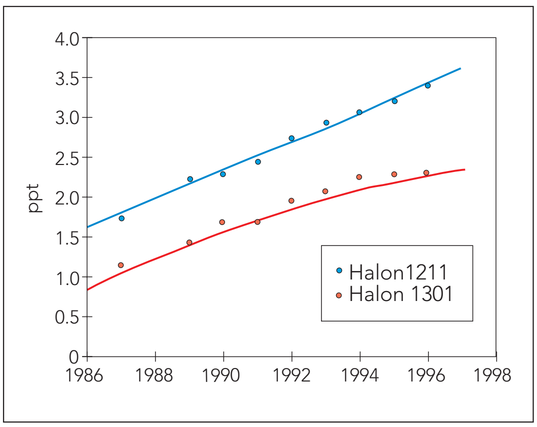
The total potential chlorine+bromine concentration, a measure for the total potential depletion of the ozone layer, reached its maximum in 1994 and is now declining. The atmospheric concentration of several HCFCs and HFCs, which are used to replace CFCs for refrigeration, foam and solvents, are shown to be rapidly increasing (Simmonds *et al.*, 1998b), although the concentrations are still low (below approximately 10 ppt).

2. Action to protect the ozone layer

2.1 The Montreal Protocol

Measures to protect the ozone layer, beginning with the 1985 Vienna Convention, represent a pioneering global environmental initiative, establishing a system of world-wide regulation of production and use of the

Measured in the troposphere; several CFC concentrations have peaked, but halons still increase — Figure 3.2.5



The potential chlorine+bromine is the sum of all chlorine and bromine atoms in the troposphere.

Source: ALE/GAGE/AGAGE (Prinn *et al.*, 1998) and NOAA/CMDL (Elkins *et al.*, 1998) networks.

chemicals which damage the ozone layer. The Montreal Protocol on Substances that Deplete the Ozone Layer (1987) established a schedule for the phase-out of CFCs and halons, and this was speeded up by the 1992 Copenhagen Amendments which also set limits on the production of HCFCs.

The current control measures in the Montreal Agreement (of September 1997), which is now awaiting ratification, are shown in Table 3.2.3. There are controls on the production and consumption of classes of ozone-depleting substances (CFCs, halons, HCFCs, HBFCs, carbon tetrachloride, methyl chloroform, and methyl bromide) and within a class, substances are weighted by their ozone depletion potentials (ODPs).

All EU Member States as well as the European Community and most of the Accession Countries have ratified the Copenhagen Amendments (Table 3.2.4), and consumption of ODSs in the remaining Accession Countries is in line with the Copenhagen Amendments (see Figure 3.2.4). In the Montreal Protocol and its amendments and adjustments the distinction is made with respect to the control measures, between developing and developed countries. Any developing country whose annual consumption of CFCs and halons is less than 0.3 kg per capita is entitled to a moratorium of 10 years to comply with the control measures required of developed countries. Romania and Slovenia are categorised as developing countries for the Montreal Protocol. In developed countries very limited production and consumption of ODSs is allowed for essential uses. Production is also permitted to meet the basic domestic needs of developing countries, up to a maximum of 15% of the base level production (of CFCs, carbon tetrachloride, methyl chloroform, halons and methyl bromide), defined as the production in a reference year (e.g. 1986 for CFCs in developed countries), to which all commitments apply. Developing countries must phase out CFCs, halons and carbon tetrachloride in 2010 and methyl chloroform in 2015. Regulation of HCFCs begins in 2016 with complete phase-out by 2040. The production of methyl bromide has to be frozen in 2002 and phased out by 2015.

The European Union Council of Ministers has adopted a common position on a proposed Council Regulation (Table 3.2.5) to set limits on the production of HCFCs (the Montreal Protocol only limits the consumption of HCFCs), to impose tighter controls on the consumption and use of HCFCs, and on the production and consumption of methyl bromide (European Commission,

Table 3.2.3. **Reduction and phase-out schedules of ODSs in developed countries**

Source: Montreal Amendments, Sept. 1997; UNEP, 1997b; EU Regulation 3093/94/EC

Compound	Year	Montreal Protocol
Halons	1994	100% phase-out
CFCs, carbon tetrachloride, methyl chloroform	1996	100% phase-out (phase-out of CFCs and carbon tetrachloride by 1995 in EU)
HBFCs	1996	100% phase-out
HCFCs	1996	freeze on calculated consumption at 2.8% of CFC consumption in 1989 plus total HCFC consumption in 1989 (calculated at 2.6% of CFC consumption in EU)
	2004	35% reduction from above freeze limit
	2010	65% reduction
	2015	90% reduction
	2020	phase out with a 0.5% tail until 2030 to service existing equipment (phase-out consumption by 2015 in the EU)
methyl bromide	1995	freeze on production and consumption at 1991 levels
	1999	25% reduction from above (25% reduction within 1998 in the EU)
	2001	50% reduction from above freeze limit
	2003	70% reduction
	2005	100% phase-out

1998). The sale and use of CFCs, halons, carbon tetrachloride, methyl chloroform and HBFCs would also be prohibited, tighter import and export controls are proposed for ozone-depleting substances.

The challenge facing developed countries and the EU is to assist developing countries in achieving their commitments. Several developing countries are reporting increased national consumption of ODSs in spite of various assistance programmes in effect.

2.2. Impact of methyl bromide on ozone layer still unclear

The Amendments to the Montreal Protocol of September 1997 established the first international regulation on methyl bromide (CH_3Br), specifying a schedule for the phasing out of its production (see Table 3.2.3). Methyl bromide has both natural and anthropogenic sources. When emitted, a large part is broken down in the troposphere. The rest reaches the stratosphere where the bromine is released and contributes to ozone depletion. The atmospheric concentration of methyl bromide is very low – between 9 and 10 ppt – with no observed trend. While the global budget of most ODSs is relatively well known, large uncertainties still exist in the sources and sinks of methyl bromide. Sinks are the different processes that remove the compound from the atmosphere or transform it into a different compound. The size of the identified sources and sinks (Table 3.2.6) are highly uncertain and the total identified sinks are much larger than the total identified sources. Identified sources thus constitute only about 60% of the identified sinks (WMO, 1999). Methyl bromide is now considered less important as an ozone-depleting substance than estimated at the time the Copenhagen amendment was negotiated. It is estimated that anthropogenic emissions of methyl bromide contribute about 3% to total ozone depletion, while natural emissions contribute about 12% (WMO, 1999). The ODP of methyl bromide is within an uncertainty range of 0.2-0.5.

Global production of methyl bromide was 62.5 ktonnes in 1996. The global use was 53.0 ktonnes, of which 12.9 ktonnes (24%) was within the EU. Only a small amount of this is produced in Europe, the rest is imported (Table 3.2.7).

2.3. The Ozone layer is expected to recover in the future

Full recovery of the ozone layer is expected to occur when the effective chlorine level in

Most European countries have ratified the Montreal Protocol and its Amendments (as of January 1999) Table 3.2.4.

	Montreal 1987	London 1990	Copenhagen 1992
European Community + 15 MSs	X	X	X
Iceland	X	X	X
Liechtenstein	X	X	X
Norway	X	X	X
Bulgaria	X	X	X
Czech Republic	X	X	X
Estonia	X		
Hungary	X	X	X
Latvia	X	X	X
Lithuania	X	X	X
Poland	X	X	X
Romania(1)	X	X	
Slovakia	X	X	X
Slovenia(1)	X	X	X

(1) Commitments are under the category of Developing Country for the Montreal protocol.

Source: Update from UNEP, 1996

Tighter proposed controls in the EU Table 3.2.5.

Compound	Year	Commission proposal
CFCs, halons, carbon tetrachloride, methyl chloroform, HBFCs		Production and use prohibited
HCFC production	2000	freeze at 1997 level
	2008	65% reduction from 1997 level
	2014	80% reduction
	2020	85% reduction
	2026	production prohibited
HCFC consumption	1999	freeze on calculated consumption at 2.6% of CFC consumption in 1989 plus total HCFC consumption in 1989
	2001	freeze on calculated consumption at 2.0% of CFC consumption in 1989 plus total HCFC consumption in 1989
	2002	10% reduction from 2001 level
	2003	65% reduction
	2004	70% reduction
	2008	95% reduction
	2015	100% phase-out
methyl bromide	1999	25% reduction of production and consumption from 1991 levels
	2001	100% phase-out, with possible exemptions for critical uses

Source: European Commission, 1998 COM (98)398

Table 3.2.6. A best estimate of the global methyl bromide budget is not in balance (ktonnes/year)

	Sources (range)	Sinks (range)
Ocean	56 (5 to 130)	-77 (-37 to -133)
Soils		-42 (-214 to -10)
Atmosphere		-86 (-107 to -65)
Gasoline	5 (0 to 10)	
Fumigation of soils, food and structures	41 (33 to 48)	
Biomass burning	20 (10 to 40)	
Totals	122 (48 to 228)	-205 (-358 to -208)

Source: Based on analysis of scientific data (WMO, 1999); the individual numbers have large uncertainty ranges. The net ocean flux ranges from -3 to -32 ktonnes/yr.

Table 3.2.7. Reported production of methyl bromide in 1996 by country (ktonnes)

	Production of methyl bromide
US	26.87
Israel	23.68
Japan	5.02
France	4.46
Ukraine	1.40
China	1.10
Romania	0.018
Total	62.54

Source: Based on data reported by the countries to UNEP (1998b). Not all countries have reported all their data.

the stratosphere falls below the 1980 level of 2 ppb (the effect of the ODSs upon ozone depletion is measured in terms of 'effective stratospheric chlorine', which combines the effects of chlorine and bromine compounds in the stratosphere using the ozone depletion potential for each chemical). The effective stratospheric chlorine is expected to peak before the year 2000 (WMO, 1999) (Figure 3.2.6). The decrease from 2000 to 2020 is only by 10%. Consequently, the depletion effect will remain above the 1993 level for another 20 years.

Nevertheless, with the estimated future production of ODSs, and assuming full compliance of the latest Amendments to the Montreal Protocol, the ozone layer should start to recover. Full recovery will take at least another 50 years.

Based on past emissions and their projected trends, the total ozone minimum is estimated to occur within the current or next decade (Figure 3.2.7: the calculations assume a -4.4%/decade trend in total ozone over Europe – see WMO, 1999, De Gruijl *et al.*, 1993; De Gruijl and van der Leun, 1994). Assuming that the observed loss in total ozone is due entirely to anthropogenic emissions, it can be expected that the minimum in total ozone and maximum change in surface UV will be reached in 1999. Interactions between ozone depletion and climate change, direct effects of greenhouse gases, changes in stratospheric temperatures and changes in aerosols and cloud cover can all affect the future ozone layer and surface UV radiation, and may result in a delay or acceleration of the recovery of the ozone layer.

In the coming two decades, the ozone layer is likely to be in its most vulnerable state. The temperature in the stratosphere has decreased over recent decades as a result of ozone depletion and increased levels of greenhouse gases. Continued high chlorine levels and low temperatures in the stratosphere could delay the recovery of the ozone layer, especially in polar regions (Shindell *et al.*, 1998).

With respect to future prospects, the baseline scenario shows the effective stratospheric chlorine assuming compliance with the latest amendments of the Montreal Protocol (see Figure 3.2.6). This scenario starts with the reported production of ODSs and applies the regulations for developed and developing countries separately. (For developing countries, the maximum production estimated by UNEP has been used – see UNEP, 1994b; WMO, 1999). Under this baseline scenario, full recovery would probably be reached by around 2050.

Recovery is brought forward in the 'Zero production' scenario. With a global cessation in production of all ODSs from the beginning of 1999, although certain emissions would still continue, effective chlorine+bromine levels would fall off at a faster rate. Full recovery would be expected in 2043.

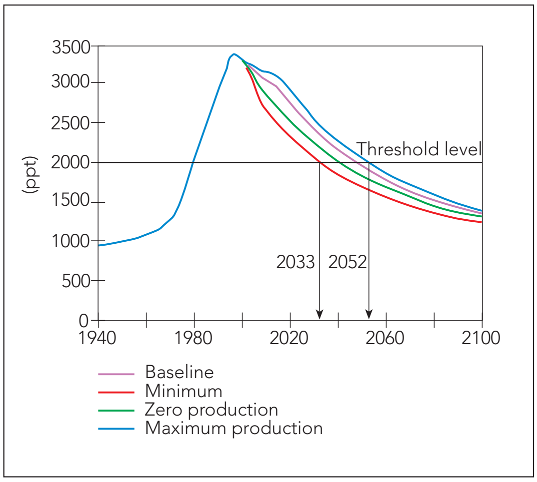
The 'minimum' scenario portrays effective stratospheric chlorine trends assuming no emissions of any ODSs from 1999 onwards. It represents the lowest limit of effective stratospheric chlorine governed entirely by natural processes. This most favourable scenario provides an estimate of the earliest possible recovery year at about 2033.

In the 'maximum production' scenario full recovery is postponed to the maximum extent consistent with existing commitments. The Montreal Protocol allows a limited production of ODSs in developed countries after phase-out, to meet the basic domestic needs of developing countries. If this production were at the maximum level (15% of the 1986 base-level production for CFCs in developed countries), recovery would be delayed until about 2052.

There are of course many other possible scenarios, depending on the rate at which production and use of the various substances are phased out in developed and developing countries. This means that, for a specific date within the possible range, there can be trade offs between policy options.

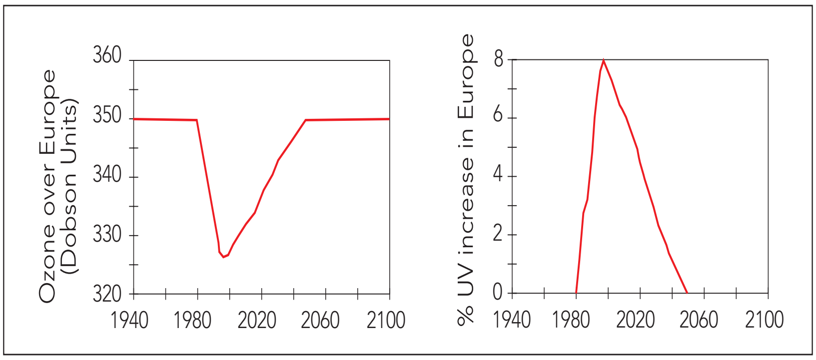
Additional control measures should influence the future ozone layer, although by amounts generally smaller than already anticipated under current regulations. The largest potential beneficial effects may be attained by eliminating global halon emissions and HCFC production (WMO, 1999). Halons are used mostly in fire extinguishers and, although production in developed countries has stopped, large quantities are still present in existing equipment. When not destroyed, these quantities will eventually be released to the atmosphere. It should be recognised, however, that technical and economic factors make the destruction of halons difficult without inadvertent partial releases to the atmosphere (UNEP, 1998a). Absolute cessation of CFCs, carbon tetrachloride and methyl bromide production would provide smaller gains since production has already been greatly reduced, while smuggling of CFCs may adversely affect future ozone recovery.

Potential recovery of the ozone layer modelled Figure 3.2.6



Source: WMO, 1999

Good news for the future, but vulnerability in the short term Figure 3.2.7

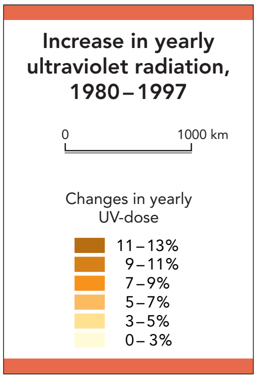


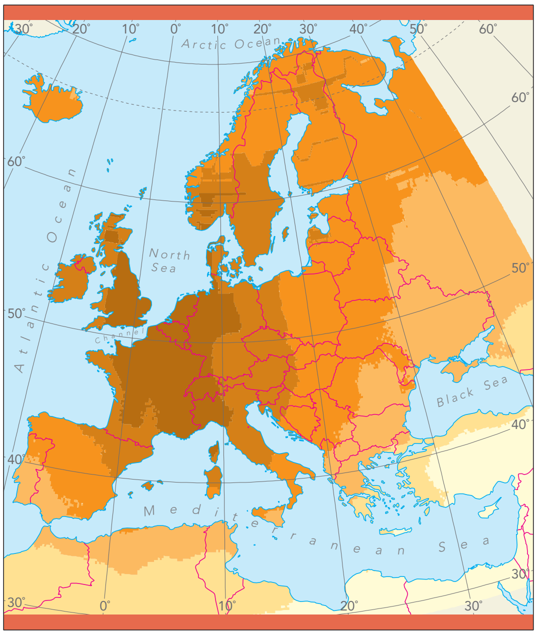
Source: The effective chlorine scenario is from WMO, 1999; the method of calculation is from Slaper *et al.*, 1996.

2.4. Smuggling of CFCs may delay the recovery of the ozone layer

Since the prohibition of CFCs in 1996 (1995 in the EU), CFC smuggling has become a lucrative business, yielding enormous profits. CFCs are still allowed to be produced for use in developing countries and for some essential uses (e.g. metered dose inhalers for people with asthma). Illegal imports of CFCs, such as for air conditioners in cars, are known to take place for example on the basis of custom interdiction reports both in Europe and in the US. The NGO Environmental Investigation Agency (EIA, 1997) estimates that illegal trade in CFCs currently amounts to some 30 000 tonnes per year of which between 6 000 and 20 000 tonnes may occur in the EU; 30 000 tonnes equals 11% of the global production of CFCs in 1995. CFCs are still allowed to be produced (until 2010) in developing countries and in developed countries, for use in developing countries.

If continued at the current estimated rate, illegal CFC production will delay the recovery of the ozone layer by a few years. It may cause an increase in the UV related health and environmental effects comparable in size (but with opposite sign) to the latest revision of the Montreal Protocol in September 1997 (some additional limits on methyl bromide), but much smaller than what has already been achieved by previous Amendments of the Montreal Protocol (WMO, 1999). Illegal production and smuggling of halons, used in fire extinguishers, may cause more harm to the ozone layer due to its larger Ozone Depletion Potential (see Table 3.2.1), but the size of this production is highly uncertain.



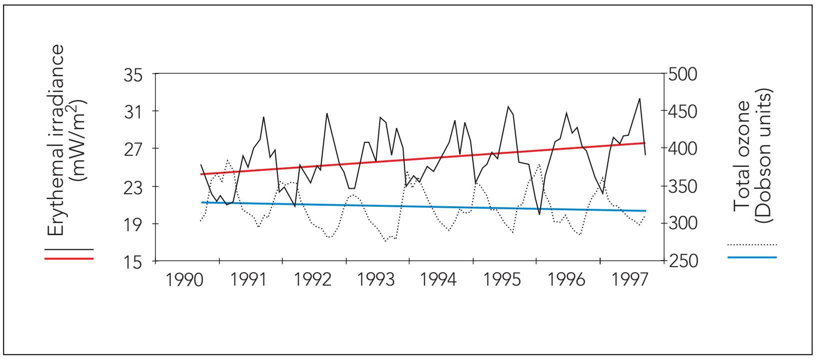


Map 3.2.1

* The increase (%) from 1980 to 1997 in erythemal UV radiation (causing the skin to turn red) is calculated using observed total ozone values from the TOMS satellite instruments and assuming clear sky conditions.

Source: Update from Europe's Environment, EEA, 1998

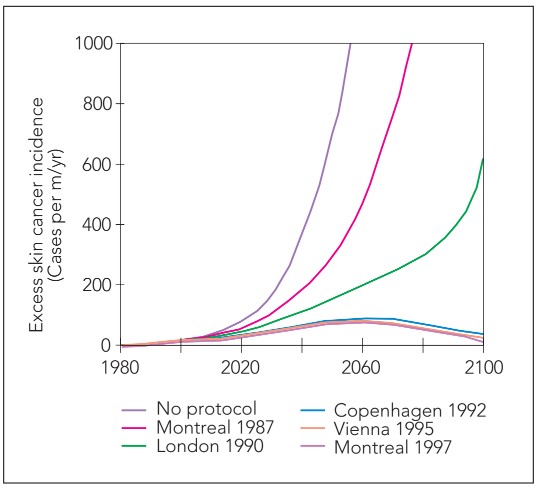
Figure 3.2.8 **Long-term change in measured total ozone and erythemal UV radiation at Thessaloniki based on clear sky measurements at a solar zenith angle of 63°**



Source: Zerefos *et al.*, 1998

Figure 3.2.9 **Montreal Protocol avoided a large increase in skin cancer**

Source: Update from Europe's Environment, (EEA, 1998), with scenarios from WMO, 1999



3. The effects of ozone depletion

A thinning of the ozone layer will tend to increase the amount of UV radiation reaching the earth's surface (Kerr and McElroy, 1993; WMO, 1999). The result can be damage to human health, including skin cancer, eye cataracts, and suppression of the immune system. Marine and terrestrial ecosystems can also be affected by UV radiation (UNEP, 1994a), and there is evidence of reduced production of phyto plankton, the basis of the ocean's food chain, in the Antarctic during ozone hole conditions (Smith *et al.*, 1992).

For Europe, the increase in UV is estimated to be largest over Northwest Europe (Map 3.2.1), associated with large depletion in total ozone (EEA, 1998). Deriving long term trends in UV radiation directly from measurements is difficult, due to the short time series and difficulties with calibration (WMO, 1994, 1999). Moreover, surface UV radiation is influenced by other factors, such as ozone in the troposphere, clouds and particles. Estimates from satellites show increases at northern mid-latitudes of 3-4% per decade and of 3-9% per decade for southern mid-latitudes (Herman *et al.*, 1996). UV increases of a few hundred percent have been observed under the Antarctic ozone hole in October (WMO, 1999).

Long-term measurements of UV radiation with high spectral resolution are scarce. One of the longest time series of spectral UV measurements is available from Thessaloniki, Greece. The data collected (Figure 3.2.8) shows a decrease in total ozone of 4.5%/decade from 1991 to 1998 accompanied by an increase in erythemal UV radiation of 19%/decade. It is estimated that about 4-5%/decade increase in UV radiation can be attributed to the observed change in stratospheric ozone and the rest to changes in other factors, for example the strong increase in local air pollution during the 1990s (Zerefos *et al.*, 1998).

International initiatives to protect the ozone layer are – thus far – a success story. The estimated benefits of the Montreal Protocol greatly exceed its costs (Box 3.2.2). In a hypothetical situation without the benefit of international regulations to protect the ozone layer, there would probably be a tremendous increase in skin cancer in the future (Slaper, *et al.*, 1996) (Figure 3.2.9). At present an incidence of about 1 100 cases per million per year is estimated for Northwest Europe. The total incidence of skin cancer could have quadrupled in Europe by the year 2100 with no intervention, or doubled with only the benefit of the original 1987 Montreal Protocol. Provided that the measures currently in force are fully implemented, the additional cases of skin cancer caused by ozone depletion will show a maximum of 78 cases per million per year around 2055. Thus, because of the time lags involved, skin cancer incidence is not expected to decline until about the middle of the 21st century.

Under the baseline scenario, additional accumulated cases of skin cancer in Northwest Europe from now until the end of the 21st century are estimated at 5 000 cases per million (European Commission, 1999). With the maximum production scenario the estimate is increased by 600 cases per million people. In the event that global ODS production ceased in 1999, an estimated 600 cases per million of skin cancer could potentially be avoided in Northwest Europe. With zero emissions in 1999, this potential avoidance could reach 1400 cases per million.

Box 3.2.2. Benefits

Montreal Protocol benefits overwhelm the costs
The global benefits of the Montreal Protocol consist of health benefits (avoided cases of skin cancer, cataracts) and reduced economic damage to fisheries, agriculture and materials. Health benefits are not translated into economic benefits. The costs of implementing the Protocol involve the full range of costs associated with eliminating the use of ODSs. The costs are broken down in developed and developing countries. The estimated global costs and benefits extend over the whole range of ozone depletion (70 years). The excess skin cancer cases and associated fatalities will not stop when the ozone layer has recovered (around 2050) due to the long inhibition for skin cancer to develop.

Health Benefits (global)		
Reduced cases of skin cancer	20 million	
Reduced cases of cataract	130 million	
Reduced skin cancer fatalities	335 000	
Economic Benefits		400 billion euros
Reduced fisheries damage	52%	
Reduced agricultural damage	42%	
Reduced damage to material	6%	
Costs		200 billion euros

	Developed countries	Developing countries
CFCs	31%	23%
Halons	5%	-
HCFCs	11%	3%
Methyl chloroform	17%	4%
Carbon tetrachloride (non feedstock)	2%	0.5%
Methyl bromide	3%	0.5%

Global net benefits are estimated at: 200 billion euros
(without health benefits)

The quantification of the costs and benefits has large uncertainty range and numbers should not be taken as definite.

Source: Environment Canada, 1997

References

AFEAS, 1998. Alternative Fluorocarbon Environmental Acceptability Study, *Production, Sales and Atmospheric Release of Fluorocarbons through 1996*, Grant Thornton Company, Washington, DC.

Brasseur, G.P., Cox R.A., Hauglustaine, D., Isaksen I., Lelieveld J., Lister D.,. Sausen R., Schumann U., Wahner A., and Wiesen P., 1998. European scientific assessment of the atmospheric effects of aircraft emissions. *Atmos. Environment, 32*, 2329-2418.

Butler, J.H., Montzka S.A., Clarke A.D., Lobert J.M., and Elkins J.W., Growth and distribution of halons in the atmosphere, *J. Geophys. Res., 103*, 1503-1511.

De Gruijl F.R., *et al.*, 1993. Wavelength dependence of skin cancer induction by Ultraviolet Irradiation of Albino hairless mice, *Cancer Res., 53*, 53-60.

De Gruijl, F.R. and van der Leun, J.C. , 1994. *Health Phys., 67*, 319-325.

EEA, 1998. *Europe's Environment, The Second Assessment*, European Environment Agency Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EIA, 1997. *Chilling facts about a burning issue, CFC smuggling in the European Union*, Environmental Investigation Agency, London, UK.

Elkins, J.W., Butler J.H., Hurst D.F., Montzka S.A., Moore F.L., and Thompson, T.M., 1998. Nitrous Oxide and Halocompounds Group/Climate Monitoring and Diagnostics Laboratory (NOAH/CMDL) web site (http://www.cmdl.noaa.gov/noah), Boulder, CO, updated data available on anonymous ftp site (file://ftp.cmdl.noaa.gov/noah).

Environment Canada, 1997. *Global Benefits and Costs of the Montreal Protocol on Substances that Deplete the Ozone layer,* Environment Canada, Ottawa, Canada.

Eskes, H.J., Piters, A.J.M., Levelt, F., Allaart, M.A.F., and Kelder, H.M., 1999. 'Variational assimilation of total-column ozone satellite data in a 2D lat-lon tracer-transport model', J. Atmos. Sci., in press.

European Commission, 1997. *European research in the stratosphere*, European Commission, Directorate-General XII, EUR 16986 EN, Luxembourg.

European Commission, 1998. Proposal for a Council Regulation on substances that deplete the ozone layer, submitted by the Commission on 17.08.98. COM (1998) 398 Final - 9810228 (SYN) Official Journal nº C 286198, p6.

European Commission 1999 (forthcoming). *Economic Assessment of Priorities for a European Environmental Policy Plan (working title)*. Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environment, Nuclear Safety and Civil Protection).

Herman, J.R., Bhartia, P.K., Kiemke, J., Ahmad, J., and Larko, D., 1996. UV-B increases (1979-1992) from decreases in total ozone, *Geophy. Res. Lett., 23*, 2117-2120.

Kerr, J.B., and McElroy, C.T. 1993. Evidence for large upward trends in ultraviolet-B radiation linked to ozone depletion, *Science, 262*, 1032-1034.

Midgley, P.M., McCulloch, A. and Simmonds. P.G., 1998. The phase-out of methyl chloroform and the decline in tropospheric chlorine, *Proceedings of Eurotrac Symposium, Garmisch-Partenkirchen*, Germany, April 1998, P.M. Borrell *et al.* (eds.).

Prinn, R.G., Weiss, R.F., Fraser, P.J., Simmonds, P.G., Alyea, F.N. and Cunnold, D. M., 1998. *The ALE/GAGE/AGAGE database,* DOE-CDIAC World Data Center (Email to: cpd@ornl.gov), Dataset No. DB-1001.

Shindell, D.T., Rind, D. and Lonergan, P., 1998., Increased polar stratospheric ozone losses and delayed eventual recovery owing to increasing greenhouse-gas concentrations, *Nature*, *392*, 589-592.

Simmonds, P.G., D.M. Cunnold, R.F. Weiss, R.G. Prinn, P.J. Fraser, A. McCulloch, F.N. Alyea, and S. O'Doherty (1998a) Global trends and emission estimates of CCl_4 from in-situ background observations from July 1978 to June 1996, *J. Geophys. Res., 103*, 16017-16027.

Simmonds, P.G., Doherty, S.O., Huang, J., Prinn, R., Derwent, R.G., Ryall, D., Nickless, F. and Cunnold, D., 1998b., Calculated trends and the atmospheric abundance of 1,1,1,2-tetrafluoroethane, 1,1-dichloro-1-fluoroethane, and 1-chloro-1,1-difluoroethane using automated in-situ gas chromatography-mass spectrometry measurements recorded at Mace Head, Ireland, from October 1994 to March 1997, *J. Geophys. Res., 103,* 16029-16037.

Slaper, H., Velders, J.G.M., Daniel, J.S., de Gruijl, F.R., and van der Leun, J.C., 1996. Estimates of ozone depletion and skin cancer depletion and skin cancer incidence to examine the Vienna Convention achievements, *Nature, 384,* 256-258.

Slaper, H., Velders, J.G.M. and Matthijsen, J., 1997. Ozone depletion and skin cancer incidence: a source-risk approach, pages 73-76, in BJM Ale, PM Janssen and MJM Pruppers eds. *Book of papers; RISK97,* International Conference Mapping Environmental Risks and Risk Comparison.

Smith, R.C., Prezelin, B.B., Baker, K.S., Bidigare, R.R., Boucher, N.P., Coley, T., Karentz, D., MacIntyre, S., Matlick, H.A., Menzies, D., Ondrusek, M., Wan, Z., and Waters, K.J., 1992. Ozone depletion: Ultraviolet radiation and phytoplankton biology in Antarctic waters, *Science, 255,* 952-959.

SORG, 1996. *Stratospheric Ozone 1996*, J.A. Pyle, J. Austin, M.P. Chipperfield, R.A. Cox, J.C. Farman, L.J. Gray, N.R.P. Harris, R.L. Jones, A.McCulloch, A. O'Neill, S.A. Penkett, C.E. Reeves, H.K. Roscoe, K.P. Shine, R. Toumi, and A.R. Webb; United Kingdom Stratospheric Ozone Review Group, Department of the Environment, DoE Ref. No. 96DPL0021, London, UK.

UNEP, 1994a. *Environmental Effects of Ozone Depletion: 1994 Assessment*, J.C. van der Leun, X. Tang, and M. Tevini, (eds.), United Nations Environment Programme, Nairobi, Kenya.

UNEP, 1994b. *Meeting of the Needs of Article 5 Parties for Controlled Substances during the Grace and Phase-out Periods – an Update*, United Nations Environment Programme, UNEP/OzL.Pro/WG.1/11/5, Nairobi, Kenya.

UNEP, 1996. *Handbook for the International Treaties for the Protection of the Ozone Layer, The Vienna Convention (1985), The Montreal Protocol (1987),* Fourth Edition, 36-39, Nairobi, Kenya.

UNEP, 1997a. *Production and Consumption of Ozone-depleting Substances 1986-1995*, Ozone Secretariat, United Nations Environment Programme, Nairobi, Kenya.

UNEP, 1997b. *Report of Ninth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer*, United Nations Environment Programme, UNEP/OzL.Pro.9/12, Nairobi, Kenya.

UNEP, 1998a. *Technology and Economic Assessment Panel, April 1998 Report*, United Nations Environment Programme, Nairobi, Kenya.

UNEP, 1998b. *Report of the Secretariat on Information Provided by the Parties in Accordance with Article 7 and 9 of the Montreal Protocol*, United Nations Environment Programme, UNEP/OzL.Pro.9/ImpCom/20/3, Nairobi, Kenya.

WMO, 1994. Report of the WMO meeting of experts on UV-B measurements, data quality and standardization of UV indices, *World Meteorological Organization, Global Atmosphere Watch – Report No. 95,* WMO, Geneva.

WMO, 1999). Scientific Assessment of Ozone Depletion: 1998, *World Meteorological Organization Global Ozone Research and Monitoring Project – Report No. 44,* WMO, Geneva.

Wuebbles (1998), D.J., R. Kotamarthi, and K.O. Patten, Updated evaluation of ozone depletion potentials for chlorobromomethane (CH_2ClBr) and 1-bromo-propane ($CH_2BrCH_2CH_3$), *Atmos. Environment*, in press.

Zerefos, C., Meleti, C., Balis, D., Tourpali, K., and Bais, A.F., 1998. Quasi-biennial and longer-term changes in clear sky UV-B solar irradience, *Geophys. Res. Lett., 25*, 4345-4348.

3.3. Dispersion of hazardous substances

Main findings

Europe is one of the largest chemical-producing regions in the world, supplying 38% of global turnover. Since 1993 the chemical intensity of EU GDP has been rising, both for all chemicals and for hazardous chemicals production. There are 20 to 70 thousand substances, or groups of substances, on the European market, many being derived from chlorine-based organic chemistry. Little is known about the toxicities, eco-toxicities or risks from most of these substances.

Figures on the quantities of substances produced or marketed are in general of little use for predicting dispersion and potential exposures which are yet difficult to estimate due to increasing non-point sources of emissions and recycling processes, despite improvements in multi-media modelling.

The European coverage of monitoring data for halogenated organics in general and persistent organic pollutants (POP) in particular is rather patchy. Information on degradations, transformations, by-products and exposures to mixtures is also poor. Most monitoring programs focus on mobile media (air, water), but often neglect soil, sediments and consumer products.

Combustion of fossil and other organic fuels is thought to account for over 90% of the environmental load of the 280 types of carcinogenic polycyclic aromatic hydrocarbons (PAHs).

Emissions of dioxins, such as polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF), which are mainly from air emissions and waste, are significant, but falling in most countries.

During pesticide application, because of losses from volatilisation or washing-out, less than 5% of the pesticide applied can reach its intended target, depending on weather conditions.

Indoor exposures to chemicals such as paradichlorbenzene from mothballs and domestic deodorants, tetrachloroethene from freshly dry-cleaned clothes, or to pesticide residues and dye-stuffs from textiles, can be significant. Exposures to dioxins have been decreasing, but remain significant. Heavy metal exposure has been reduced through improved water treatment and the phasing out of leaded petrol which more than halved emissions of lead in the EU between 1990 and 1996. Little is known about the effects of mixtures at the low concentrations to which most people are exposed. Children may have greater exposure per unit of body weight than adults.

If current trends and policies continue, there could be a growth of 30% to 50% in chemicals output for most of the EU countries by 2010 as a result of increasing economic activity, including road transport and agricultural production. Emissions of certain substances that are not included in the baseline scenario used in this report, such as platinum (used in catalytic converters) and brominated flame-retardants (electronics), are expected to increase.

Cadmium and mercury emissions are expected to increase by 26% and 30% respectively between 1990 and 2010; some countries plan to phase out these substances. Emissions from pesticides and POPs - such as dioxins/furans and PCB will continue to decrease, but PAH, HexaChloroBenzene (HCB), and xylene emissions are likely to increase.

However, the impact of some emerging trends in the management of chemicals such as: eco-efficiency improvements; a shift from products to services; the internalisation of external environmental costs into prices, via taxes etc.; increased information to the public; increased evidence on low-dose effects; greater use of the precautionary principle; and implementation of the OSPAR/Sintra agreement, the Integrated Pollution Prevention and Control Directive, and other international policies could lead to marked reductions in the chemical intensity of European GDP, particularly of those substances of concern.

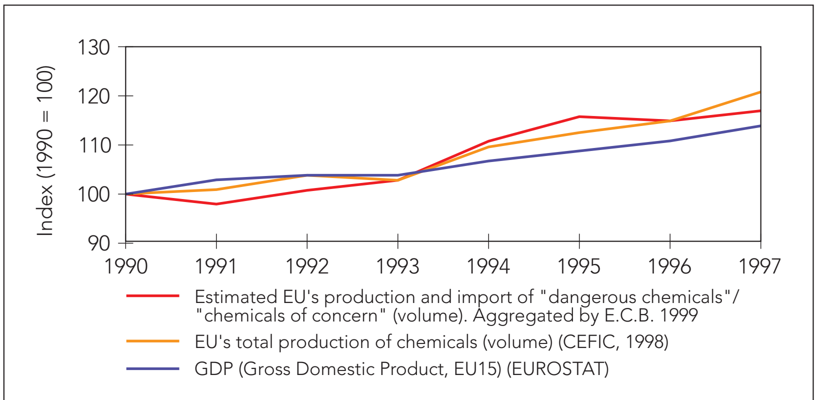
There is an urgent need to fill the considerable gaps in information about chemicals dispersion, fate, concentration and associated exposures to wildlife, eco-systems and humans, particularly for sensitive groups such as infants, children and the elderly.

1. Chemicals in society

1.1. Considerable benefits but environmental data and reaction pathways are scarcely known.

Humans and ecosystems are constantly exposed to a mixture of natural and manufactured chemicals, not all of which are necessarily harmful. The 'chemicals intensity' (EEA/UNEP, 1998) and 'dangerous chemicals intensity' of the EU economy (production plus imports per unit of GDP; Lindholt, 1999) have been increasing since 1993 (Figure 3.3.1). Supplying 38% of global turnover, with western Europe being responsible for 33%, Europe is one of the largest chemicals-producing region in the world, and the industry is expected to continue its vigorous growth. In line with the decline in their GDP between 1989 and 1995, chemical production in the Accession Countries fell, but has seen a recovery in more recent years. The higher value-added brands of the sector are expected to flourish benefiting from increases both in domestic demand and in exports.

Figure 3.3.1 **EU production and import of 'dangerous chemicals'/'chemicals of concern' and total chemical production**



These chemicals consist of 802 selected High Production Volume Chemicals (HPVC - petrochemicals are not included). The 'dangerous chemicals' are all classified by the EU and placed on Annex 1 to the Directive 67/548. The 'chemicals of concern', here estimated, are HPVC considered as problematical by some Member States. These indicators can be seen as a first attempt towards developing indicators on 'dangerous chemicals'/'chemicals of concern'.

Source: Lindholt, 1999; European Chemicals Bureau

The social and environmental costs of harmful environmental and health impacts are difficult to quantify (Holland *et al.*, 1996) and rarely borne by those responsible for these impacts (see chapter 4.1).

An assessment of dispersion processes is helpful in understanding potential environmental impacts (Box 3.3.1). This chapter specifically addresses dispersion of heavy metals (HMs) and peristent organic pollutants (POPs), while other chemicals of concern, such as volatile organic compounds, are discussed in Chapter 3.4. Exposure scenarios and dispersion routes in the environment, which are heavily dependent on the formulation and use of a chemical, include:

- dispersion during combustion processes, such as fuel conversion or waste incineration: chemicals released include HMs, polycyclic aromatic hydrocarbons (PAHs) and dioxins/furans;
- unintentional release following accidents or by slow leakage: for example, the release of polychlorinated biphenyls (PCBs) from electrical installations;
- intentional dispersion: for example in the case of pesticides and agro-chemicals.

Many other chemicals have rather low emission values during their intended use, but are dispersed once they enter the waste stream; examples are cadmium and chlorinated paraffins used as additives in polyvinylchloride (PVC) consumer products.

Human and ecosystem exposure depends upon the dispersion pattern of chemicals, which is determined by their physico-chemical properties, the respective release mode, the environmental medium into which they are first released (Mackay *et al.*, 1996), their reactivity and degradability, and the kinetics of these physical and chemical processes. Certain chemicals, most notably the chemical elements, never degrade, while organic substances may have half-lives and environmental residence times ranging from a few days up to geological timescales.

Assessment of dispersion and exposure is exceedingly difficult: while processes can be studied in a laboratory, their impact in varied environmental conditions is very uncertain. Data on environmental impacts can only be gathered through extensive and continuing monitoring of both the environmental concentrations of selected substances, and also attributable impacts on environmental compartments. A recent workshop on environmental monitoring (OECD, 1998) has emphasised the importance of long time series in order to be able to detect changes with time, but has also highlighted the need to re-evaluate older data with improved scientific insight. Data on the bio-toxicity and toxicity of chemicals is very limited (Figure 3.3.2). For 75% of large volume chemicals (marketed in excess of 1 000 tonnes a year) there is insufficient publicly available data even for minimal risk assessment under the OECD guidelines (EEA/UNEP, 1998).

As environmental regulation has developed, the focus has shifted away from emission reduction through 'end-of-pipe' treatment at point sources, geared to particular impacts of a substance on a single environmental medium. There is now an increasing emphasis on integrated approaches, which take account of the movement of chemicals through the environment over time. Because of the difficulty and cost of assessing the environmental impact of the large number of potentially hazardous chemicals, some current control strategies now are rather aimed at reducing the 'load' of chemicals in the environment through the elimination or reduction of their use (OSPARCOM; Århus Declaration, 1998; UNECE 1998a,b). Better understanding of the fate of chemicals in the environment is needed to aid the development of targeted exposure reduction measures and to aid the assessment of long-term exposure from chemicals dispersed in the environment.

1.2. Sources of chemicals

The European Inventory of Existing Chemical Substances (EINECS, Council Decision 81/437) lists over 100 000 compounds that were on the market in 1981. The estimates of the actual number currently produced and marketed in any amount varies from 20 000 to 70 000 (Figure 3.3.3; Teknologi-Rådet, 1997). A significant number of these substances do not occur naturally, but are manufactured, in some cases, in large quantities (High Production Volume Chemicals – HPVC) with a resulting high statistical probability of human exposure. Many of the HPVCs are used in a vast range of manufac-

Box 3.1.1. Some definitions

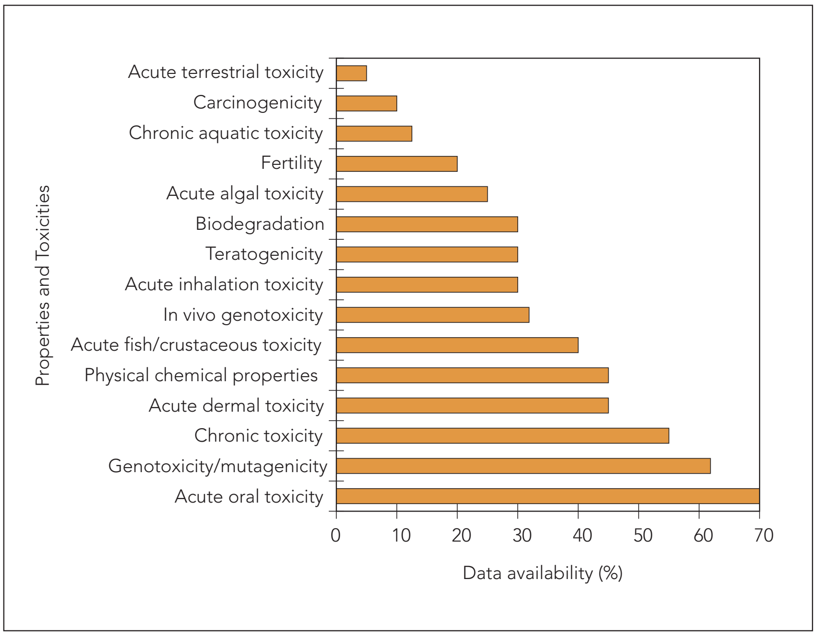
Dispersion: here the term encompasses all phenomena which give rise to the proliferation of substances through the man-made and natural environment.

Hazardous Substances '...are defined as substances, or groups of substances, that are toxic, persistent and ('or') liable to bioaccumulate. In this definition toxicity should be taken to include chronic effects such as carcinogenicity, mutagenicity and teratogenicity and adverse effects on the function of the endocrine system.' (Esbjerg Declaration, 1995). The OSPAR/Sintra agreement also added to this definition 'substances which give rise to an equivalent level of concern, especially those that act as endocrine disruptors.' (OSPAR, 1998).

Persistent organic pollutants 'are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment' (UNEP 1998; UNECE 1998a)

Heavy metals: metals or metalloids which are stable and which have a density greater than 4.5 g cm-3, namely lead, copper, nickel, cadmium, platinum, zinc, mercury and arsenic.

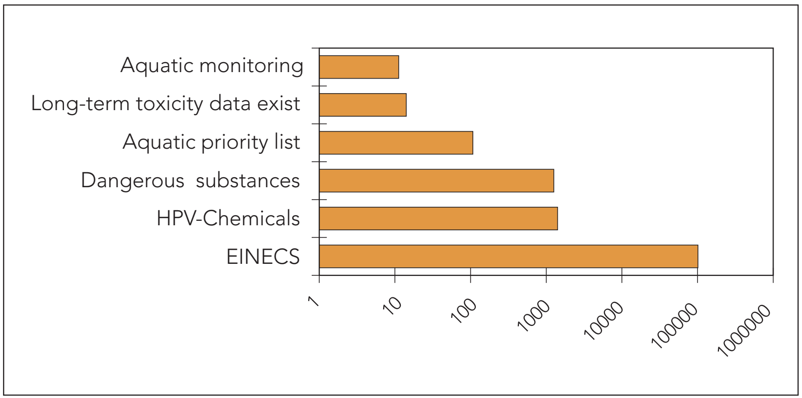
Availability of data on 2472 high-production volume chemicals submitted to the European Chemicals Bureau — Figure 3.3.2.



Following Council Decision 81/437 an inventory is being drawn up and the European Chemicals Bureau administers this data bank (IUCLID). A range of substances which are produced in large quantities are earmarked as priority substances for further data collation. The figure indicates the availability or rather scarcity of data of ecological relevance for those substances.

Source: adapted from Van Leeuwen *et al.*, 1996.

Figure 3.3.3 **The chemical universe in contrast with some current monitoring and classification activities.**



The EINECS lists over 100000 substances which are supposed to have been on the market in 1981. However, only 10 000 are produced in volumes greater than 10 tonnes/year. There is very little data on dispersion or fate or effects of most substances.

EU aquatic monitoring: various CEC Directives.

Aquatic priority: Directive CEC 76/464 List I

HPVC: see explanation in text.

EINECS: see explanation in text.

Source: Technologi-Rådet, 1997

tured goods and other products considered essential in modern life, including detergents and other 'down-the-drain' chemicals. Several hundred new substances are marketed each year and are recorded on the European lists of notified chemical substances (ELINCS), which has over 2000 substances listed.

The International Uniform Chemical Information Database (IUCLID), compiled by the European Chemicals Bureau (Hansen and Verburgh, 1997; ECB, 1994), in addition to providing data on HPVC properties, categorises them according to functional use and industrial use areas.

The Draft Protocols to the Convention on Long-Range Transboundary Air Pollution by persistent organic pollutants (UNECE, 1998a) and heavy metals (UNECE, 1998b) have identified respective categories of stationary sources (Table 3.3.1).

Table 3.3.1. **Stationary sources as examples for air emissions of heavy metals and POPs.**

Heavy Metals
Combustion installations with a net rated thermal input exceeding 50 MW.
Metal ore (including sulphide ore) or concentrate roasting or sintering installations for ferrous, copper, lead, zinc, or any gold and mercury ore treatment.
Installations for the production of pig-iron or steel including continuous casting.
Ferrous metal foundries.
Installations for the production of copper, lead and zinc from ore, concentrates or secondary raw materials by metallurgical processes, or for any primary production of mercury.
Installations for the smelting (refining, foundry casting, etc.), including the alloying, of copper, lead and zinc, including recovered products.
Installations for the production of cement clinker.
Installations for the manufacture of glass using lead in the process.
Installations for chlor-alkali production by electrolysis using the mercury cell process.
Installations for the (co-)incineration of hazardous or medical waste.
Installations for the (co-)incineration of municipal waste.
Persistent Organic Pollutants
(Co-)incineration of municipal, hazardous or medical waste, or of sewage sludge.
Sinter plants.
Primary and secondary production of copper.
Production of steel.
Smelting plants in the secondary aluminium industry.
Combustion of fossil fuels in utility and industrial boilers with a thermal capacity above 50 MW_{th}.
Residential combustion.
Firing installations for wood with a thermal capacity below 50 MW. Th
Coke production.
Anode production.
Aluminium production using the Soederberg process.
Wood preservation installations.

Source: UNECE, 1998a,b

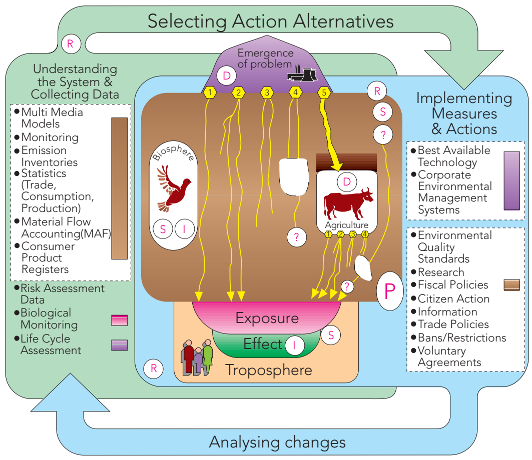
2. The fate of chemicals in the environment

2.1. Environmental Cycle: few known point sources with the majority of chemicals released from diffuse sources

Whether a chemical is hazardous to humans or ecosystems depends on its properties, form, the environmental medium in which the chemical is found, respective concentrations and the potential exposure pathways. Tracking the fate of certain hazardous chemicals in the environment is frequently complicated by the fact that the same chemicals occur naturally. Once released from the anthroposphere, chemicals will become involved in the complex natural atmospheric, geochemical, and biological cycles (Figures 3.3.4 and 3.3.5).

Environmental concentrations are the result of multiple processes affecting the mass of a chemical released from a multitude of sources. Process parameter values can be deduced – with limitations – from repeated measurements of the same variable at the same location, for instance as part of monitoring programmes. The range of variables to be considered can be narrowed, for instance, by emission inventories describing the chemicals' source terms.

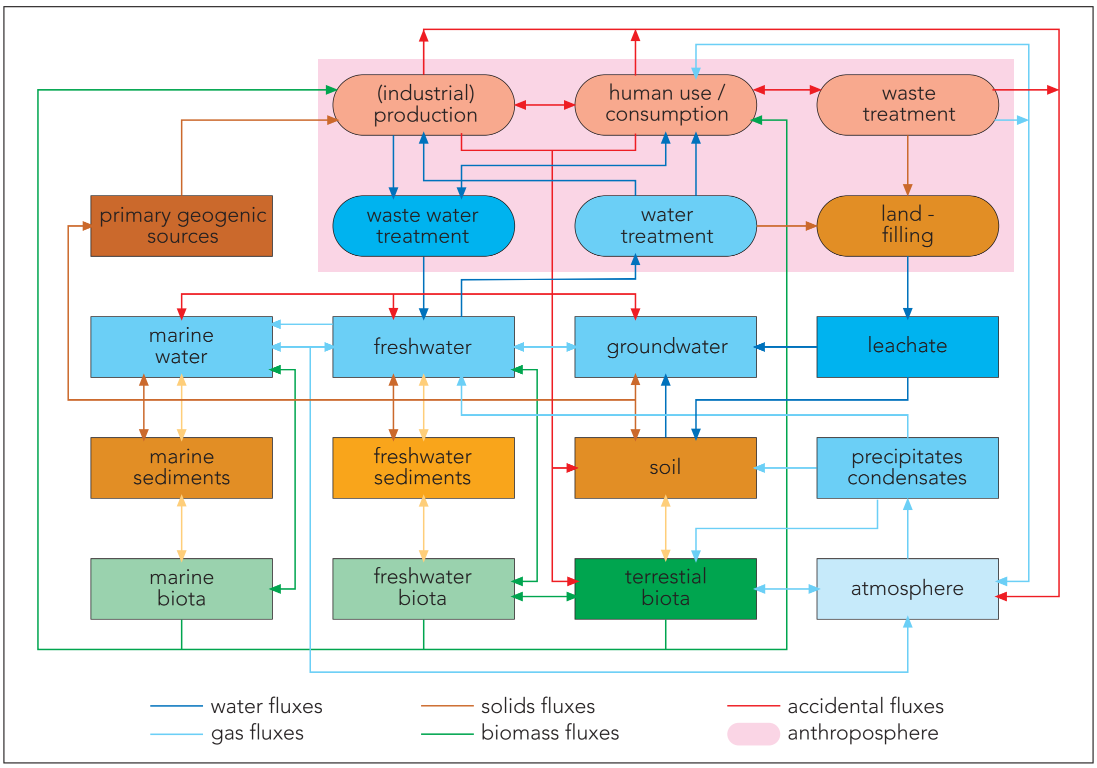
Chemical dispersion pathways — Figure 3.3.4



This is a representation of five pathways. The brown area is where the chapter focuses: pathways, resulting fate and concentration of chemicals in the environment. The main driving force (D) assumed here is a pesticide factory. Other extractive and manufacturing industries that supply raw materials may also be involved, but are not represented. Emissions (1 to 4) are point sources at the manufacturing site. In (1) the chemical is persistent and does not change in the envi- ronment. Human exposure is caused by the same molecule as released by the factory. In pathway (2) the chemical breaks down in three parts, one harmless and the other two potentially toxic. Pathway (3) is a safe chemical that degrades completely. In (4) the chemical decomposes in a natural substance (e.g. H_2O, CO_2, CH_4) and another that reacts or recombines with manufactured or natural background chemicals resulting in a new or unknown chemical. In (5) an herbicide is transported to a farm (driving force again (D)) and applied to the soil, giving rise to non-point sources where all pathways (1 to 4) are repeated. Environmental pressure (P) from chemicals is widespread. Before or concomitant to human exposure the biosphere is subject to impact (I) and stress (S). To limit environmental exposure and reduce stress, it is necessary to understand the system through data collection. Policy makers formulate response hypothesis (R) and select those that are most suitable. The darker brown area indicates where the effort for understanding the system and applying response measures are most effective. A key factor are the driving force itself which could be targeted in order to avoid or limit emissions by applying environmental management methods and techniques.

Source: EEA-P. G. Meozzi

Selection of some of the more important pathways for the transfer of chemical substances between different compartment of the natural and man-made environment (anthroposphere) — Figure 3.3.5



The cycles of chemicals in the environment are complex and manifold interwoven. The shaded area indicates the anthroposphere and its interface with the natural environment

Source: W.E. Falck

Persistent chemicals (HMs, POPs) have the potential to become dispersed over a wide area, even on a global scale, and to accumulate in certain environmental compartments, for instance in biota, where they may become metabolised. Dispersion increases the probability of exposure, while bio-accumulation can result in body burdens that increase up the food chain and which may eventually reach toxic levels.

While some chemicals of concern are released at a few known point sources, the majority of them are emitted from countless, diffuse sources. An European Integrated Emissions Inventory (EIEI) has been proposed in connection with the IPPC. Emission inventories, based on actual measurements or typical emission factors, are used to assess releases from point sources. This makes it virtually impossible to describe discrete dispersion pathways from source to exposure target in a quantitative way. Assessment of the state of the environment resulting from chemicals of concern, therefore, requires additional information from regional or even global mass balances of substances, derived from Substance Flow Analyses (SFAs; EUROSTAT, 1997). SFAs help to identify significant emissions or losses and whether a chemical's use is driven by its origins as by-product or waste from another process (Udo de Haes and van der Voet, 1997). They also help to pin-point those uses or processes that could be targeted most effectively for overall environmental impact reduction. SFAs consists of a stocktaking exercise on all fluxes of a substance to and from a region, such as a country or a river basin (Neal *et al.*, 1998). Diffuse emissions can be estimated by combining inventories and monitoring data. Evaluating mass balances on a regional or even global scale requires a combination of monitoring data and modelling.

SFAs have been prepared for a range of substances in a number of EU Member States, including Austria (Gerhold, 1997), the Netherlands, Finland (Nordisk Ministerråd, 1997) and Sweden (Statistics Sweden, 1997). Hellsten (1997) discusses the difficulty of identifying substances in the anthroposphere based on data available from national sources, such as statistical offices or custom and excise registers, as in Sweden. Movements between compartments of the natural and man-made environment also need assessing. Very detailed SFAs have been compiled for The Netherlands (Gorter, 1997).

The PIC (Prior Informed Consent) procedure, developed between by the United Nations‘ Environmental Programme (UNEP) and Food and Agriculture Organisation (FAO) allows control of technosphere (e.g. trade) cross-border fluxes of certain chemicals.

2.2. Dispersion through the environmental compartments

2.2.1. Air: particles are important carriers for contaminants

Emissions of many chemicals of concern occur into the air initially, from where they are dispersed into other media. Air is one of the main carriers of chemical carcinogens to humans (Corvalán and Kjellström, 1996).

Many chemicals emitted into the air, for instance from combustion processes, tend to become associated with particulates (see also Chapter 3.10). Removal from the air occurs through a range of complex processes involving photo-degradation, and particle sedimentation and/or precipitation, (known respectively as dry and wet deposition). Volatile and semi-volatile substances may undergo several cycles of evaporation and precipitation. Such cycling can make chemicals more accessible to photochemical or bio-degradation.

The usual mode of application for plant protection products is spraying, which results in high atmospheric emissions, drift and potential exposure of non-target species (Kleijn *et al.*, 1997). Depending on weather conditions during application, losses due to volatilisation or washing-out (Lennartz *et al.*, 1997) may be high, such that sometimes less than 5% of the substance applied reaches its intended target (Bullek *et al.*, 1991).

Substances which are not easily degraded and are semi-volatile can follow the atmospheric circulation patterns on a global scale (Wania and Mackay, 1996a). This is evidenced by the occurrence of halogenated hydrocarbons (e.g. certain pesticides, PCBs) in polar regions, far from their industrial or agricultural sources (Wania and Mackay, 1996b). The concern for the effects of long-range air-transport has led to international action (UNECE, 1998a,b).

Air pollution control measures (such as the Integrated Pollution Prevention and Control Directive and its predecessors), although not necessarily targeted primarily at hazardous chemicals, also effect reductions of chemicals air emission.

2.2.2. Water: improved means available to understand fluxes in river catchment basins

For many industrial discharges and household 'down-the-drain' chemicals, such as detergents, surface waters are the initial receiving medium. Although many countries prohibit discharge into aquifers, contaminating fluids will nevertheless reach groundwaters, for instance by the way of natural recharge, seepage from leaky municipal and industrial sewerage systems, landfills, storage tanks or accidental spills.

The migration behaviour of a chemical along the water path is largely determined by its chemical and physico-chemical properties. Re-distribution of contaminants between the aqueous and solid phase is controlled by the prevailing water chemistry and resulting surface properties. Zones of high acidity or alkalinity (measured by low/high pH) and/or *redox* potential or of high sorption capacity (for example clays) can act as geochemical barriers. Indeed, these properties are utilised in engineered landfills to prevent leakage.

Groundwater and river loads are a complex function of such phenomena and the hydrological characteristics of catchments which are linked to atmospheric and marine processes and fluxes. This is illustrated by drinking water analyses for pesticide pollution in France (Figure 3.3.6). The proposed EU Water Framework Directive (see chapter 3.5) puts much emphasis on qualitative and quantitative resources management at catchment level. The necessary information support is illustrated by the LOIS project (1999; Neal *et al.*, 1998; Leeks and Jarvie, 1998), which estimated pollutant loads for selected European rivers (Jarvie *et al.*, 1997).

2.2.3. Soils and sediments - the number of contaminated sites, including landfills, is in the order of hundreds of thousands

Soils are recipients for chemicals from combustion processes, pesticide applications, landfilling and other waste disposal methods, and leakage from petrol stations, industrial sites, etc. The estimates for numbers of contaminated sites, including landfills, are in the order of hundreds of thousands for the whole of Europe, but no definite number can be given (see Chapter 3.6). Agricultural disposal of sludges from biological wastewater treatment (BWWT) processes increasingly raises concern (Directive EEC/86/278), since HMs and certain persistent organics accumulate in these sludges and biofilms.

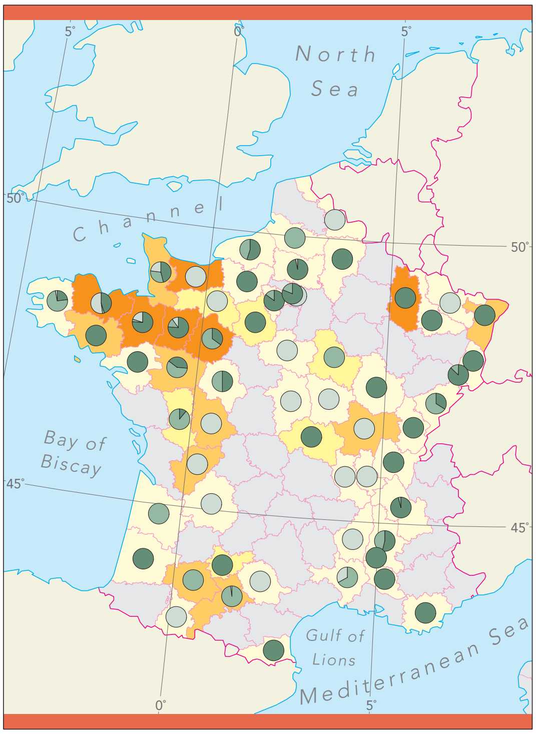
Soils and sediments act as a reservoir for many chemicals of toxicological relevance (HMs as well as lipophilic organics) owing to their affinity to solid surfaces in general and the organic fraction in particular. Slow and delayed release will occur, controlled thereafter by prevailing bio-geochemical conditions, thus extending potential environmental exposure times well beyond the initial emission event. This geochemical behaviour is an important factor to be considered in long-term exposure assessments and the design of monitoring programmes.

Eroded soil fines might act as secondary sources, from where chemicals, both inorganic and organic, are released into the air, surface and groundwaters, and ultimately the sea (Neal *et al.*, 1998).

2.2.4. Biota - concerns on the increase of persistent organic and inorganic pollutants along the trophic or reproductive chain, i.e. biomagnification.

Toxicology and risk assessment are mainly concerned with the effect chemicals have on biota. Meanwhile the biota themselves may act as a vector of dispersion.

Some tissues have an inherent affinity for certain chemicals, for instance, halogenated organic compounds are taken up into body lipids, such as in mammal milk. Other tissues remove excess chemicals from body fluids or detoxify them, as do the kidneys and the liver. The capacity to metabolise xenobiotic chemicals is species and compound depend-



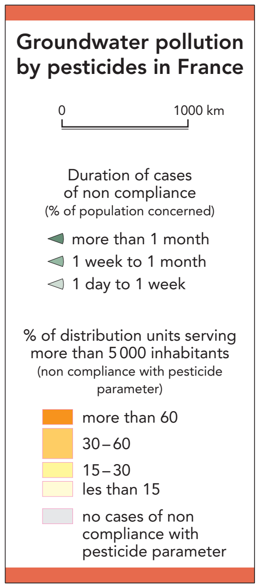


Figure 3.3.6
In France the content of pesticides in drinking water from 2 036 supply units, each serving more than 5 000 inhabitants, was analysed during the period 1993-1995.

About 43 million people were served with drinking water from these plants, of which 5.4 million (13%) received water with pesticide concentrations above the limit values (0.1 ug/l for a single pesticide or 0.5 ug/l for total pesticides as specified in the Drinking Water Directive for a mixture of pesticides). These exceedences were recorded for a certain part of the year ranging from one day to several months. As in other countries the substance most often found to exceed the limit value was atrazine.

The presence of pesticide in drinking water is well in accordance with the fact that 49% of sampling points in rivers and 35% of groundwater points are moderately contaminated by pesticide. In about half of the river sites pesticides are the main reason of pollution while for the groundwater sites it is one-fifth. In surface waters, c.a. 80 pesticide substances are involved, whereas 25 substances contribute only to groundwater contamination.

Source: Ifen, 1998

ent (Borrel *et al.*, 1995, 1996; Bernhoft *et al.*, 1997); if it is insufficient bio-accumulation ensues. Of particular concern is the concentration increase of persistent organic and inorganic pollutants along the trophic or reproductive chain, i.e. bio-magnification. Transfer of the chemical to the offspring thus can result in exposure at a time when they are most susceptible to adverse effects (Fear *et al.*, 1998).

The time lag until complete breakdown of a chemical may cause sufficient exposure and result in adverse effects. Observable effects may be considerably delayed. Metabolites, in fact, may be even more toxic than the original substance.

3. Chemicals of concern

3.1. Heavy Metals: losses during production, use and waste management

Human activity generally leads to the dispersion of metals (Renberg *et al.*, 1994) and other elements that had been concentrated by geological processes and over geological time scales. The use of, and hence human exposure to, metals has significantly increased since the onset of the industrial revolution and continues to do so on a global scale (Bergbäck and Lohm, 1997). Arsenic, cadmium, copper, lead and nickel have been identified as being of greatest concern (Denzer *et al.*, 1998).

3.1.1. Production and use

The production and use of heavy metals is driven by a wide variety of industrial, agricultural and domestic uses such as metallurgy, catalysts, pigments for paints, batteries, electronics components, fertilisers, solid fossil fuels, or plastics and fuel additives. The major diffuse anthropogenic mercury source, in Germany for instance (LAI, 1995), is burning of fossil fuels. EU average contributions from agriculture to cadmium emissions are around 1% (Vissedijk *et al.*, 1998). Cadmium in phosphate fertilisers is of some concern (OECD, 1996) and is dealt with by national legislation in Finland, Sweden and Austria.

3.1.2. In water pathways

Direct human exposure to elevated HM concentrations via the water pathway has been of limited importance in many western European areas, but has regained importance as a result of declining control over the quality of (groundwater) resources and the distribution system (see also Chapter 3.10). This may, for example, increase human lead exposure from drinking water, countering lead solubility control measures for water piping. Exposure to surface water-derived HMs might occur indirectly via bio-accumulation in freshwater or estuarine or marine fish consumed by humans. The latter, for instance, accounts for half of the mercury intake in Germany (LAI, 1995).

The increasing abundance of biological wastewater treatment (BWWT) plants throughout Europe leads to a shift of environmental dispersion pathways of HM from effluents to sludges. Sludges are either used as fertiliser (if contaminant concentrations are within legal limits), or are incinerated. River loads have decreased considerably as a result of waste-water treatment (see for example UBA, 1997; Chapter 3.5).

The LOIS studies (*Land Ocean Interaction Study*, 1999) have confirmed that elevated concentrations of HMs in river waters are linked to the presence of high suspended particle loads and natural or anthropogenic complexants. HMs re-mobilised from stream sediments are of some concern where drinking water resources are augmented by bankfiltration. Ultimate recipients for HMs in surface waters are the large marine basins of the Baltic, the North Sea, the Black Sea and the Mediterranean. The European countries have, through the North Sea Conference, the Oslo-Paris Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPARCOM) and the Helsinki Commission on Baltic Marine Environment Protection Commission (HELCOM), agreed to reduce overall inputs of HMs.

3.1.3. In the atmosphere

Combustion processes as part of fuel conversion, metal production and processing, or waste treatment constitute important airborne sources of HMs on a European scale. Until the introduction of lead-free petrol, air dispersion was the most important pathway for human exposure to lead (cf. Århus Declaration, 1998, p. 18).

HMs emitted to air are often chemically bound in, or physico-chemically attached to, particles, and follow their global dispersion patterns (see Chapter 3.4). True gaseous transport is an important mechanism for mercury and results in an even higher potential for long-range transport and extensive atmospheric cycling (LAI, 1995). Air transport of HMs can be in the order of thousands of kilometres, as is indicated by their occurrence far from their sources (Renberg *et al.*, 1994). Wet or dry deposition will eventually transfer airborne HMs to water, soils or onto plant surfaces (Dmuchowski and Bytnerowicz, 1995; Herpin, 1995).

3.1.4. In soil

Higher HM concentrations in soils tend to be more localised, either from high natural background levels (mineral deposits), or from mining, ore processing, and other industrial activities.

3.1.5. In food

The major pathway for human uptake, after inhalation, is ingestion of plant and animal derived foodstuffs. The chemical processes associated with bio-accumulation, both in humans and animals, lead to preferential accumulation in certain tissues. Wahlström *et al.* (1996) concluded that the consumption of fish or game in general in Finland can be considered safe, but their liver and kidneys should be avoided. Human exposure to HMs may not only result from the dietary uptake, but also from smoking.

3.2. Persistent Organic Pollutants (POPs)

The number of chemicals to be considered as Persistent Organic Pollutants (POPs) is unknown, but certainly exceeds those that are listed as being of concern (UNEP, 1998; UNECE, 1998a) or are included in current monitoring programmes.

3.2.1. Polycyclic Aromatic Hydrocarbons (PAHs) - combustion still a major sources for the environmental concentrations

PAHs comprise a suite of around 280 substance from which 16 have been selected by EU and US EPA as priority substances (Howsam and Jones, 1998; Keith and Telliard, 1979). PAHs are ubiquitous and many have environmental half-lives in excess of weeks or months. They are subject to various chemical and photochemical processes in the environment; some of which result in degradation to less toxic products, while others lead to more hazardous compounds, such as nitrosubstituted PAHs (Harvey and Jones, 1998).

The major source of PAHs are fossil and other organic fuels such as wood. Combustion is thought to account for over 90 % of the environmental concentrations. Non-combustion processes such as the production and use of creosote and coal-tar, though poorly quantified, are potentially very significant primary and secondary sources (Howsam and Jones, 1998). Combustion processes have the highest dispersion potential over wide areas, but may decrease in relative significance as emissions are reduced by integrated pollution prevention and control (IPPC) measures (see also Chapter 3.4), although total emissions are liable to increase with economic activity (see Chapter 2.2).

Human exposure occurs mainly through inhalation of smoke particles to which the PAHs readily attach. Indeed, certain voluntary practices such as smoking and the use of household chemicals such as air fresheners result in significant indoor PAH concentrations and human exposures (Wallace, 1993).

3.2.2. Organochlorines dispersal in soil, groundwater and some global scale problem

Chlorine-based organic chemistry has become one of the most important branches of the chemical industry (Nolte and Jonas, 1992), accounting for some 55 % of the production (EuroChlor, no dated). The main products are pesticides and biocides, and components for a wide range of industrial and household goods.

A class of chlorinated hydrocarbons released into the natural environment on purpose are those which are intended as *plant protection products* (insecticides, fungicides, herbicides) and *biocides*. Active ingredients may be not only chlorinated hydrocarbons, but also other organic, metal-organic or metal compounds. Application generally results in diffuse source emissions (for example from agriculture, or organo-tin anti-fouling paints on ships), but for specific applications linear (e.g. weed control on railways), or point sources (wood protection, sheep dips, accidental spills) may be relevant.

Emission factors in industrial applications and household goods vary considerably, but are generally quite low during normal use; there are small losses from the technosphere by way of abrasion, wear, or leakages, notably PCBs from electrical installations. PVC-based plastics have been of some concern, mainly due to emissions of additives, such as stabilisers or plasticicers (e.g. phthalates, chlorinated paraffins), in the waste stream (Wolff *et al.*, 1994) and from consumer goods intended for children's use. Recycling of many PVC-based goods and better process control in incineration has reduced the impact from dioxin formation in thermal waste treatment.

Most lipophilic organochlorines (those that are absorbed by fats) will be found on the soil solids (the organic or clay fraction), from where they can migrate into deeper strata. A number of European countries have reported pesticides in groundwater, although there is little reliable information for POPs in general (Denzer *et al.*, 1998). The pollutants eventually reach the sea via surface waters and, *inter alia,* by colloid or particle-mediated transport (Craig and Guth, 1996).

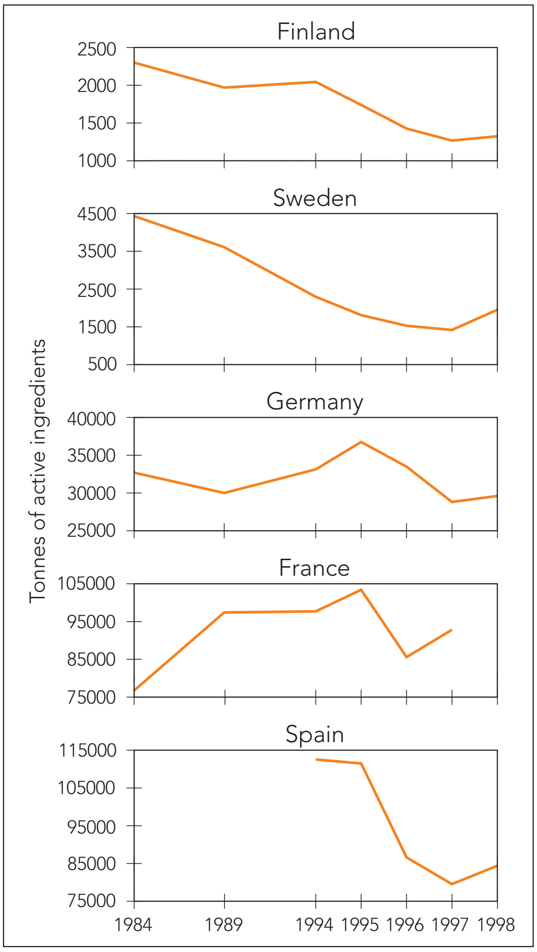
Primary emission into the air or evaporation during application furthers global dispersion of pesticide-derived POPs, following atmospheric circulation patterns (Pacyna and Lindgren, 1997). Both transport behaviour and possible breakdown of air-borne POPs are linked to the presence of particles and oxidants. Under tropical conditions, biocide formulation derived POPs are broken down relatively fast when they reach the ground, but air-borne, re-volatized and particle-bound POPs spread northward towards the Arctic in the train of the global movement of air masses (Wania and Mackay. 1996a). (Re-)volatilisation and deposition complicate the assessment of emissions and depositions.

Figure 3.3.7

Pesticide consumption [tonnes of active ingredient] as a function of time for selected European countries.

Pesticide consumption in the various EU countries does not follow a uniform trend, being a function of agricultural activity and legislation on certain substances. Absolute levels reflect the size of the country as well as the respective importance of the agricultural sector. Consumption in terms of mass, however, does not necessarily reflect environmental impact, as more active and more specific substances are being developed.

Source: New Chronos/ EUROSTAT)



Acute poisoning of humans by chlorinated hydrocarbons is rare in the European region and usually associated with accidental releases during manufacturing, storage or application. Bio-accumulation (Blomkvist *et al.*, 1992) and persistence in many environmental media can lead to long-term low-level exposure of non-target species. Health effects on humans and animals from continuous or intermittent long-term exposure to low levels are varied and frequently difficult to attribute. Certain pathological observations, including eggshell thinning in various bird species, skeleton malformation in seals and otters, hormonal (endocrine) or reproductive disturbances in various species, were found to coincide with pesticides in the animal tissue (Swedish EPA, 1996).

The continuing use of some active ingredients of concern, for instance DDT in developing countries, results in dispersive input to European regions, even though the respective ingredients have been phased out in Western Europe (UNECE, 1998a). Lower acute human toxicity and easier handling for less well-educated farmers might be valid reasons for continuing their use in developing countries (Koss, 1997). The ever-increasing global trade in plant material (foodstuffs, textiles) provides another, anthropogenic, pathway for transboundary dispersion and possible human exposure in Europe.

Overall pesticide use – measured by mass of active ingredient – appears to have been decreasing in most EU countries over the past two decades (Thyssen, 1999; Figures 3.3.7 and 3.3.8); but even though the production and use of DDT and Lindane have been reduced or prohibited for decades, it will take considerable time for the reservoirs in various environmental compartments to become depleted and for stock-piles to become run down.

3.2.3. Dioxins and furans: reasonable data on air emissions but not for other pathways

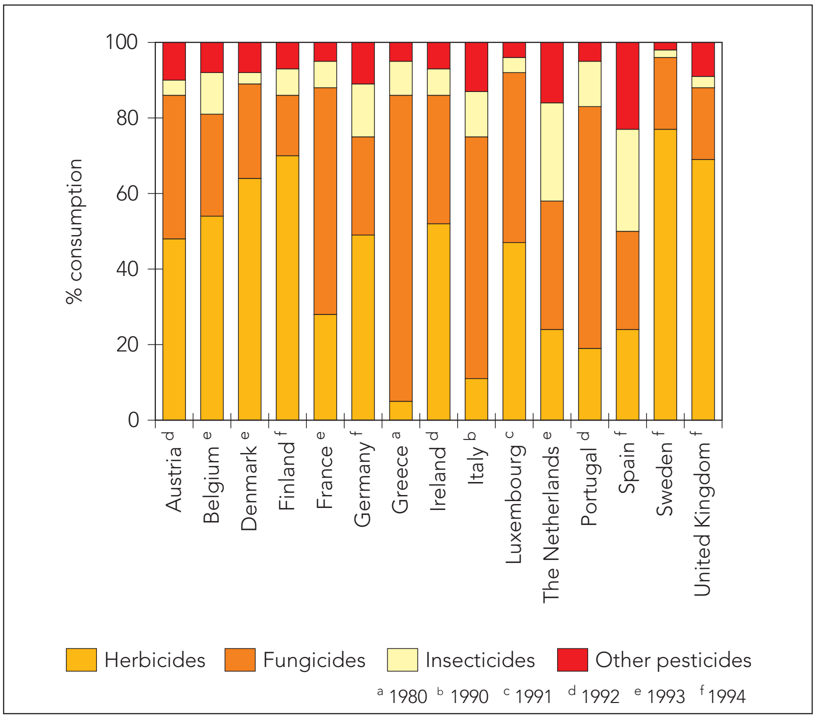
Dioxins are a category of POP which became notorious following the 1977 accident at Seveso, Italy, involving the most toxic dioxin, congener 2,3,7,8-TCDD, an impurity in certain herbicides, which is at present the only congener recommended for classification as being carcinogenic to humans (Becher *et al.*, 1998).

Polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) and their congeners are present in traces naturally, but are formed on a larger scale as by-products of sub-optimal combustion processes of organic matter in the presence of chlorine (ICC, 1996).

Dioxins have atmospheric half-lives of the order of days, which is sufficient for their global dispersion (Renner, 1996). Their half-lives in soil and biota, where they accumulate in fatty tissues of top-predators, are of the order of years (Becher *et al.*, 1998) (Figure 3.3.9). Food is the main pathway to humans.

The Fifth Environmental Action Programme (1993) set out to reduce dioxin emissions until the year 2005 by 90% as compared to the reference year 1985. Residential burning of wood and possibly co-burning of domestic refuse is a significant source of dioxins in some Member States (Figure 3.3.10). Such sources are difficult to monitor and control, and are likely to constitute an unavoidable anthropogenic background level. Industrial and transportation sources are more accessible to assessment. The latter are linked to the use of leaded fuel and, therefore, should soon vanish completely. There are regulations controlling dioxin emissions from hazardous waste incineration (see Chapter 3.7), but not from industrial installations.

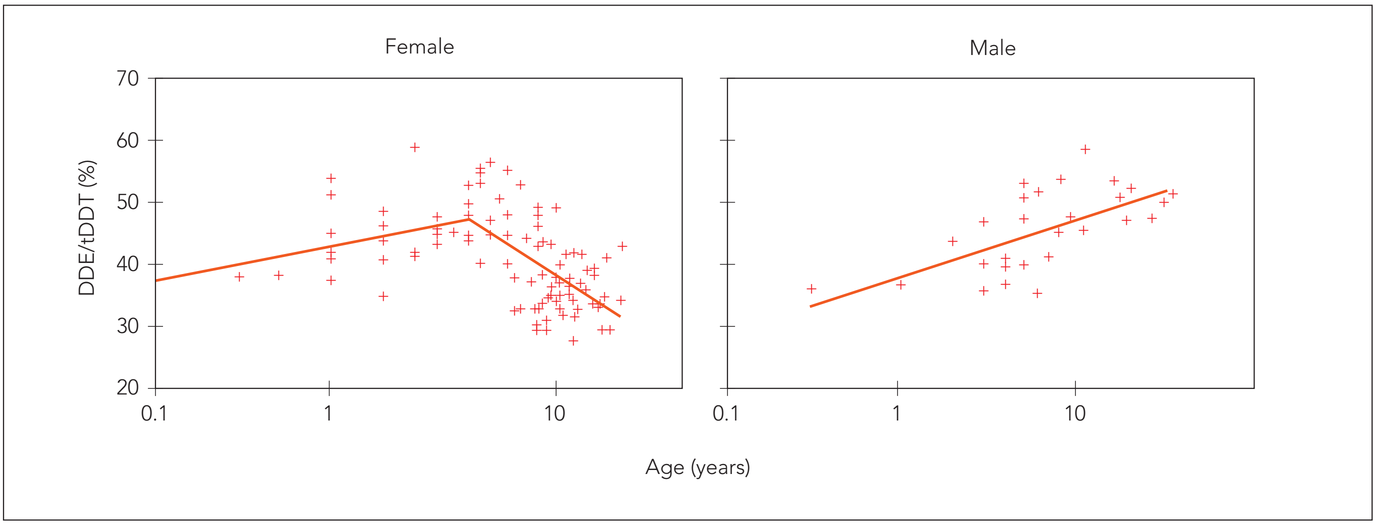
Percentage consumption of pesticides according to type of pesticide Figure 3.3.8



Pesticides are not only used in agriculture, although this is the main user in many countries. The type of pesticide required reflects the specific problems in each geographical area: humid countries such as the Mid-European and the Scandinavian countries mainly face weed control problems, while Mediterranean countries are consuming pesticides mainly in agricultural fungus control.

Source: New Chronos/EUROSTAT

Comparison of DDE/total DDT ratios in arctic mammals, males and females, of different age Figure 3.3.9



Low DDE/tDDT ratios at higher age indicate loss of DDE by reproductive transfer.

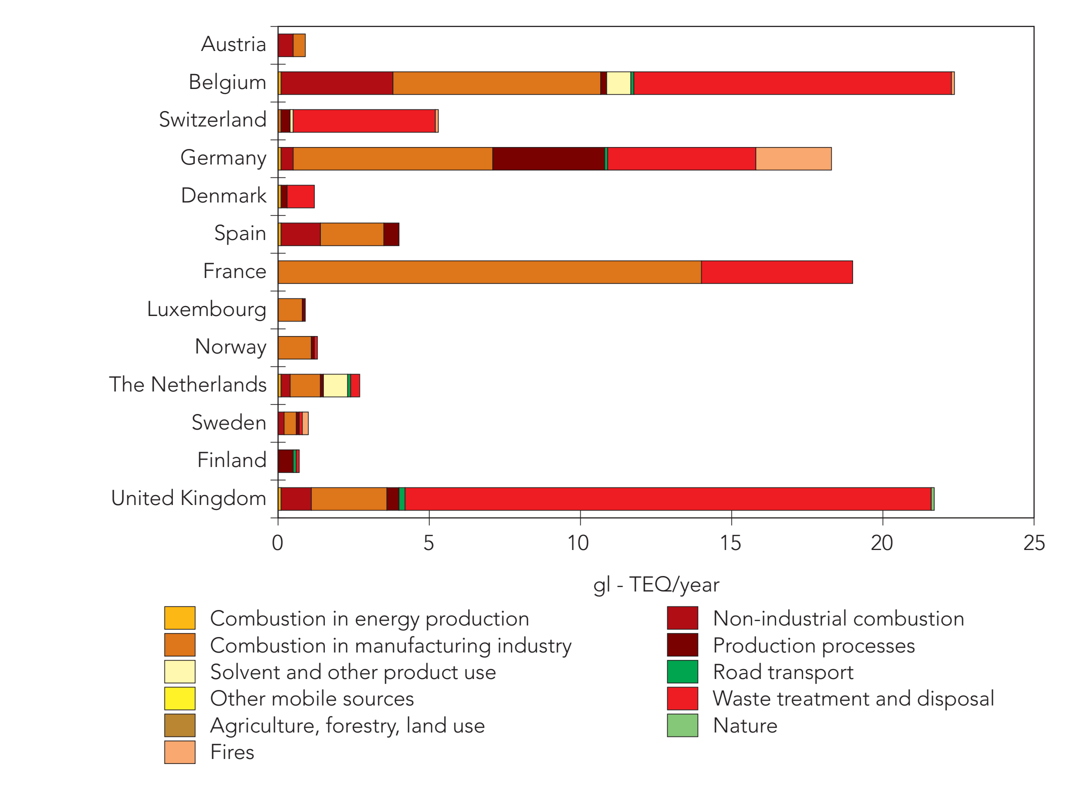
Source: Borell *et al*, 1995

Figure 3.3.10

PCDD/PCDF air emissions for selected countries and for those CORINAIR categories in which significant contributions have been observed.

Dioxin and furan air emissions in four countries for which reasonable data coverage existed. In Belgium, Germany and the UK the predominant source is waste treatment, while in France it is combustion in the manufacturing industry. Absolute figures indicate not necessarily poor pollution control but the relative importance of industry and waste management techniques (incineration).

Source: Quass and Fermann, 1997



4. Exposure estimation

4.1. Dispersion, exposure pathways and the difficulties of linking health effects to exposure

Various factors have to be taken into account when estimating exposures from environmental monitoring data and linking these to observed health effects (Corvalán and Kjellström, 1996). Variables controlling the dose received include: the duration of exposure; the time of exposure in relation to the total life-span of an organism (children may have greater exposure per unit of body weight than adults -EEA/UNEP, 1998); the capacity to bio-accumulate; and absolute concentrations, or concentrations above certain threshold values. Typical exposure pathways are ingestion, inhalation and dermal uptake, and for humans the total environment, lifestyle and diet, including breast milk, must be taken into account (Figure 3.3.11).

Exposure to a particular chemical does not necessarily follow from its mere presence in a environmental medium (Feijtel *et al.*, 1997b), and the uncertainties in predicting exposures are considerable (Box 3.3.2).

For heavy metals, physico-chemical characteristics alone are not sufficient to assess bio-availability and ecotoxicity (van Brummelen *et al.*, 1998), because in many instances the bio-availability is enhanced by organic complexation and the formation of metal-organic compounds. Not only the concentration-related total dose received by a recipient might be of relevance, but also the dose received by particular tissues over time. The specific problem of bio-accumulation and magnification in secondary and tertiary compartments requires special attention in exposure assessment (Feijtel *et al.*, 1997). Similarly, transformation of chemicals *in vivo* and in other environmental media, and the exposure to resulting transformation products needs to be considered. It appears therefore that impact assessments based on PEC (predicted environmental concentration) to PNEC (predicted no-effect concentrations) ratios may not be sufficient in the case of some bio-accumulating chemicals.

Exposure-based threat assessments can be used to identify priorities for exposure reductions. EEA/UNEP, 1998, states:

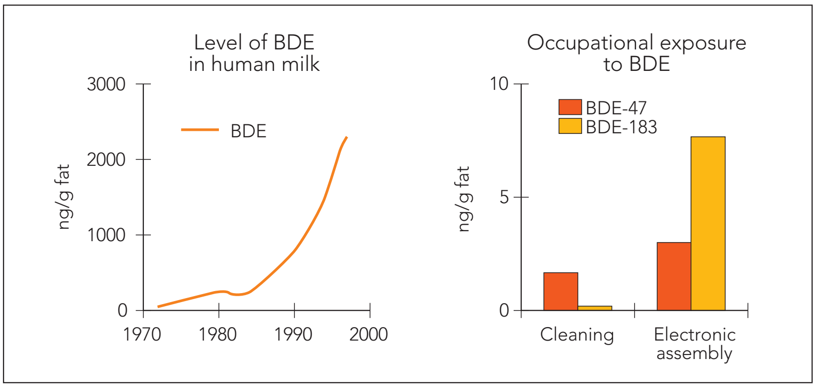
'An exposure-based assessment that uses the persistence and spatial range of the chemical as an indicator of environmental threat requires less data and can usually be performed faster, than a toxic effects-based risk assessment (Scheringer and Berg, 1994). It can also help to identify any gap between those who benefit from chemicals and those who bear the environmental or health damage, as chemicals with a high persistence and spatial range can distribute costs over a much wider area than that which receives the benefits, as, for example, with CFCs and ozone layer damage. It has been suggested that exposure-based threat assessment can be used for the initial screening of chemicals, complemented by toxic effects risk assessment, where this is likely to be cost effective and where data is available (Scheringer, 1997).'

Some of the complexities of exposure assessment and its relation to risk estimates can be illustrated with dioxins (Box 3.3.3).

4.2. Mixtures and unidentified chemicals are issues of concern

The significance of personal activities contributing to exposure has been emphasised by Wallace (1993). Household dust stirred-up by domestic activities leads to higher exposure to particles and particle-bound chemicals. Indoor personal exposure to chemicals such as paradichlorbenzene from mothballs and domestic deodorants, to tetrachloroethene from freshly dry-cleaned clothes, or to pesticide residues and dye-stuffs from textiles can be significant. Bulk

Exposure from polybrominated diphenyl (PBDE) Figure 3.3.11



Eight individual PDBE were analysed in Swedish mothers milk as pooled samples which were collected from the years 1972, -76, -80, -84/85, -90, -94, 96 and -97. The mothers were between 27 and 31 years of age. The total PBDE concentrations (ng per gram extracted lipids (l.w.) are given as the sum of the eight PBDE congeners analysed. The major PBDE congener in the mothers milk was 2,2',4,4'-tetrabromodiphenyl ether making up approximately 60% of the total PBDE levels in the milk. The level of the PBDE should be compared to total PCB concentrations of approx. 1100 ng/g l.w in 1972 and 320 ng/g l.w. in 1997. The PBDE concentrations are increasing in milk from women in Sweden at the same time as other environmental contaminants are decreasing, e.g. PCB. The difference is today 80 times and a doubling of the PBDE concentration in the milk can be expected in five years unless the trend is changed.

Source: Left: Norén, K. and Meironyté, D., Organohalogen Compounds 38 (1998) 1-4;. Right: Meironyté, D., Bergman, Å. and Norén, K., Organohalogen Compounds 35 (1998) 387-390

Box 3.3.2. Uncertainty in exposure predictions

Uncertainty in exposure predictions is an important aspect in the regulatory context and arises from the fact that we inherently cannot know all system properties at any point in space and time. Conceptually there are five sources of uncertainty (Cowan *et al.*, 1995):

- deterministic variance (e.g. experimental error);
- stochastic variance (e.g. variations in nature) resulting from environmental properties changing in time and space and which cannot be controlled;
- variance in reaction rates which are both deterministic and stochastic;
- lifestyle variances such as age, ingestion rates, and food preferences;
- errors in model implementation by the developer and improper problem conceptualisation by the user.

Box 3.3.3. Dioxins: Current public exposures, lowest adverse effect levels, and recommended daily intake

	Daily intake of dioxins and dioxin-like compounds[1] (TEQ TCDD pg/kg/gw/day)[2]
Current adult dose (industrialised countries)	2-6
Lowest adverse effect level, adults (estimated from animal studies)	14-37
Recommended tolerable dailyintake (WHO: lowest effect level divided by 10 as the composite uncertainty factor for differences in susceptibility between animals and humans; between humans, such as foetuses and adults; and differences in half-lives of the chemicals in the TEQ mixtures)	1-4

[1] 29 dibenzo-p-dioxins, dibenzofurans and PCBs have been allocated toxic equivalency factors (TEFs) based on the most hazardous dioxin, TCDD, and these, in combination with their concentrations in the mixtures, can be summed to a toxic equivalent concentration (TEQ), based on the assumption that their effects are additive.

[2] Toxic equivalent concentration to TCDD dioxin, in picograms per kilogram of body weight per day.

Source: EEA, derived from WHO (in press) concentrations in ambient media, such as air or water, and respective consumption rates may, in consequence, lead to an underestimation of actual exposure.

Humans and the ecosystems are constantly exposed to a mixture of natural and manufactured chemicals, yet only a few are monitored or have been even identified. The toxic effects of exposure to some chemicals via certain pathways, such as oral ingestion or inhalation, is well understood and lethal or acceptable doses have been established. Very little is known, however, about the effects of mixtures of chemicals at low concentrations (van Leeuwen *et al.*, 1996) in particular, if the effects of single substances do not manifest themselves immediately. The poor understanding of the interrelation between an individual‘s historic record of exposure to the chemical environment and any observed effects hampers the deduction of clear causalities in most cases (Nurminnen *et al.*, 1996). Even within a human population the susceptibility of certain sub-groups, such as children, may depart considerably from the average.

Groups of substances of increasing concern, for which only limited insight in their environmental impact is available, include brominated flame retardants (Box 3.3.4) and substances affecting the endocrine system (Weybridge, 1996).

Box 3.3.4. Brominated flame retardants

Flame retardants are a diverse group of organic and inorganic compounds used to improve the fire resistance of polymers and other materials. IPCS (1997) lists 175 known compounds, most of which are brominated organics. Main areas of application are plastic housings of electrical and electronic equipment, such as TV-sets, computers and household appliances, circuit boards, cables, and textiles.

The respective compounds such as polybrominated biphenyls (PBBs; IPCS, 1994a) and diphenyl ethers (PBDEs; IPCS, 1994b) are precursors for the brominated analogues PBDD/F to PCDD/F (IPCS,1998) and may form under similar circumstances. Elevated concentrations of PBDD/F have been found in house and office fires, where fabrics, insulating material and office equipment are the source.

Health and environmental properties of PBDEs and similar compounds are poorly known, but they are persistent in the environment. Bioaccumulation decreases with increasing degree of bromination, but dehalogenation cannot be ruled out (Kemi, 1996).

Rising environmental concentrations are of concern. Drawing on the lessons learnt from PCB, it is evident that there is a risk of complex and harmful effects on a longer time-scale. Measures to prevent further dispersion from the technosphere should therefore be undertaken (Kemi, 1996).

4.3. Monitoring and modelling in predicting the fate of chemicals; more data on environmental properties are needed

Monitoring and modelling are two elements of the same process aimed at understanding the fate of chemicals in the environment. Monitoring programmes tend to focus on the relatively mobile media air and water. Soils, sediments, and other solid substrates are often neglected (OECD, 1998 - see also chapter 3.6), although they can absorb pollutants, eventually becoming a long-term secondary source. Pollutant releases are triggered by changes in water chemistry or, in the case of river sediments, by storm-flow events and thus may escape monitoring programmes (Leeks and Jarvie, 1998). Monitoring chemical exposures from consumer products is also neglected. The Land-Ocean Interaction Study (Neal *et al.*, 1998) and a recent workshop, (OECD, 1998), have highlighted the importance of flexible environmental monitoring programmes and the importance of their proper design.

Models mainly serve two purposes:

a) to test hypotheses on the behaviour of natural systems, on the dispersion of chemical substances; and
b) to make predictions about the fate of chemicals using the tested hypotheses.

Besides mechanistic models, describing the migration behaviour of chemicals at a given site using site-specific data, multi-media models have gained importance (Figure 3.3.12).

A not yet fully explored application of MMMs is the coherence testing of environmental standards: permissible concentrations of contaminants in the various media are usually set without regard for each other and may not be achievable at the same time (Cowan *et al.*, 1995). MMMs will also help to set priorities for further research and to assess the value of proposed additional data generation. MMMs thus help to focus exposure assessment and monitoring programmes on that compartment or pathway with the highest predicted impact.

On a grander scale MMMs have been used to predict global dispersion of POPs using a chain of models arranged along a meridian (meridional model), simulating the ‘grasshopper effect’ (CCEC, 1997) and permitting estimation of the ‘recovery time’ of the environment following the phasing-out of a chemical (Mackay *et al.*, 1996).

5. The outlook to 2010

The use of certain chemicals is expected to decline over the next decade in the EU. However, a growth of 30% to 50% in chemicals output is expected for most of the EU countries by 2010 as a result of increasing economic activity, including road transport and agricultural production (European Commission, 1999; Table 3.3.2). This anticipated growth could accentuate concerns with respect to human and ecosystem health (see sections above). Considerable uncertainties exist over both the projections for emissions (and consequently concentrations and depositions levels) and the relationships between exposure and effects; emission uncertainties for dioxin, for example, range from 5 to 20.

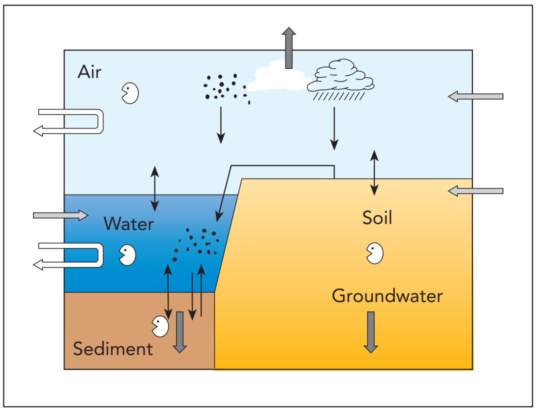
Nevertheless, it is important to consider the future trends for major groups of persistent chemicals because of the potential risk of significant impacts. Atmospheric emissions, concentrations and depositions have been modelled (European Commission, 1999) on a European scale for selected HMs, POPs, and for fine particulate matter (PM10). Emission estimates for 1990 have been prepared within the framework of the joint OSPARCOM-HELCOM-UNECE emission inventory (UBA-TNO '97) and are used to construct projections for the year 2010. More recent estimates from RIVM show slightly different emission levels for several substances. These are not used in this report because: a) the emission levels have not been evaluated in terms of state and impact indicators; and b) the documentation needs to be verified.

5.1. Emission trends of heavy metals

Phasing out leaded petrol (85/210/EEC) has, on average, more than halved lead emissions in the EU and the AC between 1990 and 1996, and further reductions are expected by 2010. The concurrent introduction of catalytic converters, however, will most likely result in increased platinum emissions, either through direct release or in the course of reprocessing.

Projections indicate that positive trends from abatement measures, such as improved efficiency and geographical coverage in recycling, are likely to be counteracted by a general increase in economic activity (European Commission, 1999). Thus the overall cadmium and mercury emissions are expected to increase in EEA countries by 26% and 30% respectively between 1990 and 2010

Pictorial representation of a multi-media model — Figure 3.3.12



Multi-Media Models (MMM) are based on the subdivision of a ‚unit-world' into representative fractions of relevant media, such as the air, surface and groundwaters, soil, and biota. Chemicals are distributed between the media according to certain physico-chemical properties.

Source: Cowan *et al.*, 1995

Examples of drivers for chemicals use and resulting exposure — Table 3.3.2.

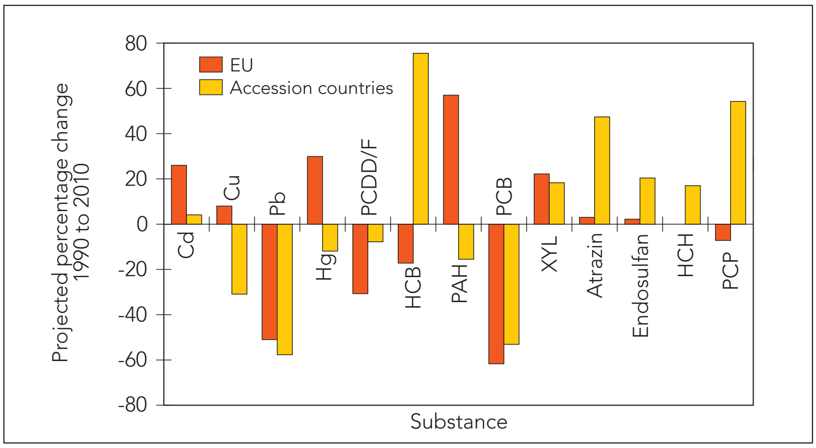
Main Drivers	Chemical	Source
Food production	Pesticides, Cd, Hg	crop treatment phosphate fertilisers seed treatment
Transport	Pb Pt, Pd, PAHs organics	petrol additive (in some countries); catalytic converters; incomplete combustion oil refining
Fuel conversion	PAHs, Cu, Cd, Hg, As	incomplete combustion fly ash
Mining, metals industry	Cu, Cd, Hg, As, Cd	ore processing zinc refining
Consumer goods and products (GDP growth)	Dioxins, furans	waste incineration

Source: EEA

(Figure 3.3.13). Copper emissions (mainly from mining and smelting activities) increase by 8% and are unevenly distributed between countries. Policies in the pipeline lead to an appreciable decrease in emissions of lead, copper and mercury in the Accession Countries, although cadmium emissions are expected to increase by about 4% due to an increase in road transport and growth of the chemical industry.

A reduction in the sulphur content of fuels (following EU legislation COM(97)88), and a switch from solid to liquid fuels (UNECE, 1998b) heavy metal (HM) and arsenic emissions will also be reduced, as these are frequently associated with pyrite, the main sulphur source in coal and lignite. Improvements in waste-water treatment techniques and the degree of water-treatment connections, as well as tighter controls on industrial discharges, have led to reduced HM river

Figure 3.3.13 **Projected percentage changes 1990 to 2010 in emissions of selected chemicals**

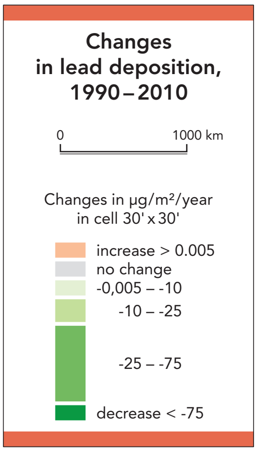


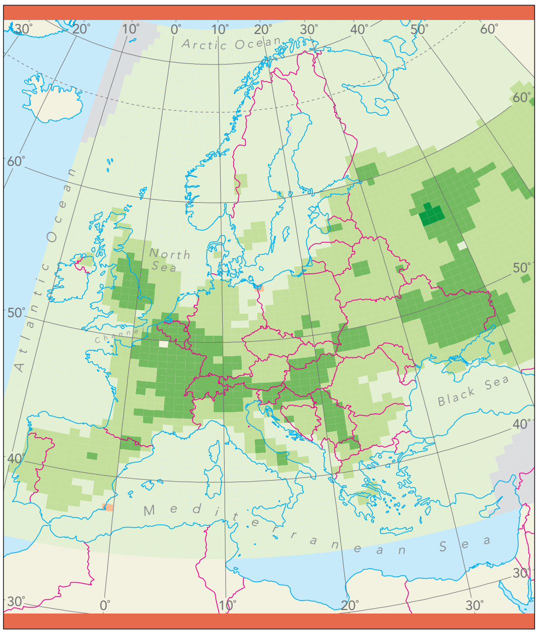
Source: European Commission, 1999

loads, but have exacerbated the problem of contaminated sludge disposal.

5.2. Emission trends of pesticides and persistent organic pollutants

Increases in general economic activity including agricultural production are projected to counteract positive trends from abatement measures (European Commission, 1999). Policy measures in the framework of the Integrated Pollution Prevention and Control (IPPC) Directive and its predecessors are expected to reduce emissions of dioxins/furans (from large-scale combustion plants) and of PCBs. Measures aimed at reducing energy consumption and/or improving conversion efficiency are also expected to have positive effects. In Western Europe anticipated growth in road transport is expected to increase PAH (for instance benzo[a]pyrene, Figure 3.3.13) and xylene emissions. In the Accession Countries this will be offset by the introduction of cleaner vehicles, although an expected increase in the annual volumes of incinerated waste will lead to increased emissions of HexaChloro-Benzene (HCB).





Map 3.3.1

Source: European Commission, 1999

5.3. Concentrations and deposition

Among the heavy metals, while significant declines can be anticipated for the rate of lead (Map 3.3.1), a substantial increase is expected in cadmium in the environment (Map 3.3.2). Atmospheric concentrations in the EU are projected to increase over the period 1990 to 2010 by about 38% and 31%. Countries, such as Austria, Italy, the Netherlands and Belgium, which had high concentration levels in 1990, are likely to substantially increase concentration levels by 2010. Other countries, such as Germany and Greece, with high 1990 concentration levels, should experience only marginally increased levels in 2010. The UK, France, and Spain, with below EU average concentrations in 1990, will be above this average in 2010.

For the EU as a whole, deposition levels of cadmium are predicted to increase from 0.26 to 0.34g ha/year, or 31%, between 1990 and 2010. For specific countries, only Finland, Sweden and Germany are likely to maintain stable or relatively stable deposition rates over the 20 year timeframe. In comparison, both Spain and Portugal should experience an increase of over 65% in deposition rates. In 2010, the countries with the highest deposition levels are predicted to remain the Netherlands, Austria, Italy, Belgium and Germany.

Dioxin atmospheric concentrations and depositions both are likely to decrease in the EU15, over the period 1990 to 2010 with the implementation of policies in the pipeline. Dioxin depositions will decrease by 10% between 1990 and 2010. The highest levels are predicted for the Netherlands, Belgium, Germany, France, UK and Northern Italy, but depositions will decrease quite rapidly (typically 40%) from 1990 to 2010 in the majority of these countries. In contrast dioxin depositions in Spain and Portugal are forecast to increase sharply, by a factor of 3. Nevertheless, north-west Europe will continue to have the highest deposition levels.

PAH atmospheric concentrations are likely to rise to 2010 (Map 3.3.3), owing to the increasing number of combustion sources (mainly transport-related internal combustion engines) or their level of activity. Diffuse and domestic sources are difficult to control, but certain practices, such as stubble burning, are already banned in several EU15 countries.

Pesticide concentrations and re-distribution processes, such as leaching to the groundwater, depend on the substance and the environmental properties. Lindane concentrations (Map 3.3.4) are expected to fall, following its widespread ban, while those of other pesticides are likely to rise as a result of increasing agricultural activity.

Human indoor exposure to POPs is strongly linked to personal activities and the availability and use of consumer products (cleaning fluids, air fresheners), and thus closely linked to GDP growth.

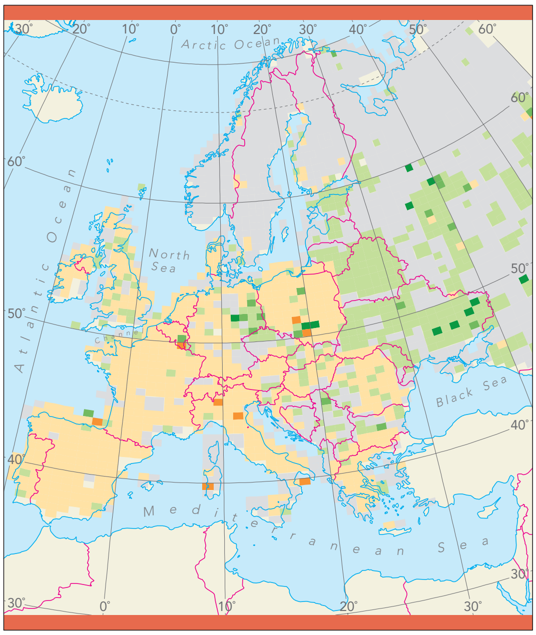
Bio-accumulation phenomena will continue as a result of redistribution processes for a long time after a substance has been banned from use.

5.4. Influence of main policies and distance to target

The ultimate objective of the 1988 Convention on Long Range Transboundary Air Pollution (regarding heavy metals and persistent organic pollutants) is the elimination of discharges, emissions and losses to the natural environment. In the first instance the amount of HM in applications with high emission factors during use should be reduced; a successful example is the replacement of lead or cadmium in pigments (UNECE, 1998b). A similar objective adopted by the parties to OSPAR of bringing discharges and emissions to near background levels for HMs and synthetic substances within one generation, however, is much more challenging.

The second Sulphur protocol, although not explicitly addressing HMs and arsenic, will to reduce their emissions from combustion sources. Improved controls of emissions to the air and water will reduce respective exposures, but generate potential secondary sources in the form of HM enriched wastes which have to be disposed of safely.

For many substances, including HMs and pesticides, target and/or action threshold groundwater concentration levels have been set at EU (for instance in the proposed Water Framework Directive) and at national



Changes in cadmium emissions, 1990 – 2010

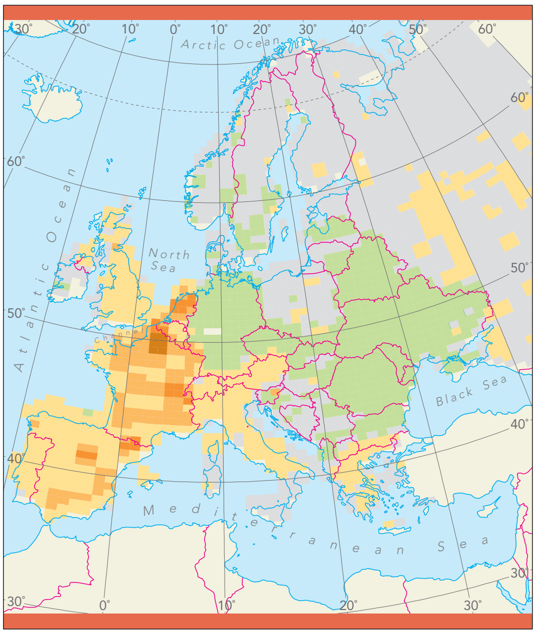
0 — 1000 km

Changes in kg/km²/year in cell 30' x 30'

- increase > 0.25
- 0.005 – 0.25
- no change
- -0.005 – -0.25
- -0.25 – -0.50
- decrease < -0.50

Map 3.3.2

Source: European Commission, 1999



Changes in benzo(a)pyrene emissions, 1990 – 2010

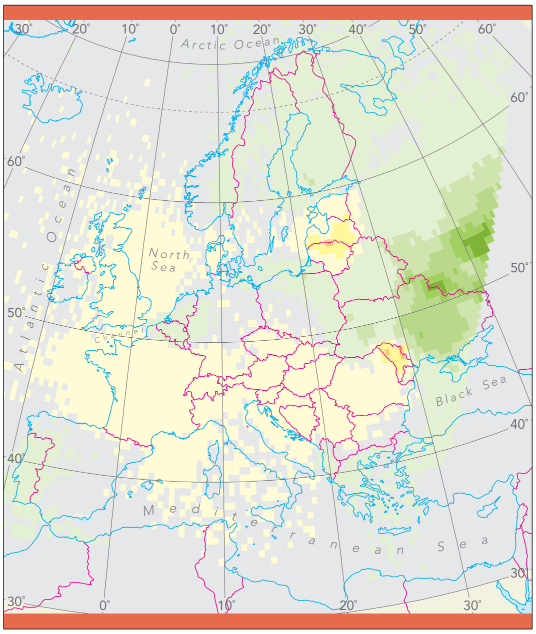
0 — 1000 km

Changes in kg/km²/year in cell 30' x 30'

- increase > 3.0
- 1.5 – 3.0
- 0.5 – 1.5
- 0.005 – 0.5
- no change
- -0.005 – -0.5
- decrease < -0.5

Map 3.3.3

Source: European Commission, 1999



Changes in lindane deposition, 1990 – 2010

0 — 1000 km

Changes in µg/m²/year in cell 30' x 30'

- increase > 50
- 25 – 50
- 0.005 – 25
- no change
- -0.005 – -25
- -25 – -50
- -50 – -75
- -75 – -100
- decrease < -100

Map 3.3.4

Source: European Commission, 1999

levels, but in some areas the specified standards may be difficult to achieve.

6. Emerging trends: minimisation of dispersion and substitution by less harmful substances

The currently rising chemicals intensity of EU GNP and the increases in some chemical emissions predicted in the "outlooks" section could well be reversed over the next decade if some recently agreed international and Member State policies on chemicals exposure reduction are implemented, such as the OSPAR/Sintra agreement and UNECE policies on POPS and Heavy Metals (EEA/UNEP, 1998).

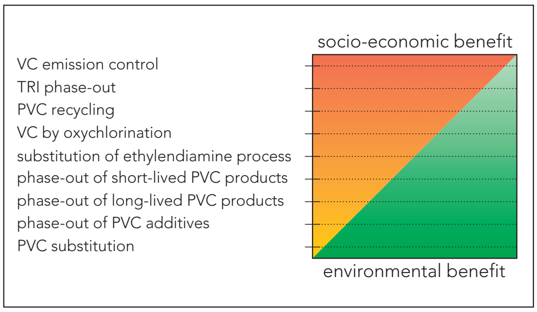
Other emerging trends that could lead to reductions in the quantities of chemicals produced and used in the EU include:

- the shift of low value bulk chemicals production to Asia and other areas, and an increasing EU focus on high value speciality chemicals;
- the green chemistry and other eco-efficiency developments described in Chapter 2.1;
- the replacement of chemical technology with biological technology;
- the internalisation of the environmental costs of chemicals into market prices, via taxes and other instruments (EEA/UNEP, 1998);
- the shift from products to services such as sales of degreasing services rather than solvents; and plant protection rather than pesticides (Seuring, 1994; Stahel, 1998);
- voluntary agreements such as in the Dutch chemical industry, and parts of the "Responsible Care" and "Sustainable Technology" programmes of CEFIC;
- EU investment in the production of less harmful products in the Accession and developing countries could remove environmental exposures in the EU from imported goods;
- increased information to the public and consumers, via toxic emissions inventories and product registers and labels;
- the development of toxic use reduction policies similar to those in the USA (Massachusetts and New Jersey) and Norway (REDUCE, 1998);
- increasing research and evidence on the harmful impacts to people, (particularly the foetus and children), wildlife, and ecosystems from multiple low-level exposures to chemicals and their break down products;
- increased use of the precautionary principle (Raffensperger, 1999; CECFSU, 1999).

In achieving reductions in exposures there must be a balance between the economic benefits of using hazardous substances and their impacts and risks to health and the environment. It is also important to carry out integrated environmental assessments of all measures banning or substituting substances: substitutes fulfilling the same function often are similar to, and give rise to the same problems as the original substance; or the cost of substitution may be disproportionate to the perceived benefit (Figure 3.3.14). Furthermore, a ban or substitution entails the problem of safe disposal or destruction of obsolete stockpiles. Alternative compounds may just shift the source of environmental pressure and may be more detrimental to the environment. Similarly, recycling does not always reduce overall human exposure and environmental impact because of higher emission factors during reprocessing.

Some of the emerging trends described above have been discussed during the current EU review of chemicals policies, and may be included in the proposed European Commission Communication on Chemicals, due in 1999.

Figure 3.3.14 **Qualitative representation of the socio-economic and environmental cost of interventions in the PVC product stream**



When considering the ban or replacement of substances in product streams the environmental and socio-economic consequences have to be analysed carefully. This has been done, for instance, in a study of the chlorine industry on behalf of the German Umweltbundesamt. A careful balance between expected benefits from measures and resulting costs is required.

Source: adapted from Wolff *et al.*, 1994; and Nolte and Jonas, 1992

References

Århus Declaration, 1998. Declaration by the Ministers of Environment of the Region of the United Nations Economic Commission for Europe (UN/ECE). 4th Ministerial Conf. "Environment for Europe" 23-25 June 1998, Rep. ECE/CEP/56.

Becher, H. *et al.*, 1998. *Risikoabschätzung für das Krebsrisiko von polychlorierten Dibenzodioxinen und Furanen (PCDD/Fs) auf der Datenbasis epidemologischer Krebsmortalitätsstudien*. Umweltbundesamt Report UBA-FB 97-110, Berlin, Erich Schmidt Verlag, 261 p.

Berg, M and Scheringer, M., 1994. *Problems in environmental risk assessment and the need for proxy measures*. Fresenius environmental Bulletin, 3, p 487-492. Basel

Bergbäck, B. & Lohm, U., 1997. "Metals in Society" Ch. 16 in *The Global Environment – Science Technology and Management*:. Eds.: Brune, D. *et al.*, Oslo/Weinheim, Scandinavian Science Publisher/VCH Verlagsgesellschaft, pp. 276-89.

Bernhoft, A., Øynstein, W. & Skaare, U., 1997. *Organochlorines in Polar Bears (Ursus maritimus) at Svalbard*. In *Environ. Poll.*, Vol 95(2), pp. 159-75.

Blomkvist, G. *et al.*, 1992. Concentrations of SDDT and PCB in Seals from Swedish and Scottish waters. In *AMBIO*, Vol 21, No 8.

Borrell, A. *et al.*, 1996. 'Evaluation of toxicity and sex-related variation of PCB levels in Mediterranean striped dolphins affected by an epizootic'. In *Chemosphere*, Vol. 32(12), p.2359-2369.

Borrell, A., Bloch, D. and Desportes, G., 1995. 'Age Trends and Reproductive Transfer of Organochlorine Compounds in Long-Finned Pilot Whales from the Faroe Islands'. *Environ. Poll.*, Vol. 88, pp. 283-92.

Bullek, D.A., Benjamin, S.L. and Dawson, T., 1991. 'Groundwater contamination by Atrazine and its metabolites'. In *Pesticides Transformation Products, Fate and Significance in the Environment*, ACS Symposium Series 459, Eds. Somasundaram, L. & Coasts, J.R. Washington, D.C. (ACS), pp. 254-73.

CCEC, 1997. *Continental pollution pathways*. Council of the Commission for Environmental Cooperation. Montreal

CECFSU, 1999. Background papers for the workshop in the Precautionary Principle. European Commission, Forward Studies Unit, Brussels.

Corvalán, C. & Kjellström, T., 1996. 'Health and Environment Analysis for Decision-Making'. In *Linkage methods for Environment and Health Analysis - General Guidlines*, Eds. Briggs, D., Corvalán, C. and Nurminen, M., Geneva, UNEP, WHO, USEPA, pp. 1-18

Cowan, C.E. *et al.*, 1995. *The Multimedia Fate Model: A Vital Tool for Predicting the Fate of Chemicals*. Soc. Environ. Toxicol. Chem., Pensacola, FL (SETAC).

Craig, N.C.D. & Guth, J.A., 1996. 'Pesticides and the North Sea'. In *Proc. Sci. Symp. North Sea Qual. Status Rep. 1993, 18-21 April 1994, Ebeltoft, Denmark* Eds.: Andersen, J., Karup, H. and Nielsen, U.B., Copenhagen, Danish EPA, pp. 105-8.

Denzer, S. *et al.*, 1998. *Proposal for a List of Priority Substances in the Context of the Draft Water Framework Directive COM(97)49FIN*. Fraunhofer Inst. f. Umweltchemie und Ökotoxikologie, Rep. 97/723/3040/DEB/E1, 69 p., Schmallenberg.

Dmuchowski, W. & Bytnerowicz, A., 1995. 'Monitoring Environmental Pollution in Poland by Chemical Analysis of Scots Pine (*Pinus sylvestris* L.) Needles'. In *Environ. Poll.*, Vol 87, pp. 87-104.

ECB, 1994. *Priority Setting Using the IPS Method: From IUCLID to IPS Ranking*. European Chemicals Bureau, Rep. XI/ECB/8883/93 (Rev.1), JRC Ispra, Italy.

EEA/UNEP, 1998. *Chemicals in the European Environment: Low Doses, High Stakes?* EEA and UNEP Annual Message 2 on the State of the Environment, Copenhagen, Geneva, 32 pp.

European Commission, 1999 (forthcoming). *Economic Assessment of Priorities for a European Environmental Policy Plan* (working title). Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environment, Nuclear Safety and Civil Protection).

Eurostat, 1997. *Material Flow Accounting – Experiences of Statistical Institutes in Europe*. 290 pp., Luxembourg, Statistical Office of the European Communities.

Fear, N.T. *et al.*, 1998. 'Childhood Cancer and Paternal Employment in Agriculture: The Role of Pesticides'. In *British J. Cancer*, Vol 77(5), pp. 825-9.

Feitjel, T. *et al.*, 1997. 'Integration of Bioaccumulation in an Environmental Risk Assessment'. In *Chemosphere*, Vol 34(11), pp. 2337-50.

Gerhold, S., 1997. 'Work on Material Flow Accounting at the Austrian Central Statistical Office'. In *Material Flow Accounting*, Eurostat, Luxembourg, pp. 23-24.

Gorter, J., 1997. 'Material Flow Accounting at Statistics Netherlands'. In *Material Flow Accounting*, Eurostat, Luxembourg, pp. 27-30.

Hansen, B. & Verburgh, J., 1997. *Overview of Industrial and Use Categories of EU H(L)PVCs*. 3rd Meeting of the Working Group on Exposure Assessment, Ministry of VROM, The Hague, 11 April 1997.

Harvey, R. & Jones, K.C., 1998. Ch. 1 in *The Handbook of Environmental Chemistry*, Vol. 3: Anthropogenic Compounds, Part I: PAHs and Related Compounds, Chemistry, Eds. Neilson, A.H. & Hutzinger, O., Berlin, Springer, pp. 1-54.

Hellsten, E., 1997. 'Material Flow Analysis in Sweden'. In *Material Flow Accounting*, Eurostat, Luxembourg, pp. 35-43.

Herpin, U., 1995. *Monitoring der Schwermetallbelastung in der Bundesrepublik Deutschland mit Hilfe von Moosanalysen*. UBA Texte 31/95, Berlin, Umweltbundesamt, 161 p.

Holland, A., O'Connor, M. and O'Neill, J., 1996. *Costing Environmental Damage: A Critical Survey of Current Theory and Practice and Recommendations for Policy Implementations*. European Parliament/STOA, Report PE 165 946/2, Luxembourg, EP/STOA, 78 + 18 p.

Howsam, M. & Jones, K.C., 1998. 'Sources of PAHs in the Environment'. Ch. 4 in *The Handbook of Environmental Chemistry*, Vol. 3: Anthropogenic Compounds, Part I: PAHs and Related Compounds, Chemistry, Eds. Neilson, A.H. & Hutzinger, O., Berlin, Springer, pp. 137-174.

ICC, Immission Control Committee of the Federal Government/Federal States 1996. *Determination of the Requirements to Limit Emissions of Dioxins and Furans*. UBA Texte 58/95, Berlin, Umweltbundesamt, 149 p.

Ifen, (French Institute for the Environment) October 1998. *Pesticides in Water.* Orléans, France.

IPCS, 1994a. *Environmental Health Criteria 152: Polybrominated Biphenyls*. WHO, Internatl. Progr. on Chemical Safety, 577 p.

IPCS, 1994b. *Environmental Health Criteria 162: Brominated Diphenyl Ethers*. WHO, Internatl. Progr. on Chemical Safety, 347 p.

IPCS, 1997. *Environmental Health Criteria 192: Flame Retardants: A General Introduction*. WHO, Internatl. Progr. on Chemical Safety, 133 p.

IPCS, 1998. *Environmental Health Criteria: Polybrominated Dibenzo-p-Dioxins and Dibenzofurans*. WHO, Internatl. Progr. on Chemical Safety.

Jarvie, H.P., Neal, C. and Tappin, A.D., 1997. 'European Land-Based Pollutant Loads to the North Sea: An Analysis of the Paris Commission Data and Review of Monitoring Strategies'. In *Sci. Tot. Environ.*, Vol 194/195, pp. 39-58.

Keith, L.H. & Telliard, W.A., 1979. 'Priority Pollutants I – A Perspective View'. In *Environ. Sci. Technol.*, Vol 13, pp. 416.

Kemi, 1996. *The Flame retardants project, Final report*. Swedish national Chemical Inspectorate. Solna.

Kleijn, D. & Snoejing, G.I.J., 1997. 'Field Boundary Vegetation and the Effects of Agrochemical Drift: Botanical Changes Caused by Low Levels of Herbizide and Fertilizer'. In *J. Appl. Ecol.*, Vol 34, pp. 1413-25.

Koss, V., 1997. *Umweltchemie*. Berlin, Springer, 288 p.

LAI, 1995. *Immissionswerte für Quecksilber/Quecksilberverbindungen – Bericht des Unter-suchungsausschusses ‚Wirkungsfragen' LAI*. Länderausschuß für Immissionsschutz, LAI-Schriftenreihe Vol 10, Berlin, Erich Schmidt Verlag, 47 p.

Land-Ocean Intereaction Study (LOIS) (1999), "LOIS Content", at URL: http://www.pml.ac.uk/lois/index.html, Last Modified: 17 March 1999 10:01:58 GMT.

Leeks, G.J.L. & Jarvie, H.P., 1998. "Introduction to the Land-Ocean Interaction Study (LOIS): Rationale and international context". In *Sci. Tot. Environ.*, Vols 210/211, pp. 5-20.

Lennartz, B., *et al.*, 1997. "Diuron and Simazine Losses to Runoff Water in Mediterranean Vinyards". In *J. Environm. Qual.*, Vol 26, pp. 1493-1502.

Lindholt, S., 1999. Unpublished report for the European Environment Agency based on CEFIC, 1998 . *Facts & Figures - The European Chemical Industry in a world wide perspective*. European Chemical Industry Council, 1998.

Mackay, D. *et al.*, 1996. "The Multimedia Fate Model: A Vital Tool for Predicting the Fate of Chemicals". In *Environ. Toxicol. Chem.*, Vol 15, pp. 1618-26.

Neal, C. *et al.*, 1998. 'Conclusion to Special Issue: Water Quality and Biology of United Kingdom Rivers Entering the North Sea: The Land Ocean Interaction Study (LOIS) and Associated Work'. In *Sci. Tot. Environ.*, Vol 210/211, pp. 585-94.

Nolte, R.F. & Jonas, R., 1992. *Handbuch Chlorchemie I: Gesamtstofffluß und Bilanz.* UBA Texte 55/91, Berlin, Umweltbundesamt, 460 p.

Nordisk Ministerråd ed., 1997. *Nordiska naturresurs- och miljöräkenskaper - delrapport II.* TemaNord, 1997:598, København, 143 p.

Nurminen, T. *et al.*, 1996. 'Exposure Assessment'. In *Linkage methods for Environment and Health Analysis - General Guidlines*, Eds. Briggs, D., Corvalán, C. and Nurminen, M., Geneva, UNEP, WHO, USEPA, pp. 55-67

OECD, 1998. *Workshop on Improving the Use of of Monitoring Data in the Exposure Assessment of Industrial Chemicals*, 13-15 May 1998, Berlin, Germany.

OECD, 1996. *Fertilizers as Sources of Cadmium*. Proc. Cadmium Workshop 16-20 Oct. 1995, Saltsjöbaden/ Sweden: 252 p., Paris, OECD.

Pacyna, J.M. & Lindgren, E.S., 1997. 'Atmospheric Transport and Deposition of Toxic Compounds'. Ch. 22 in *The Global Environment – Science Technology and Management*, Eds. Brune, D. *et al.*, Oslo/ Weinheim, Scandinavian Science Publisher/VCH Verlagsgesellschaft, pp. 386-407.

Quass, U. & Fermann, M., 1997. *Identification of Relevant Industrial Sources of Dioxins and Furans – Final Report*. Materialien, 43: Essen, Landesumweltamt Nordrhein-Westfalen.

Raffensperger, C. and J. Tickner, 1999 forthcoming (June). *Protecting Public Health and the Environment: Implementing the Precautionary Principle*. Washington, DC, Island Press.

REDUCE, 1998. *What is Reduce?* Reduce (AMVS), Floyveien,2, Arundel, Norway.

Renberg, I. *et al.*, 1994. 'Pre-Industrial Atmospheric Lead Contamination Detected in Swedish Lake Sediments'. In *Nature*, Vol 368(24.03.94), pp. 323.

Renner, R., 1996. 'Researchers Find Unexpected High Levels of Contaminants in Remote Sea Birds'. In *Environ. Sci. Technol.*, Vol 30, pp. 15A-16A.

Scheringer, M., 1997. 'Characterisation of Environmental Distribution Behaviour of Organic Chemicals by Means of Persistence and Spatial Range'. In *Environmental Science and Technology.* Vol 31 (10), pp.2891-2897.

Scheringer, M., Berg, M., 1994. 'Spatial and Temporal range as Measures of Environmental Threat', *Fresenius Environronmental Bulletin*, Vol 2, (8), pp. 493-498.

Seuring, S., 1994. 'Ertragsversicherung statt Pestizidverkauf'. In *Schr. Bayreuther Initiative f. Wirtschaftsökologie*, Vol. 1: *Kreislaufwirtschaft statt Abfallwirtschaft: Optimierte Nutzung und Einsparung von Ressourcen durch Öko-Leasing und Servicekonzepte.*. Ulm, Universitätsverlag Ulm, pp 217-8.

Stahel, W.R., 1998. 'Selling Performance instead of Goods', Paper to Dusseldorf Conference on Eco-efficiency, March, The Product Life Institute, Geneva.

Statistics Sweden, 1997. 'Hazardous Chemicals'. In *Material Flow Accounting*, Eurostat, Luxembourg, pp. 249-272.

Swedish Environmental Protection Agency, 1996. 'Swedish Environmental Protection Agency Home Page' at URL: http://www.environ.se/www-eng/enghome.htm.

Teknologi-rådet, 1997. *The non-assessed chemicals in EU*. Presentations from the conference 30 October 1996. Report of the Danish Board of Technology 1997/1. ISBN 87-90221-19-2.

Thyssen, N., 1999. 'Pesticides in groundwater: an European overview.' In IHOBE (ed.) Forum Book, 5th International HCH and Pesticides Forum. 25-27 June, 1998, Bilbao. pp 45-54.

UBA, 1997. *Daten zur Umwelt – Der Zustand der Umwelt in Deutschland, Ausgabe 1997*, Umweltbundesamt, Berlin, Erich Schmidt Verlag, 570 p.

Udo de Haes, H.A. & Voet, E. van der, 1997. 'Material Flow Accounting and Life Cycle Assessment'. Ch. 72 in *The Global Environment – Science Technology and Management*, Eds. Brune, D. *et al.*, Oslo/Weinheim, Scandinavian Science Publisher/VCH Verlagsgesellschaft, pp. 1151-71.

UNECE, 1998a. *Draft Protocol to the Convention of Long-Range Transboundary Air Pollution on Heavy Metals*. UNECE Rep. EB.AIR/1998/1: 36 p.

UNECE, 1998b. *Draft Protocol to the Convention of Long-Range Transboundary Air Pollution on Persistent Organic Pollutants*. UNECE Rep. EB.AIR/1998/2: 52 p.

UNEP, 1998. 'Persistent Organic Pollutants A Global Issue' at URL: http://irptc.unep.ch/pops/, Last Modified: 02 October 1998 09:15:58 GMT.

van Brummelen, T.C. *et al.,* 1998. 'Bioavailability and Ecotoxicity of PAHs'. Ch. 14 in *The Handbook of Environmental Chemistry*, Vol. 3: Anthropogenic Compounds, Part J: PAHs and Related Compounds, Biology. Eds. Neilson, A.H. & Hutzinger, O., Berlin, Springer, pp. 201-63.

van Leeuwen, J.C. *et al.,* 1996. 'Risk asssessment and management of new and existing chemicals'. In *Environmental Toxicology and Pharmacology*, Vol 2.

Visschedijk, A., Pulles, T., Coenen, P. and Berdowski, J., 1998. *Emissions of selected Heavy Metals and Persistent Organic Pollutants in Europe - A Background Study for the SoER98 and EU Priority Study Report*. TNO Report TNO-MEP-R 98, Apeldoom NL, 35 pp.

Wahlström, E., Hallanaro, E.-L. and Manninen, S., 1996. *The Future of the Finnish Environment*. Finnish Environment Institute, Helsinki, Edita, 272 pp.

Wallace, L., 1993. 'A Decade of Studies of Human Exposure: What Have We Learned ?". In *Risk Anal.*, Vol 13(2), pp. 135-9.

Wania, F. & Mackay, D., 1996a. 'The Global Fractionation of Persistent Organic Pollutants'. In *Environ. Sci. Technol.*, Vol 30, pp. 390.

Wania, F. & Mackay, D., 1996b. 'Tracking the distribution of persistent organic pollutants'. In *Environ.Sci. Technol. News,* Vol. 30, No 9.

Weybridge, 1996. *European Workshop on the Impact of Endocrine Disrupters on Human Health and Wildlife*, Report of Proceedings, Weybridge, UK, 2-4 December, 1996, EUR 17549.

Wolff, H., Alwast, H. and Buttgereit, R., 1994. *Technikfolgen Chlorchemie - Szenarien für die ökonomischen und ökologischen Folgen technischer Alternativen.*, Berlin/Stuttgart, PROGNOS AG/ Schäffer-Poeschel Verlag, 182 p.

3.4. Transboundary air pollution

Main findings

Transboundary air pollution (generated in one country and impacting in others) makes a major contribution to acidification and summer smog (caused by tropospheric ozone), and also to eutrophication of soil and water and dispersion of hazardous substances. The main sources of this pollution are energy use and transport in which international shipping is of growing importance. The cost-effectiveness of measures to reduce emissions from ships has been demonstrated by the European Commission in its strategy to combat acidification. However, sufficient measures are yet to be implemented.

Major emission reductions for sulphur dioxide and nitrogen dioxide adopted under the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and EU legislation have reduced the harmful effects of transboundary air pollution. Projected further reductions fall short of EU targets for 2000 and 2010 and further intiatives are needed in the framework of integrated abatement strategies.

Projections for 2010 suggest that, despite the projected emission reductions, areas of the EU and (especially) the Accession Countries will continue to be affected by acid and nitrogen deposition above the level defined as the 'critical load'. Ecosystems in the EU still receive 7% acid deposition and 39% nitrogen deposition above their critical loads. European countries where over 70% of ecosystems will still be affected by excess nitrogen deposition include the Czech Republic, Lithuania, Poland, the Slovak Republic and Switzerland.

With respect to ozone, despite the considerable efforts in precursor emission reductions, the long-term objective for protection of crops is expected to be reached only in the north-west parts of Europe (Ireland, Scandinavia). The health-related ozone threshold concentration will continue to be exceeded 50 days per year. The highest number of exceedances will be found in the more densely-populated north-western part of Europe (Netherlands, Belgium and northern France).

Moreover, despite reductions in precursor emissions, smog will remain a health threat due to increases in ozone worldwide: this calls for action on a global scale to reduce emissions of carbon dioxide, nitrogen oxides and methane.

1. Transboundary air pollution: a complex problem

1.1. It is all intertwined

Transboundary air pollution is a pan-European problem, requiring pan-European solutions. The main causes are emissions from transport and energy usage of sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and various toxic materials such as heavy metals and persistent organic pollutants (POPs). These pollutants (particularly carbon monoxide (CO) and methane (CH_4)) can remain in the atmosphere sufficiently long to be transported thousands of kilometres and thus to spread over the whole of Europe, across national borders, far from the original sources of polluting emissions.

The main effects are manifested in acidification of water and soil, summer smog caused by tropospheric ozone, eutrophication of soils and waters, and dispersion of hazardous substances (see also Chapter 3.3). The environmental impacts caused by the main pollutants SO_2, NO_x, VOCs, ammonia (NH_3) and toxic substances are summarised in Table 3.4.1.

Main air pollutants and their environmental impacts Table 3.4.1.

Environmental Impact	Caused by
Acidification	SO_2, NO_x, NH_3
Eutrophication	NO_x, NH_3
Ozone	VOCs, NO_x
Bioaccumulation of toxic substances	Heavy metals, POPs

Table 3.4.1 is of course a simplified summary, which abstracts from a reality of complex interactions. For instance, all the acidifying compounds are precursors of particulates which are harmful to human health, and VOC species such as benzene also have toxic effects and contribute to the formation of harmful particulates. VOC and NO_x emission controls vary in their effectiveness in reducing ozone concentrations. As a rule of thumb, ozone concentrations in highly polluted areas are most efficiently reduced by a combination of NO_x and VOC controls. In regions with low NO_x concentrations, both NO_x and VOC control reduces ozone levels but NO_x control is more effective. In parts of north-west Europe, reductions in NO_x emissions alone will actually *increase* ozone levels, although a reduction in NO_x emissions is still desirable to mitigate effects of acidification and eutrophication and to reduce ozone formation on the hemispheric and global scale.

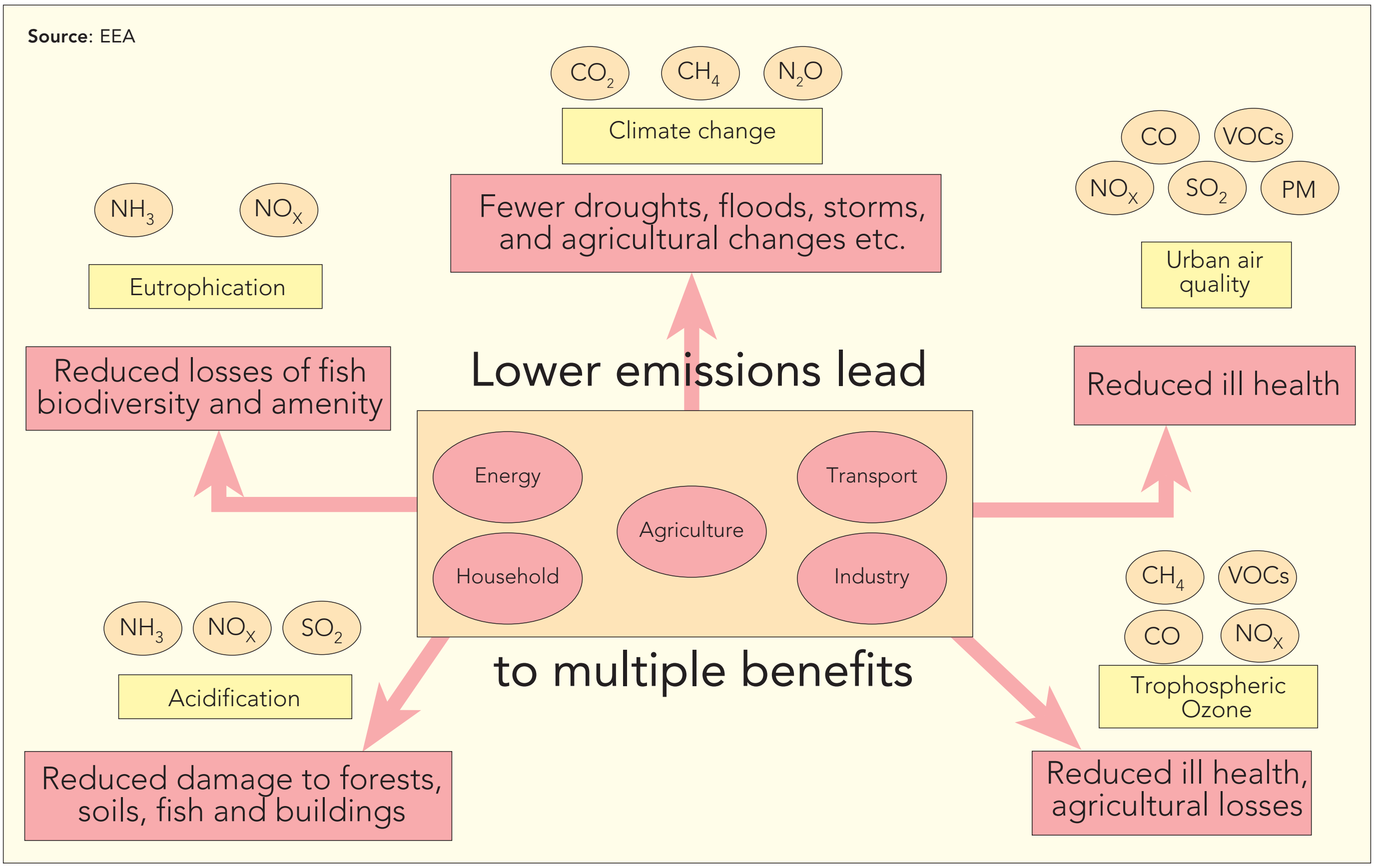
Further complicating factors are the multiple environmental impacts of human activities. Thus, for example, energy-saving measures to reduce CO_2 emissions and the ensuing pollutants released mitigate climate change (see Chapter 3.1) and also reduce SO_2, NO_x and CO emissions, with beneficial impacts on acidification, tropospheric ozone and urban air quality (Figure 3.4.1).

1.2. Targets and policies at European level

The UNECE Convention on Long-Range Transboundary Air Pollution (CLTRAP) signed in Geneva in 1979 was the first multilateral treaty concerning air pollution. It has provided an important demonstration that international co-operation can achieve results. During its first 10-15 years, the CLRTAP resulted in protocols aiming at a reduction in acidifying emissions and abatement of ozone concentrations. Protocols on heavy metals and persistent organic pollutants (1998) aim at a reduction of emissions of these toxic materials. A second protocol on NO_x and NH_3 emissions is under negotiation.

Parties to the CLRTAP were committed to a stabilisation of NO_x emissions at the 1987 level by December 1994. The VOC protocol signed in 1991 requires emissions to be either stabilised or reduced by at least 30% from the base year (usually 1988) in 1999. The second Sulphur Protocol signed in 1994

Figure 3.4.1 **Multi-pollutants, multi-effects**



has the objective to reduce the extent by which critical loads are exceeded in Europe by 60% in the year 2000; the various countries are required to reduce their emissions by different amounts. The Protocol also has obligatory clauses regarding emissions standards, including application of 'Best Available Technology' emission standards for new plants. A further requirement is a reduction in sulphur content to 0.2% and to 0.05% respectively in gas oil for stationary sources and in diesel fuel for road traffic.

EU limit, guide or target values for air quality concentration levels of pollutants including SO_2, NO_2 and ozone are now being revised through so-called 'daughter directives' to the Air Quality Framework Directive (96/62/EC).

The EU Fifth Environmental Action Programme (5EAP) set emission targets up to the end of the century for reduction of acidifying compounds and ozone precursors. Further targets, up to 2010, were proposed in the 1997 Community Strategy to combat acidification (European Commission, 1997; Table 3.4.2). This strategy emphasised the multi-pollutant multi-effect framework and showed that, in terms of cost-effectiveness, there is more potential for reducing sulphur rather than nitrogen emissions; this is because SO_2 is mainly emitted from a small number of relatively controllable large sources (power plants) whereas NO_x is also emitted from a wide range of smaller sources, including vehicles.

New strategies for emission abatement face the challenge of satisfying protection requirements from all inter-related effects caused by tropospheric ozone, acidification and eutrophication. The Commission is currently developing an ozone-abatement strategy. In line with the 5EAP, the aim is to address the 'symptoms' by setting interim and long-term air quality objectives and the 'causes' by developing strategies and measures to reduce polluting emissions and also to stimulate changes in society's patterns of behaviour. The new strategy will be linked with provisional national emission ceilings for SO_2, NO_x, NH_3 and VOC.

More specific measures for abating precursor emissions are defined in a number of EU Directives:

- Large Combustion Plants Directive.
- Directives on Sulphur Content of Certain Liquid Fuels.

EU air emissions reduction targets — Table 3.4.2.

	SO_2	NO_x	VOCs
5EAP	35% (1985-2000)	30% (1990-2000)	30% (1990-99)
CLRTAP	62% (1980-2000)	stabilise 1987 emission levels by 1994	30% (1987-99)
COM(97)88 (proposed targets)	84% (1990-2010)	55% (1990-2010)	

Source: European Commssion, 1997; UN-ECE CLRTAP, 1998

- Integrated Pollution Prevention and Control Directive.
- Implementation of measures developed through the Auto-Oil Programme:
  - A two-step tightening of vehicle emission limit values for passenger cars and light commercial vehicles with the first step in the year 2000 and the second step in 2005;
  - new environmental specifications for petrol and diesel fuels to take effect from the year 2000; very low-sulphur fuels to be mandatory from 2005;
  - provision made for earlier phase-in of very low-sulphur fuels;
  - phase-out of leaded fuels by 2000.
- The Solvent Directive and the Directive to reduce emissions from storage and distribution of petrol aim at reduction of VOC emissions from stationary sources and at all stages of the chain of petrol storage, distribution and usage.

Guided by the work done by the WHO on human-health effects and by UNECE on effects on vegetation, the Commission has proposed new ozone reference levels (Table 3.4.3). In addition to the long-term objective for the protection of human health, threshold values to inform both the general and informed population have been defined. For the protection of human health, short-term concentrations (peak values over one to eight hours) are of concern. For protection of agricultural crops and forests, ozone concentrations integrated over the growing season are of importance.

2. Trends in emissions

2.1. Emissions of sulphur dioxide (SO_2)

Since 1980, SO_2 emissions in Europe have been reduced considerably: by approximately 50% over the period 1980-1996 (Figure 3.4.2) although in comparisons between countries, allowance should be made for differences in initial emission rates and economic circumstances. In the EU, the 5EAP target of 35%

Table 3.4.3.

Ozone air quality reference levels proposed in the working EU draft Ozone Directive

Source: Europaen Commission, 1999b

Concern	Description	Metric	Value
Health	Long Term Objective value for the protection of human health	Moving 8 hours average concentration	120 mg/m³ *
	Alert threshold sensitive population	1 hour average concentration	180 mg/m³
	Alert threshold general population	1 hour average concentration	240 mg/m³
Damage to crops and vegetation	Long Term Objective value for the protection of vegetation	AOT40, May-July, 08.00-20.00 CET	6 000 mg/m³.h**
	Reference level concerning visible damage on forests	AOT40, April-September, 08.00-20.00 CET	20 000 mg/m³.h

Ozone concentrations integrated over a certain period of time are indicated as AOTxx-values where xx is a threshold value expressed in ppb (1 ppb O_3 = 2 µg/m³ O_3). The AOT40, for example, is defined as the sum of all excess concentrations above the threshold of 40 ppb (80 µg/m³). It is calculated by subtracting 80 µg/m³ from all hourly concentrations and subsequently summing all positive values.

* In addition to the Long-term Objective, a Target value has been proposed: by the year 2011 a daily eight-hour maximum of 120 mg/m³ may not be exceeded more than 20-25 times per calendar year averaged over 3 years. Current legislation (92/72/EC) has the limit value 110 mg/m³ average over a fixed eight -hour period.

** In addition to the Long-term Objective, a Target value has been proposed: by the year 2011 the AOT40 value may not exceed 18 000 mg/m³.h averaged over 5 years. Current legislation (92/72/EC) has the limit value 65 mg/m³ average over 24 hours.

reduction from 1985 levels by the year 2000 was met in 1994. EU emissions were reduced from 19 600 ktonnes in 1985 to 10 700 ktonnes in 1995. The reduction, which will continue, is expected to meet the commitments of the Second Sulphur Protocol.

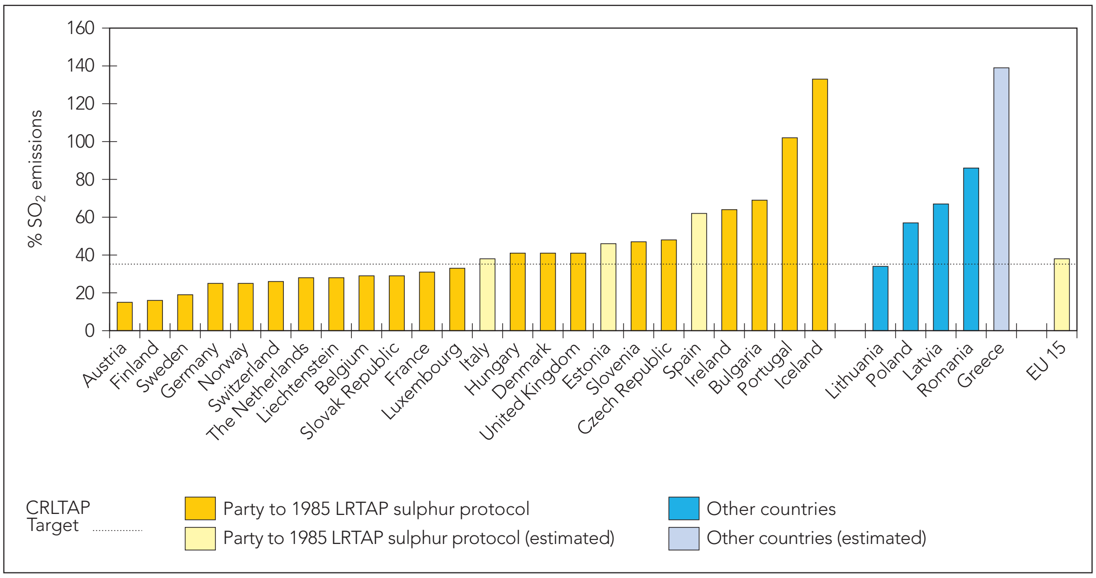
The decrease in emissions from the Accession Countries is most notable since 1990, largely caused by the economic reconstruction in these countries. Since 1994, the 5EAP target of 35% reduction has also been met by Accession Countries, as result of the general European overfulfilment of the 30% emission reduction objective set by the First Sulphur Protocol. At present, the relative reduction in emissions from the Accession Countries is similar to that in the EU, while their total emissions amounts to approximately one-quarter of EU emissions.

Figure 3.4.2

Sulphur dioxide emissions were strongly reduced between 1980 and 1996 (1980 = 100%)

In general, Parties to the 1985 LRTAP-Sulphur Protocol (on the left) have achieved a larger reduction than other countries (on the right). Data officially submitted is in dark colour, estimates are in light colour.

Source: EMEP/MSC-W, Report 1/98



2.2. Emissions of nitrogen oxides (NO_x) and ammonia (NH_3)

Emission targets for nitrogen oxides set in the 5EAP are far more restrictive than the stabilisation at 1987 levels required by the First NO_x Protocol of the LRTAP Convention. By 1994, the average NO_x emission reduction for the EEA and the Accession Countries was 13%, thus complying with the commitments of the First NO_x Protocol (Figure 3.4.3). However, the EU (which had a reduction of 11%) is unlikely to achieve the 5th EAP emission target for 2000 of a 30% reduction; in contrast, the Accession Countries have already met this target according to the most recent official emission estimate.

Reported ammonia emissions decreased by 14% in the EEA and the Accession Countries, from 5 000 ktonnes in 1990 to 4 300 ktonnes in 1996. Again, emission reductions in Accession Countries are considerably higher (28%) than those reported from the EU (8%). At present, there are no emission targets for ammonia, but these are expected to be specified in the new multi-effect multi-pollutant directives and protocols.

2.3. Emissions of volatile organic compounds (VOCs)

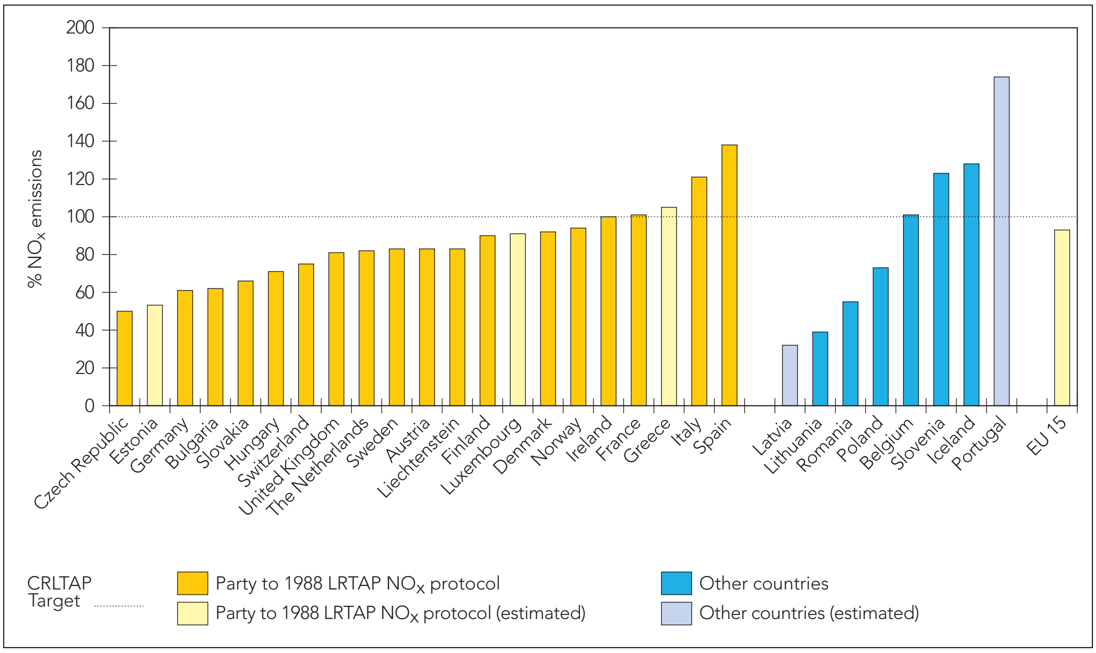
The requirements for reduction of emissions of non-methane volatile organic compounds (VOCs) by 30% in 1999 are different on the choice of the base year: 1990 for the 5EAP and 1987 for the VOC Protocol. For the year 1995, Accession Countries reported emissions well on the way to complying with the VOC Protocol, while VOC emission reduction in the EU amounted to 11% with respect to 1990 levels and 15% with respect to 1987 levels. EU emissions were reported to be 11 500 ktonnes in 1995, that is, six times higher than the reported emissions from the Accession Countries (Figure 3.4.4). Therefore, as in the case of NO_x emissions, it is unlikely that the 5EAP VOC target emission reduction can be reached by 1999.

In contrast to other pollutants, a large proportion of VOCs are emitted by natural processes. Biogenic VOC emission strongly depends on temperature. During ozone smog episodes, the natural contribution might be as high as 60% (Slanina *et al.*, 1998) while on an annual basis, biogenic emission contributes 40% of total VOC emissions over Europe (Simpson *et al.*, 1999).

3. Photochemical smog

Photochemical smog, or simply *summer smog*, is formed in the lowest few kilometres of the atmosphere. It has adverse effects on human health, agricultural crops, natural vegetation, and materials. The main component of smog is ozone, although levels of other aggressive oxidants are elevated as well. There is, however, only limited information

Compared with 1987 (=100%) emissions of nitrogen oxides in 1996 show a reduction in most countries. Figure 3.4.3



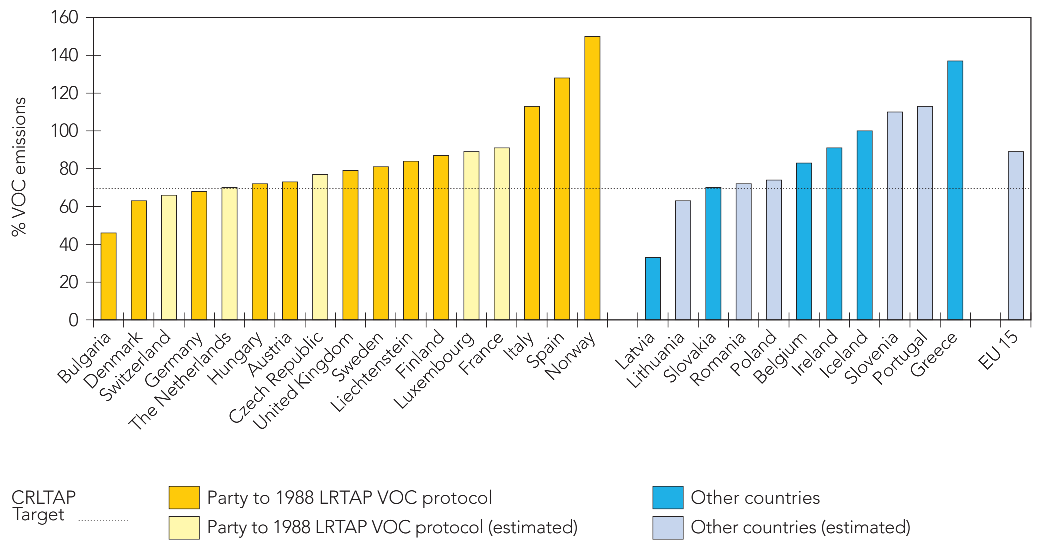
Parties to the 1988 NO_x Protocol of the Convention on LRTAP are on the left in the diagram. Other countries are on the right. Data officially submitted is in a dark colour, estimates are in a light colour.

Source: EMEP/MSC-W Report 1/98

Figure 3.4.4 **Compared with 1988 (=100%) most countries have achieved the reduction in VOC emissions**

Parties to the CLRTAP VOC Protocol are on the left (officially submitted data in dark blue, estimates in light blue). Non-parties to the Protocol are on the right (officially submitted data in yellow, estimates in brown).

Source: EMEP MSC-W Report 1/98



available on concentrations and effects of these other oxidants. As no significant effects have been observed at current ambient levels, no international guidelines have been set for the other photochemical oxidants found in summer smog.

Ozone and its precursors have an atmospheric residence time of several days or more. Under average summer conditions, air pollutants are transported over distances of 400-500 km per day. Besides the transboundary character, summer smog may show a more local character. For example, in the Mediterranean Basin, air masses re-entering the source regions have been shown to raise pollution levels (Millan *et al.*, 1997).

High levels of ozone occur during short periods of two to four days. Threshold values set for the protection of human health are exceeded regularly over large parts of Europe. Smog episodes are often found during summer over most parts of the continent, during periods with clear skies, increased solar radiation and elevated temperatures (Map 3.4.1). The occurrence and duration of these episodes varies strongly from one year to the next.

3.1. Accumulated exposure

Based on a series of controlled exposure experiments, the concept of AOT40 (accumulated ozone hourly concentrations above 80 µg/m^3) is chosen as an indicator for exposure of ecosystems. The great advantage of the AOT concept is that it is indicative of the ozone situation during the relevant growing season. The AOT is a practical indicator for ozone effects on vegetation. It must be realised, however, that it is only a first, crude estimate of the real ozone exposure of vegetation. Due to its simplifications, the link between AOT and actual vegetation damage might be weak.

First of all, the AOT gives a *potential* but not an *actual* exposure of vegetation. Under dry and hot conditions, the plant protects itself by closing its stomata. Although ozone concentrations are likely to be high under these conditions, the closed stomata prevent uptake of ozone and the damaging effects of ozone will be small. In the AOT concept this can be included by adding a constraint on relative humidity. This makes it, however, more complex and less transparent.

In the newly proposed daughter directive on ozone, the integration time of AOT is clearly defined: May to July using all one-hourly values measured between 8 AM and 8 PM CET. This period may differ from the active period of the plants. Daylight hours, defined as solar radiation above a certain minimum might be more appropriate. Also the growing season varies all over Europe and in places extends beyond the three months specified in the directive.

The simple and clear definition of AOT suggests that monitoring will be easy. Unfortunately, there are a number of complicating factors which make the observed AOT value sensitive to monitoring conditions:

- the measuring height: monitoring ozone at a height of 1 m (crops) or at 10 m (at crown level of trees) might result in a factor of 2-3 difference in AOT;
- missing data will lead to systematic underestimation of the AOT; an agreed correction method will be required.

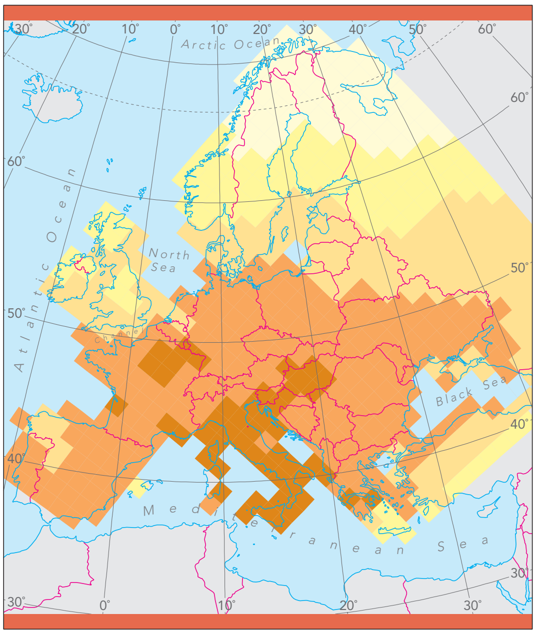
For practical reasons, the time resolution applied in the current atmospheric models is six hours, which is too coarse to calculate an AOT without further assumption on the diurnal variation of ozone. This problem will be solved in the next generation of models. Notwithstanding these drawbacks, the AOT40 is, according to current knowledge, the best indicator for vegetation exposure.

3.2. Threshold values for ozone are exceeded

All EU threshold values set for ozone under the current Ozone Directive (92/72/EC) have been exceeded since 1994, the year the Directive came into force. Thresholds set for the protection of human health and vegetation are exceeded in all Member States every year. Short-term thresholds for protection of vegetation and the threshold values for public information are exceeded in most Member States. The threshold concentration for warning the population is exceeded only occasionally (Beck *et al.*, 1998).

One of the 5EAP targets is that air quality guidelines recommended by the WHO should be mandatory by 1998. Routine monitoring (Hjellbrekke, 1997; de Leeuw and de Paus, 1998) indicates that the WHO value of 120 µg/m^3 eight-hour average is exceeded in all EU Member States and in all other European states which report data. Model calculations, allowing for estimation of exceedance in the whole of the European territory (Map 3.4.2) indicate that 99% of EU inhabitants are exposed to at least one exceedance per year. For the development of abatement strategies, the AOT60 (accumulated excess above 120 µg/m^3) has been taken as indicative of ozone health impacts.

According to WHO recommendations, the AOT40 for daylight hours in May-July should not exceed 6 000 µg/m^3.h for the protection of natural vegetation and the prevention of more than 5% crop yield loss (this is also the critical level for ozone protection of crops under CLRTAP). According to observations, this AOT40 parameter exceeds 6 000 µg/m^3.h in most of the EU, with the exception of northern parts of both Scandinavia and the UK (Hjellbrekke, 1997). Modelled results indicate that, averaged over five years, 94%

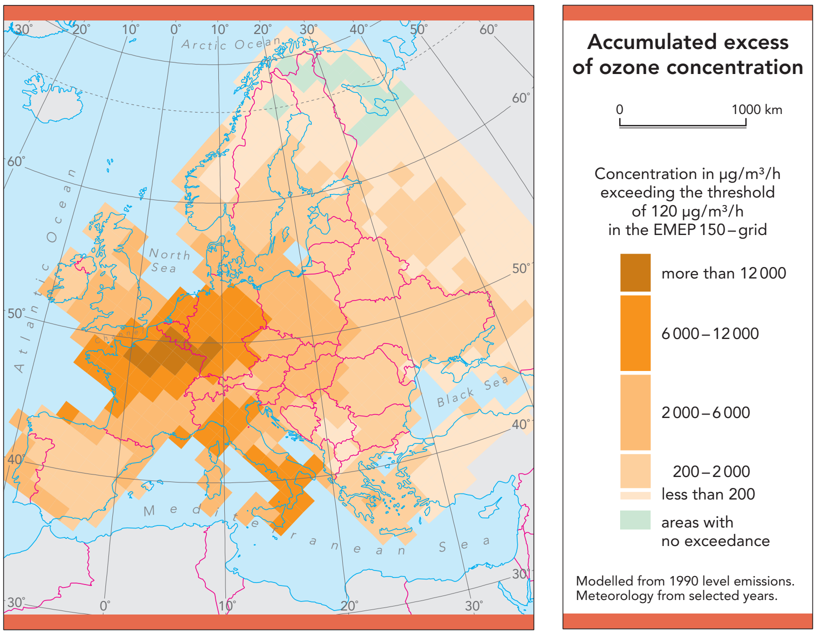


Map 3.4.1
The model indicates a clear gradient over Europe: summertime concentrations ranging from 60 mg/m^3 in the northern part to more than 100 mg/m^3 in the central part and in the Mediterranean region (1 ppb O_3 » 2 mg/m^3).

Source: Simpson *et al.*, 1997

of arable land is exposed to exceedance of this WHO guideline.

For protection of forests, the WHO and CLRTAP have set a guideline/critical level of AOT40, 24 hours, April-September of 20.000 µg/m^3.h. Both monitoring and modelled data indicate that Scandinavia, Ireland and the UK are below the critical level most years. In the rest of Europe, the level is exceeded by up to a factor of three. Calculations indicate that about 35% of Europe's



Map 3.4.2
Almost the entire population of Europe is exposed to ozone levels exceeding the WHO guideline for protection of human health. This map shows the average accumulated excess of ozone concentration above a level of 60 ppb (=120 mg/m^3) modelled over five years.

Source: Simpson et al., 1997

coniferous forests and 70% of broadleaf forests experience exceedances.

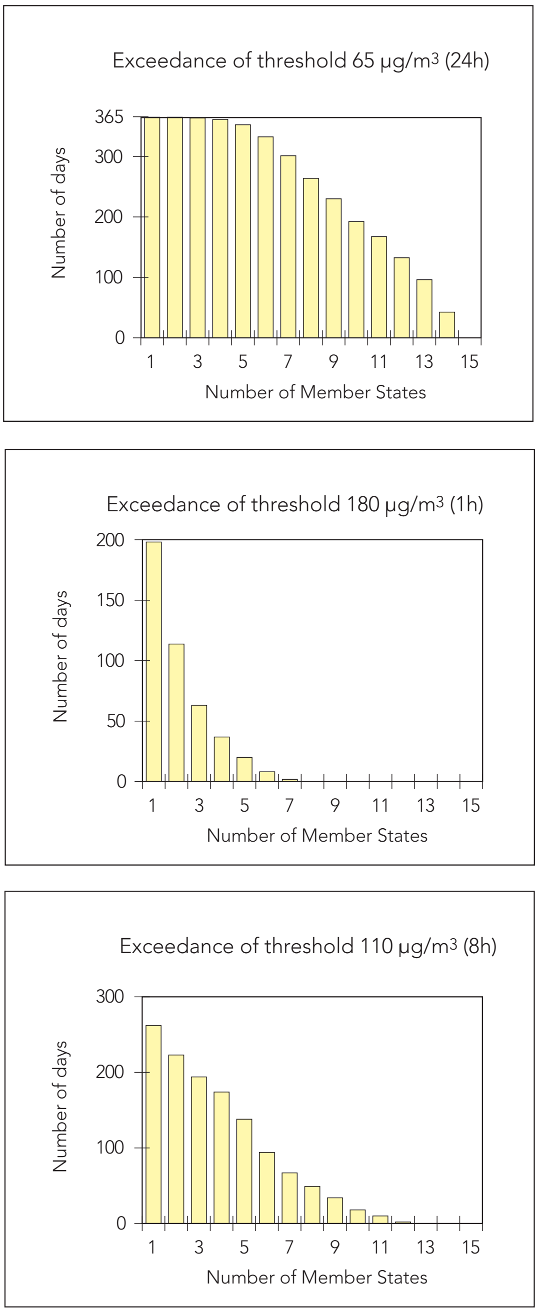
3.3. Ozone levels vary from year to year and over Europe

Ozone concentrations, particularly peak values, vary considerably from year to year due to specific meteorological conditions, whose occurrence is very variable in time and space (Figure 3.4.5). Typical variations from year to year for peak concentrations (98 percentile) are 10-15%, while AOT40 may show variations of about a factor of three.

Figure 3.4.5 **Threshold values defined in the EU Ozone Directive (92/72/EC) are exceeded frequently and widely**

This figure shows the number of days as a function of the minimum number of Member States where at least one exceedance of a threshold value was observed in 1997 (e.g. on 174 days the threshold value of 110 mg/m³ was exceeded in at least four Member States). Note: information on exceedances of 65 mg/m³ and 110 mg/m³ were submitted by 14 Member States only.

Source: de Leeuw and de Paus, 1998



Distribution of ozone concentrations over Europe also differs considerably from year to year. While the mean daily maximum value is highest in Italy and France, exceeding 104 μg/m³ (see Map 3.4.1), the AOT60 is highest in northern France, Belgium and south western Germany (see Map 3.4.2).

Average ozone concentration in summer shows an increase from north-west to central Europe. In mountainous regions, average ozone concentrations are higher than in lowland plains. There are indications, still to be confirmed over the long-term, that peak ozone levels are higher in southern Europe than in the north. Characteristics of ozone formation and transport in major Mediterranean cities and coastal areas differ from those normally occurring in northern continental areas (Millan *et al.*, 1997).

3.4. Present trends in ozone are small, and hard to detect

In the late 1990s, rural ozone levels are three times higher than in the pre-industrial era. Around the year 1880, average ozone levels at a rural site near Paris were about 20 μg/m³, but by 1950, rural ozone levels had increased to 30-40 μg/m³, and to 60 μg/m³ around 1980. However, trends in rural ozone in the last decade are statistically insignificant (Beck *et al.*, 1998). Studies are underway to try to explain these trends from the analysis of the trends in the emissions of ozone precursors (Lindskog *et al.*, 1998).

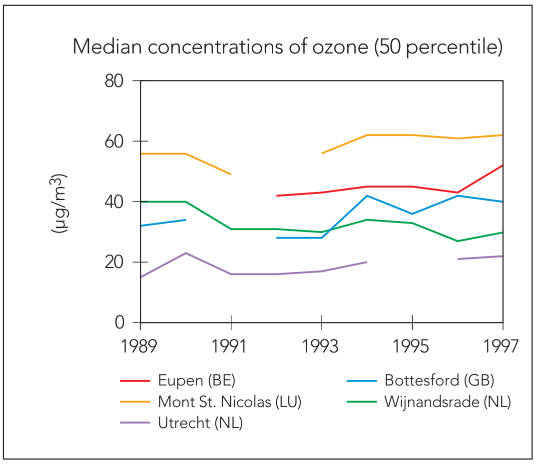
Trends in ozone episodes are even more difficult to assess because of annual variability of peak ozone concentrations (Figure 3.4.6). A recent analysis of peak ozone data submitted under the Ozone Directive (de Leeuw *et al.*, 1997) showed for 68 stations over the period 1989-1997 a significant upward trend at only two stations and a downward trend at 22 stations. For the majority of the 68 stations analysed, no significant trend was detected.

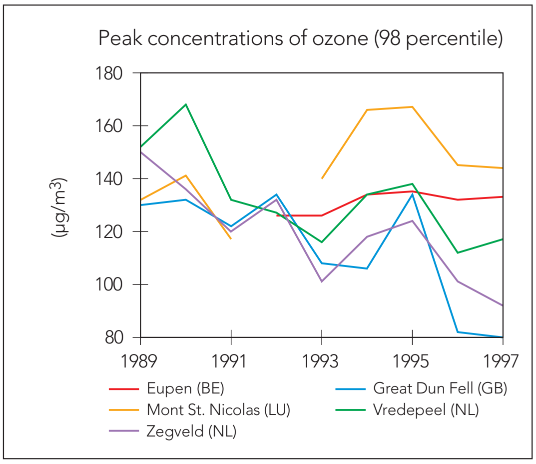
A detailed analysis of ozone data in the UK (PORG, 1997) showed a decrease in peak ozone levels. The hourly maximum ozone concentrations, averaged per month over the period 1986-1995, are 40-60 μg/m³ below that during the period 1972-1985. At nine out of 16 rural stations, there is however a significant positive trend in annual mean concentrations.

Urban ozone showed downward trends in Central London between 1973 and 1992, while monthly means increased by 15% per year at a suburban station in Athens in the period 1984-1989.

Ozone concentrations in 'unpolluted' air masses arriving over the North Atlantic region at the Irish station Mace Head appeared to increase over the 1990-1996 period with 0.18 µg/m³ per year equivalent to 0.2% per year (PORG, 1997). Model calculations on a global scale support the findings of an ongoing change in chemical composition of tropospheric background air (Parrish *et al.*, 1993; Collins *et al.*, 1998; Berntsen *et al.*, 1997; Hov and Flatøy, 1997). Current daily mean concentrations of ozone are three to four times higher than in the pre-industrial era mainly as a result of the considerable growth in NO_x emissions from industry and the transport sector.

Ozone concentrations differ widely between monitoring stations — Figure 3.4.6





The reason for this difference is the local impact of NO_x sources: in urban areas and especially in streets the locally emitted traffic emissions result in a temporary reduction of ozone levels. Further downwind, ozone levels will resume previous high levels.

Source: de Leeuw *et al.*, 1997

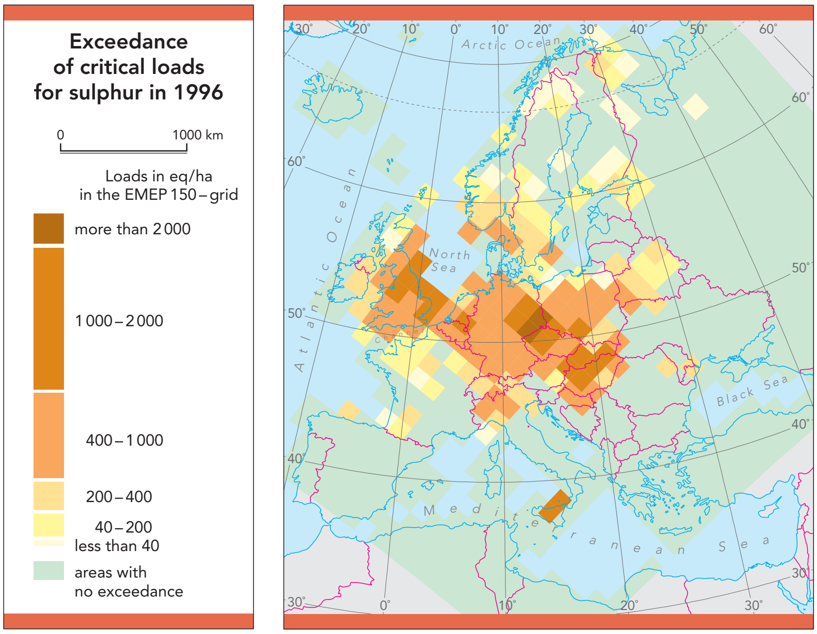
4. Acidification

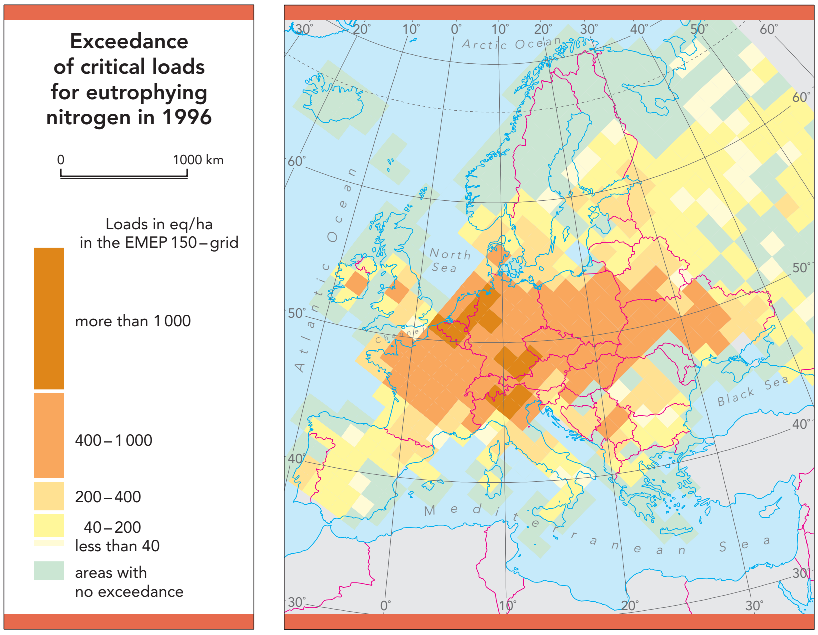
4.1. Critical loads

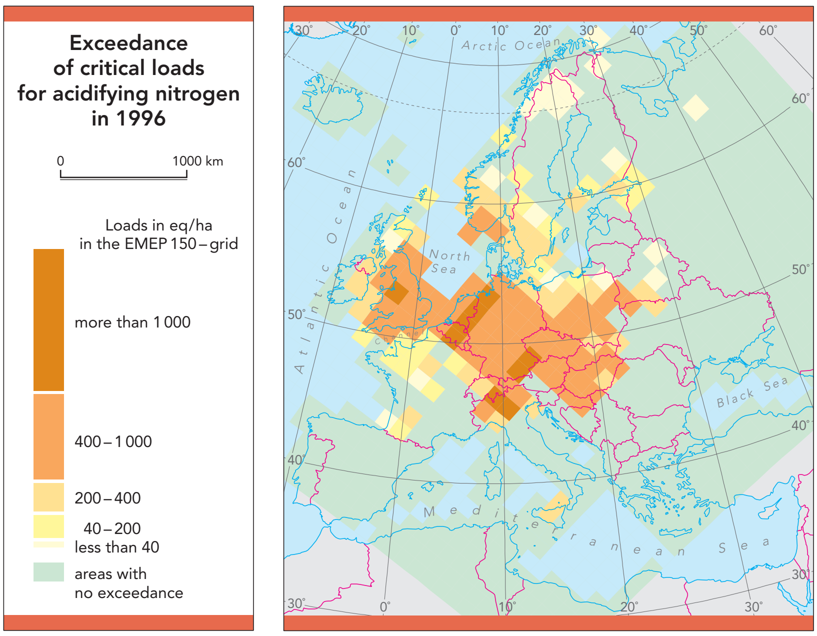
Acid deposition originates largely from man-made emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH3). Major sources of these pollutants are the usage of fossil fuels for power generation, transport and agricultural practice. Deposition of these three primary components and their secondary-reaction products leads to acidification (sulphur and nitrogen deposition) and euthrophication (nitrogen deposition). Acidification is causing damage to freshwater systems, forest soils and natural ecosystems in large areas of Europe. The effects of acidification have been evident in various different ways, including defoliation and reduced vitality of trees, declining fish stocks and decreased diversity in acid-sensitive lakes, rivers and streams and changes in soil chemistry. Nitrogen contributes also to the eutrophication of terrestrial and marine ecosystems and it is an important precursor of ground-level ozone. Along with these effects on ecosystems, there are also corrosion effects on materials, cultural monuments and buildings. In addition, there is growing concern about the adverse health effects related to secondary-reaction products of acidifying and eutrophying pollutants.

Since the signature of the 1979 LRTAP Convention, significant reductions in harmful emissions have been achieved. Increasing attention is now being given to the analysis of effects of emissions, in order to differentiate reduction commitments according to the varying sensitivity of the natural environment. There is now an increasing focus on the concept of 'critical load', defined as the highest deposition of chemical compounds that will not cause long-term harmful effects on the ecosystem structure and function, in order to target emission reductions towards the actual damage. The critical load depends on characteristics of the soil and ecosystem and varies strongly over Europe. Lake systems in Scandinavia are very sensitive (low critical load) whereas the Iberian Peninsula is less sensitive – partly because the deposition of base cations (e.g. Sahara dust) neutralises the acid deposition to some extent.

The effects of acidification on forests and freshwater ecosystems and the effects of eutrophication on terrestrial ecosystems are included in the present definition of critical loads. Other effects, such as corrosion damage to monuments, eutrophication of marine ecosystems, or health effects, are not included within the critical load approach. The new strategies for emission reduction face the challenge of satisfying protection requirements from all these inter-related effects.







4.2. Exceedances of critical loads

Sulphur and nitrogen deposition combined contributes to exceedance of critical loads (Maps 3.4.3, 3.4.4, and 3.4.5; excess deposition was calculated as the percentage of ecosystems in each grid with acid deposition above the critical loads, for scenario calculations in preparation for the Second CLRTAP Sulphur Protocol. The excess deposition over the fifth percentile was used as the main criterion driving emission reductions.)

Pollution 'hot spots' can be identified, such as the so-called Black Triangle (Box 3.4.1). Exceedances of critical loads of acidification and eutrophication over Europe are at present mostly dominated by nitrogen deposition, the relative importance of which is increasing, showing the need for a new nitrogen protocol. There are different ways to determine critical loads and their exceedances, because the amount of nitrogen deposition that an ecosystem may tolerate without harmful effects also depends on the level of the sulphur deposition and vice versa. The critical load function for each separate ecosystem can be approximated taking account of sulphur deposition, acidifying nitrogen and eutrofying nitrogen. Exceedances are recorded for each particular ecosystem whenever the actual depositions fall outside the function.

In preparation for the EU acidification strategy, an 'area of exceedance' (AE) concept was developed for scenario analysis. The alternative way to calculate exceedances was to consider the area occupied by the ecosystems, rather than the number of ecosystems with depositions exceeding their critical loads.

Recently, a further refined measure for evaluating ecosystem protection has been developed. The so-called 'average accumulated exceedance' (AAE) actually calculates the exceedance of critical loads for all ecosystems in a given grid cell (Posch *et al.*, 1997). Exceedances of individual critical loads are added for all ecosystems and averaged in terms of the area covered by each individual ecosystem in the grid cell.

Map 3.4.3

Map 3.4.4

Map 3.4.5

Source: EMEP

Box 3.4.1. Air pollution in the Black Triangle

On a Europe-wide scale, problems with acidification are most serious within the Black Triangle. Exceedances of critical loads show their European maximum over this area and they are primarily related to sulphur deposition, despite effective reductions in past years. The brown coal belt, which forms the heart of the Black Triangle, stretches from Lower Silesia (Poland) to Southern Saxony (Germany) and Northern Bohemia (the Czech Republic). It covers a mountainous area with 6.4 million inhabitants. Climate, soils, geomorphology, and geology vary substantially. Poor and acid soils are common and low levels of critical loads of sulphur characterise these areas.

The long-term annual precipitation totals are in a range of 500 mm in the basin to 1 350 mm at higher altitudes. Annually, there are more than 50 days of continuous fog and 70% of the days are cloudy. Situations of stagnant air often occur during winter, causing accumulations and the highest concentrations of air pollutants.

The intensive exploitation of lignite began in the 19th century and the development of mining, heavy and chemical industry intensified after World War II. The most dense concentration of large emission sources in the Black Triangle region is in industrial areas of Most, Chomutov and Ústí nad Labem in the Czech Republic and Zwickau, Chemnitz, Dresden, Plauen and Elsterber in Germany.

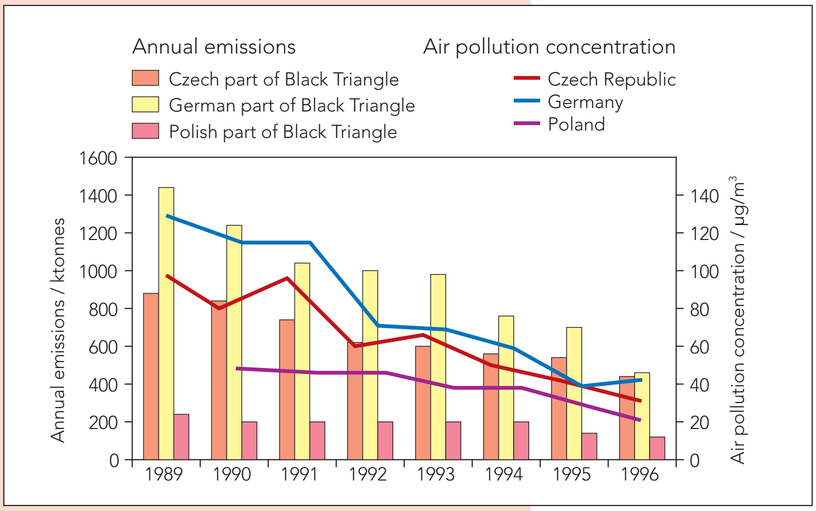
Between 1989 and 1996, the air emissions from the largest Black Triangle sources were reduced significantly (Figure 3.4.7). Sulphur dioxide emissions were reduced by 50% in Poland and the Czech Republic and to 30% in Germany. The nitrogen oxides emissions also decreased by 50% in the Czech Republic and Germany. The improvement of air quality in the Black Triangle region is the result of emission abatement of German and Czech sources, as well as the reconstruction of Turów Power Plant in Poland. There is also a remarkable decrease of coal consumption by small sources and households, due to substitution with gas and other types of fuel.

Concentrations of sulphate and nitrates in precipitation show decreasing trends similar to those for emissions and air pollution. However, the deposition of sulphur and other acidifying substances in the Black Triangle area is still fairly high (Map 3.4.6). Sulphur deposition is expected to further decline from about 9 g/m²/year in 1990 to 1 g/m²/year in 2010.

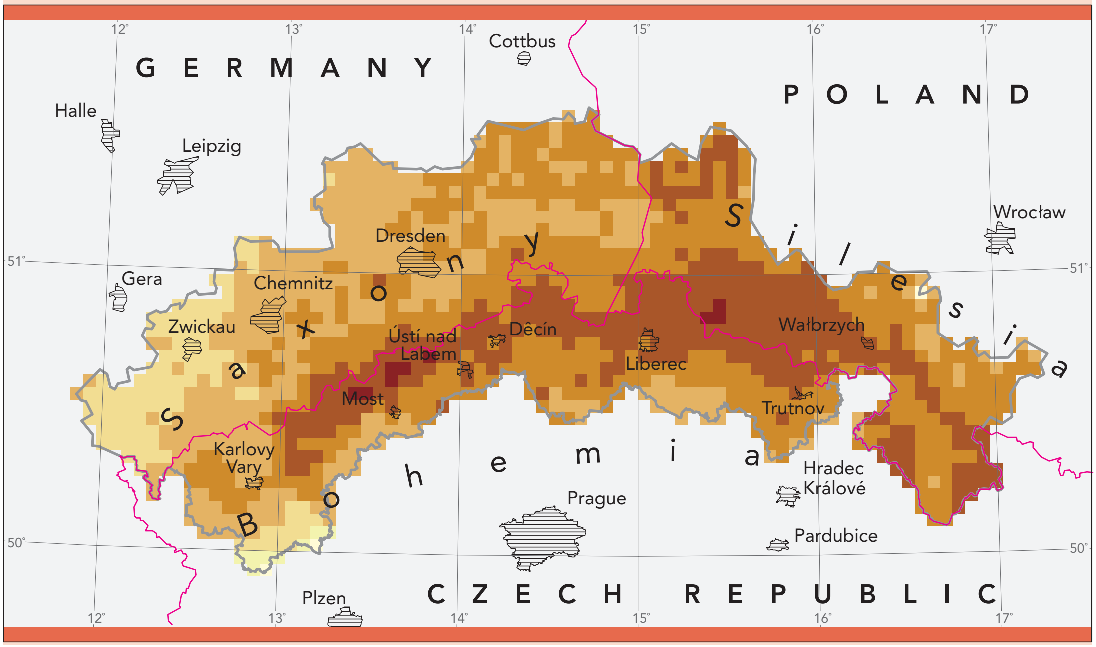
The long-term exceedances of critical loads by atmospheric deposition of sulphur are highest on top of the mountains. These are the areas with the worst forest damage. During the period 1972-1989, about 50% of the coniferous forests in the Ore Mountains disappeared. The most affected areas were on slopes facing south and south-east. The absolute deforestation rate decreased from 26.7 km²/year in the beginning of the period to 7.8 km²/year in 1989. Only 26% of the Bohemian forest, 45% of the Saxonian forest, and 22% of the Silesian forest remains undamaged (Hlobil and Holub, 1997). Air pollution has changed the ecosystem in North Bohemia, which resulted in soil acidification, loss of base cations, changes in plant community composition and forest damage. Deforestation negatively influences availability and quality of water and soil erosion.

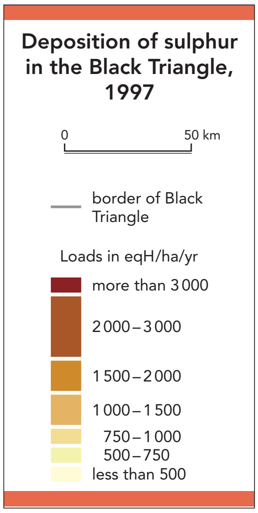
Time courses of total annual emissions and air pollution by sulphur dioxide in the Black Triangle

Figure 3.4.7



Source: PHARE Topic link - ETC/AQ





Map 3.4.6
The demarcation is that of the EU PHARE-funded Black Triangle Project
Source: Phare Topic Link/AQ

The various approaches to calculating exceedances of critical loads have implications for reaching the environmental goals set by present policies. The improved accuracy of the AAE approach allows quantification of environmental improvements that were largely underestimated by the calculations based on the AE of critical loads. For example, recent calculations (Amann *et al.*, 1998) indicate that scenarios aiming at a 90% reduction of the AAE exceedance of critical loads (90% AAE gap closure) did not reach a 50% reduction of the area exceedance in all places(50% AE gap closure), because the AE calculations had overestimated the actual exceedances.

The present critical loads evaluate damage to soils, vegetation and freshwater. The actual types of ecosystems considered in the calculations vary considerably from country to country. In all countries, the incorporation of other effects, such as adverse health effects or corrosion damage to materials in the critical load analysis is an important issue for integrated assessment, as new policies and responses will necessarily focus on the diverse effects of closely linked atmospheric pollutants. In addition, the consequences for the critical loads resulting from the interaction of different pollutants are not yet well understood. The study of damaging effects should combine the analysis of both tropospheric ozone and acidifying pollutants.

5. Effects on flora and fauna

The assessment of adverse effects on vegetation caused by ozone exposure is based on the critical level concept. In a series of international workshops organised under the auspices of UNECE CLRTAP, critical levels of ozone were agreed upon to prevent damage to the most sensitive crops, forests and natural vegetation.

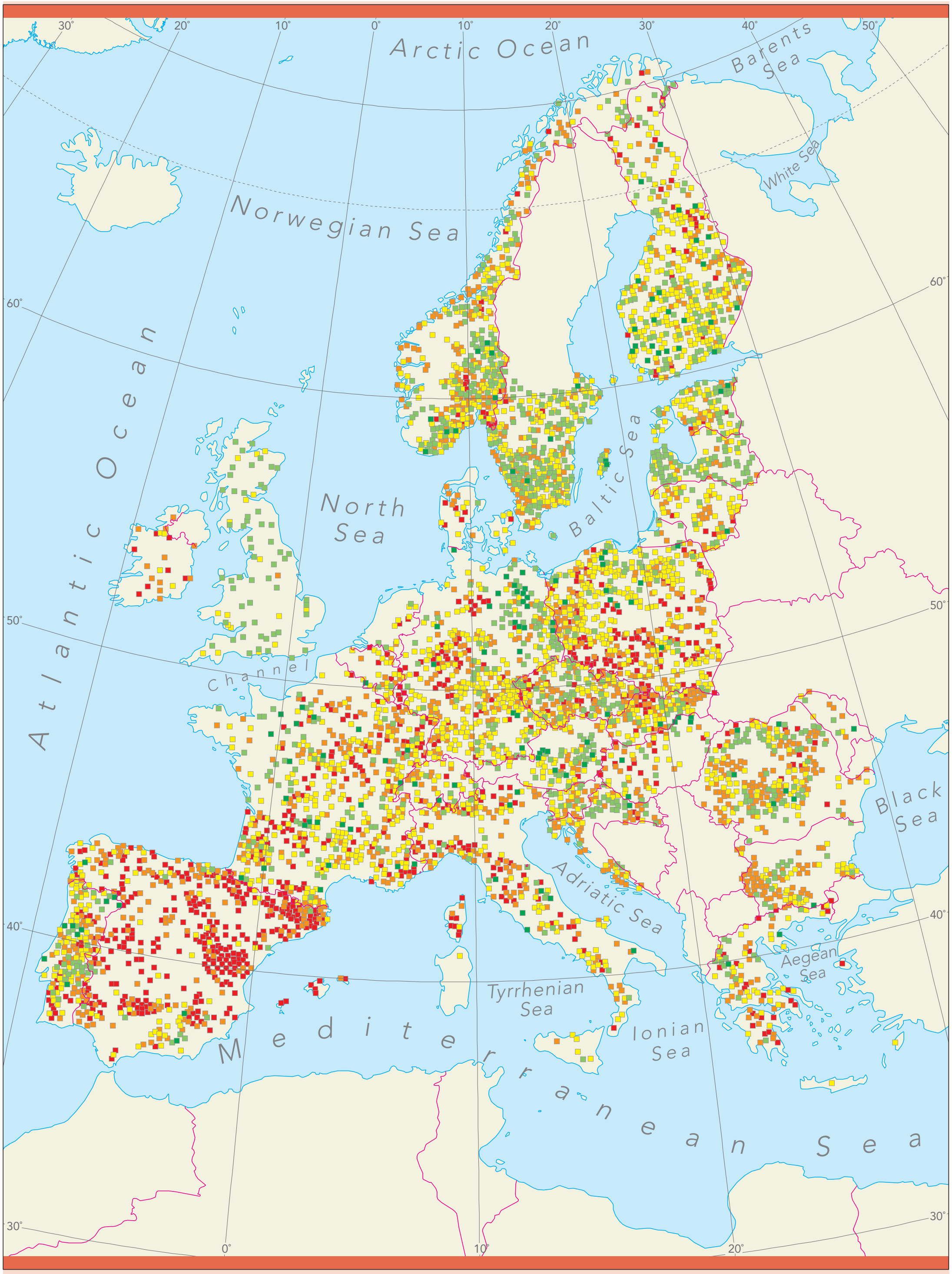
The UNECE International Co-operative programme on assessment and monitoring of air pollution effects on Forests (ICP Forest) has observed the forests of Europe where tree crown condition has been deteriorating on a large scale over several years. Distinct areas with heavily damaged trees exist in various parts of Europe (Box 3.4.2). The deterioration is most severe in the regions of central Europe where sulphur and nitrogen depositions are highest. In some of those regions, Scots pine recovered after a decrease in air pollution and improved weather conditions. Crown conditions are affected by many stress factors and the trends of the most common species are related to soil and humus types. However, large-scale deterioration over more than a decade is not readily explicable by natural stresses alone (UNECE, 1998). On a large scale, air pollution is considered as a predisposing or triggering factor (see also Chapter 3.11).

Nitrogen deposition affects ecosystems in particular in nutrient-poor areas. The increasing domination of grass species on many lowland dry-heathlands in western Europe can largely be attributed to the effect of excess nutrient deposition. There is in fact growing evidence that excess nitrogen input increases frost and drought sensitivity of heather.

Transboundary transport and deposition of heavy metals lead to accumulation of these metals in the ecosystem. Acidification also increases the bio-availability of metals. The long-term accumulation of metals in the topsoil and vegetation also leads to increased concentrations in animals. It may be concluded that high concentrations of cadmium and lead found in birds and mammals (reindeer, moose) in remote areas are attributable to long-range transport. The reported concentrations are below the lowest acute effect-levels but sub-lethal effects (impaired vision, co-ordination and body movement) might well occur (AMAP, 1997).

The tendency of persistent organic pollutants to bio-accumulate and bio-magnify results in significant exposure levels for organisms at highest trophic levels, such as humans and marine mammals. It is known that POP exposure affects reproduction either by diminishing survival of offspring or by disrupting reproductive function and reproductive cycles of adult animals (see also Chapters 3.3 and 3.11).

Short-term exposure of crops during smog episodes may lead to visible injuries. However, the largest effect on agricultural crops is caused by chronic exposure during the growing season which might lead to reduction in crop yield. For the Netherlands alone, it is estimated that a 30% reduction in average ozone concentrations during the growing season will yield an annual benefit of 200 million euros (Tonneijck *et al.*, 1998). This compares with an estimated cost of half a million euros per year.



Trend in defoliation for all tree species, 1989–1995

0 500 km

- significant improvement
- improvement
- no clear trend
- deterioration
- significant deterioration

Map 3.4.7

Source: SC-DLO

Box 3.4.2 Defoliation

There is a distinct cluster of deterioration in central and eastern Europe and in Spain. It is well known that the air pollution differs strongly between the two regions, indicating that other factors than air pollution alone must be responsible for the decrease. There is however, a clear coincidence between the high air pollution in central Europe and the high deposition of acidity. In this area critical loads are strongly exceeded (Klap et al., 1997). The temporal changes in defoliation for the Norway Spruce, one of the most common coniferous trees over Europe (Figure 3.4.8) shows a slow deterioration in crown conditions between 1989 and 1995 with a peak in 1992. The fraction of trees with a defoliation of more than 50% increased steadily over the period. The fraction of healthy trees (defoliation of 10% or less) decreased over the period from 47% in 1989 to 39% in 1995. However, the deterioration slowed down after 1992 with little change in crown condition occurring in the period 1993-1995 (see also Chapter 3.11).

As an example of a typical Mediterranean tree, the results for Holm oak (Quercus ilex) are shown in

... /...

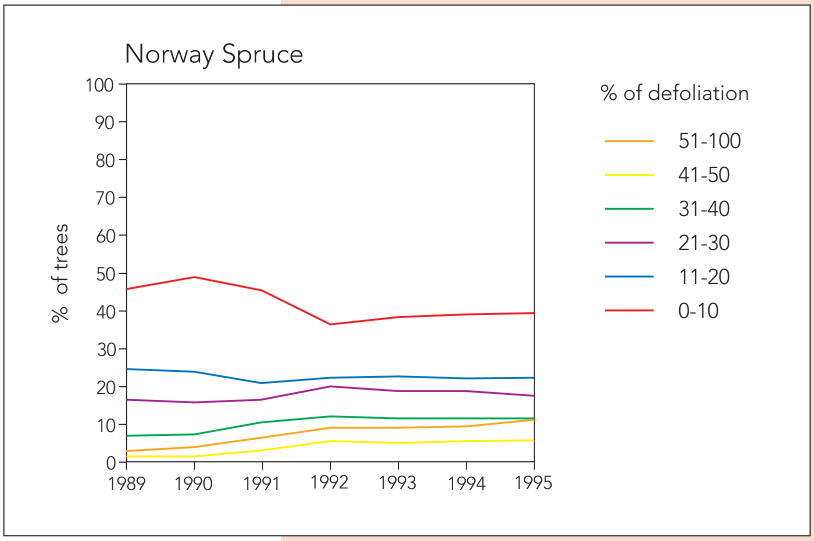


Figure 3.4.8
Temporal changes in defoliation for the Norway Spruce

Source: SC-DLO

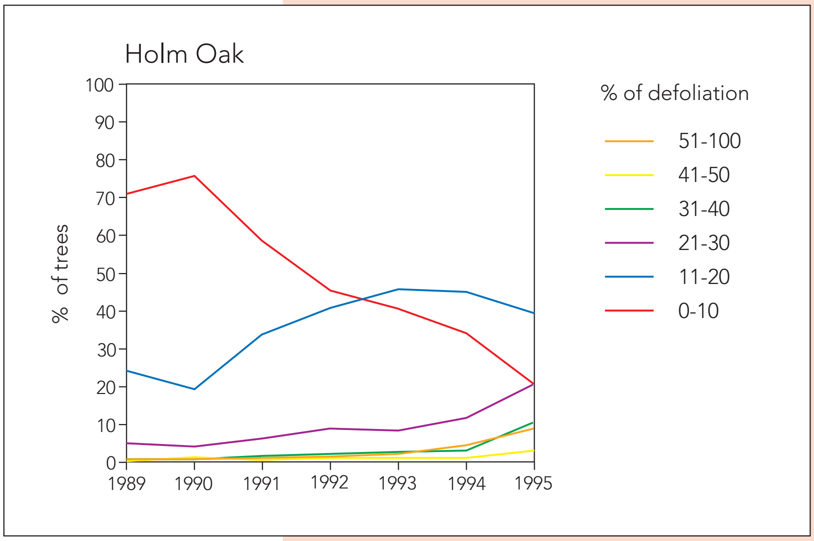


Figure 3.4.9. This species presents the most serious deterioration of all species considered by the UNECE International Co-operative programme on Forest. While crown condition improved between 1989 and 1990, it subsequently declined sharply. In 1989 more than 70% of Holm oaks were considered not defoliated whereas in 1995, nearly 80% of the trees showed some sign of defoliation (Müller-Edzards et al., 1997).

Figure 3.4.9
Temporal changes in defoliation for the Holm Oak

Source: SC-DLO

6. Future trends

6.1. Total emissions

Implementation of policies in the pipeline is likely to substantially reduce emissions in Europe by 2010 (European Commission, 1999). For the EU and AC10 combined the SO_2 emissions are expected to decrease by 65% in 2010 from 1990 levels. NO_x emissions are expected to decline by 40% and VOC emissions by 43%. It is anticipated that reductions in SO_2, NO_x and VOC emissions will be larger in the EU than in the Accession Countries (Table 3.4.4). The projected reduction in ammonia emissions is lower than for the other pollutants (14%). Germany and the Netherlands are projected to make significant contributions to these overall reductions. A small 1% reduction of NH_3 emissions is expected in the AC10 for the period 1990 to 2010, while substantial increases in NH_3 emissions are projected in some AC10 countries.

The implications of EU emission reductions against its targets are summarised in Table 3.4.5.

SO_2 emissions are mainly originating from the energy sector (power generation) and industry, while the most important sources of NO_x emissions are the transport sector followed by the energy and industry sector. The main source of NH_3 emissions is agriculture.

Under the baseline scenario, the share of SO_2 emissions from energy is projected to decrease, due to measures such as fuel shift from coal to natural gas, while the share from industry is projected to increase (Table 3.4.6). However, all sectors are expected to substantially decrease SO_2 emissions in absolute terms. Also, NO_x emissions from transport, energy and industry are projected to decrease substantially, resulting in a decrease in the share from transport. Only small reductions of NH_3 emissions from agriculture are projected under the baseline scenario.

Transport and other sectors, mainly solvent use in industry and households, are the main sources of NMVOC emissions. Under the baseline scenario, emission reductions are mainly expected in the transport sector, resulting in a lower share in 2010.

6.2. Emissions from the transport sector
The transport sector accounts for a substantial proportion of VOC and NO_x emissions, and is therefore a main contributor to the problem of tropospheric ozone and to a lesser extend acidification (EEA, 1998). Total passenger-km travelled is projected to increase by 40% between 1990 and 2010 (Figure 3.4.10) (the figures for the EFTA and AC10 are 230% and 115% respectively). A 50% increase is projected in freight transport tonne/km between 1990 and 2010; projections also show 85% growth in road freight with an increase in fuel consumption of 70% – indicating some gains in fuel efficiency (for further details of these projections, see Chapter 2.2).

6.3. Emissions from ship traffic
The European Commission's acidification strategy (European Commission, 1997) recognises the cost-effectiveness of reducing emissions from ship traffic in the North Sea and the north-eastern Atlantic Ocean relative to reduction of land-base emissions.

In absolute values, the emissions of SO_2 and NO_x from international ship traffic in 1995 were similar in magnitude to the contribution of individual large countries. The contribution of emissions from international ship traffic sources to the total deposition over western Europe is about 10-15% (Tsyro and Berge, 1997).

Projected emission reductions in Europe (in ktonnes) Table 3.4.4.

	EU15			Accession Countries		
Pollutant	**1990**	**2010**	**reduction**	**1990**	**2010**	**reduction**
SO_2	16 300	4 800	71%	10 300	4 300	59%
NO_x	13 200	7 300	45%	3 500	2 600	27%
NH_3	3 600	2 900	14%	1 400	1 390	1%
VOC	14 000	7 200	49%	2 600	2 300	10%

Source: European Commission, 1999

EU progress in achieving key EU environmental targets (1990 = 100) Table 3.4.5.

Acidification	target year	expected level in target year	target
SO_2 emissions	2000	53*	60
	2010	29	16**
NO_x emissions	2000	81*	70
	2010	55	45
NMVOC emissions	1999	81*	70

*) based on current reduction plans of Member States

**) proposed target within the Acidification Strategy (European Commission, 1977) will be revised in the forthcoming National Emission Ceiling Direktive, linked to the forthcoming combined EU ozone/acidification strategy.

Source: EEA

The relative importance of international ship traffic emissions will increase if no measures are taken to control this type of emission. Since the total reported emissions of SO_2 and NO_x in European countries decreased markedly from 1990 to 1995, the relative contribution of international ship traffic increased in the period to 3.5% for SO_2 and 7.5% for NO_x. If no further reductions are accomplished, it is expected that the relative contribution of emissions from

Contribution to EU emissions of SO_2, NO_x, NH_3 and NMVOC, per sector, in 1995 and in 2010 Table 3.4.6.

Sector	SO_2		NO_x		NH_3		NMVOC	
	1995	**2010**	**1995**	**2010**	**1995**	**2010**	**1995**	**2010**
Energy	58	49	19	19	0	0	0	0
Industry	25	32	12	17	2	2	8	13
Agriculture	0	0	0	0	94	95	*)	*)
Transport	7	7	63	55	4	3	40	29
Other	10	12	6	10	0	0	52*)	58*)

*) VOCs from agriculture is included in 'other'. The dominating contribution in the sector 'other' is from solvent use within industry and households.

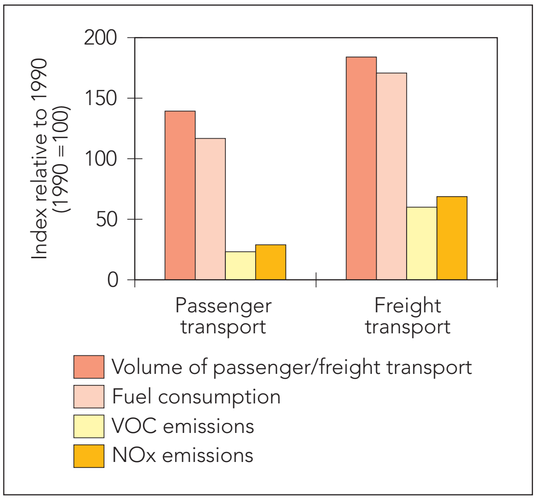
Source: European Commission, 1999

Figure 3.4.10

Indexed EU development of various road transport parameters in 2010, relative to 1990

Between 1990 and 2010, passenger and freight transport will grow by about 40% and 80% respectively. Consumption of fuel will grow less, with the introduction of more efficient engines. With the introduction of technical 'end-of-pipe' measures, a further reduction in emissions will be achieved. For NO_x and VOC, a reduction substantially below the 1990 levels is projected.

Source: European Commission, 1999



international ship traffic will have doubled by the year 2010 (Figure 3.4.11).

As a consequence, reductions of emissions from international ship traffic would translate into considerable reductions of the pressures/depositions in western European countries, with the additional advantage of reducing the costs for reaching the established environmental targets.

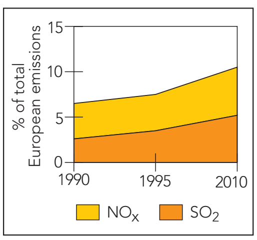
In 1997, the International Convention for the Prevention of Pollution from Ships (MARPOL) proposed a new protocol to reduce pollution from ships' exhaust emissions. Reducing emission from international ship traffic could be more cost-effective than reducing land-based sources (Amann *et al.*, 1997). The estimated savings are about 1 000 million euros/year. While the costs for limiting the sulphur content of marine bunkers in the North Sea and the Baltic to 1.5% (the maximum value accepted by MARPOL) were estimated at about 87 million euros/year, land-based sources would experience a decline in their costs of about 1 150 million euros/year.

Figure 3.4.11

Contribution from international shipping in the North Sea and north-east Atlantic Ocean to total European acidifying emissions

Nitrogen compounds and sulphur compounds each contribute about 50% to ongoing acidification.

Source: EMEP



These values are presently under re-evaluation, taking into account revised emission estimates calculated by Lloyd's Register of Shipping. Since the latest emission estimates are more than a factor of two larger than before, the estimated cost-benefit could be even higher than 1 000 million euros/year.

6.4. Emissions from aircraft

Although aircraft NO_x emissions are in absolute terms small when compared with the NO_x emissions from road transport, their impact on ozone formation is relatively large. In the main flight corridors about 1-4% of the ozone in the upper troposphere and lower stratosphere is formed from aircraft emissions (Brasseur *et al.*, 1998). According to aircraft scenarios the enhanced ozone formation will increase between 1990 and 2015 by 50-70% (Valks and Velders, 1999).

6.5. Damage to ecosystems and health

Under the baseline scenario, significant improvements in the area of ecosystems which are protected against acidification and eutrophication will be achieved (Figure 3.14.12). The acidification impact reductions are concentrated in northern Europe: the UK, northern France, Belgium, the Netherlands, Germany, Poland, Czech Republic, Slovak Republic and Austria (see section 4.3 in Chapter 3.11). For eutrophication, the improvements are more dispersed across Europe.

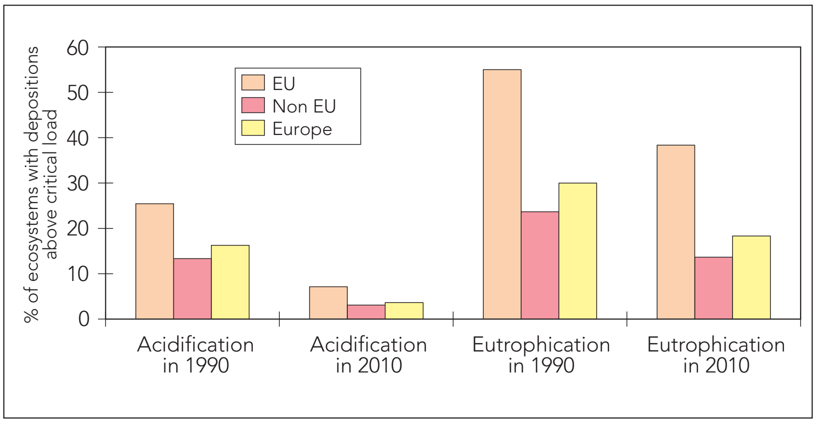
In the EU, ecosystems that receive acid deposition above their critical loads could decrease from 25% of the total (38.6 million ha) in 1990 to 7% in 2010 (10.6 million ha). Ecosystems in several countries, such as France, Ireland, Italy, Spain are virtually no longer exposed to exceedances of critical load. Other countries, where the proportion of ecosystems affected by acidification was high in 1990 show considerable improvement. In 2010, the two countries with the highest proportion of ecosystems affected by acidification remain Germany and the Netherlands, although considerable improvement will be experienced; there will be reductions from 84% above critical loads to 33% in Germany and 89% to 45% in the Netherlands.

In the AC10, the area of ecosystems with a deposition above the critical load for acidification could decrease from 44% of all natural and semi-natural ecosystems (18.1 million ha) to 6%. In Norway and Switzerland, these improvements are from 25% to 13% and from 38% to 4% respectively. Very large improvements in the impact of acidification are projected for some Accession Countries. For example, the proportion of ecosystems adversely affected by acidification drops from 91% to 19% in the Czech Republic, from 44% to 4% in Lithuania, and from 73% to 8% in Poland.

In the EU, the area of ecosystems that receives nitrogen deposition above critical loads for eutrophication could decrease from 55% (68.0 million ha) in 1990 to 39% in 2010 (48.8 million ha). Countries where a high proportion of ecosystems remains adversely affected by eutrophication in 2010 include Belgium, France, Germany, Luxembourg and the Netherlands.

Ecosystem damage in Europe: fraction of ecosystems with depositions above their critical loads

Figure 3.4.12



Source: European Commission, 1999

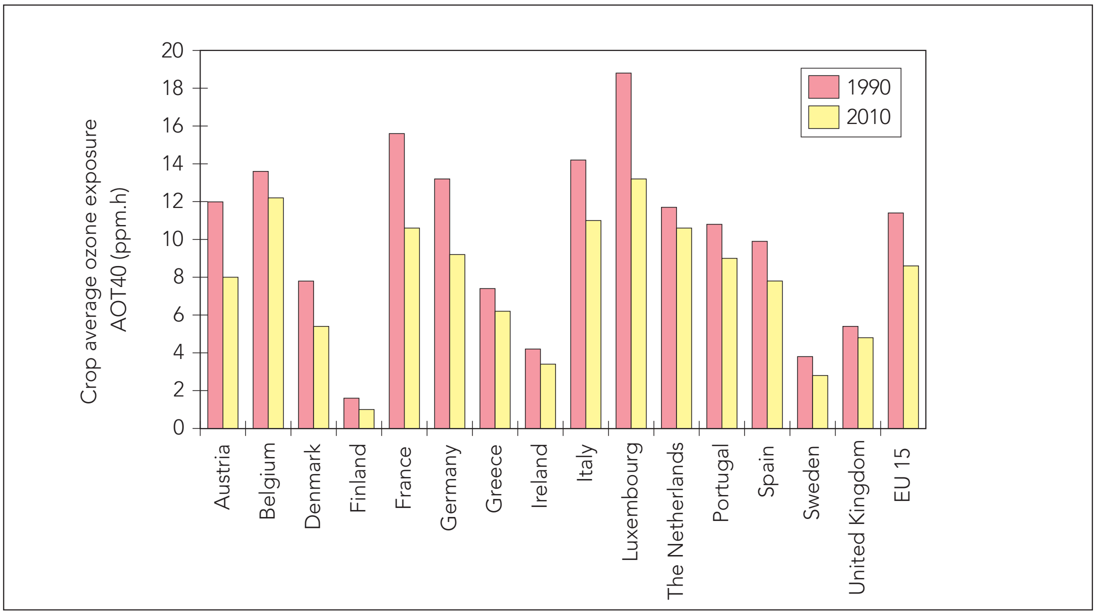
Eutrophication impact levels, however, remain high in most of the EFTA countries and in the AC10. In the AC10, the eutrophication indicator improves to a lesser degree from 84% of the area (33.4 million ha) having a nitrogen deposition exceeding the critical load to 72%. Countries where over 70% of ecosystems will still be affected by excess nitrogen deposition include the Czech Republic, Lithuania, Poland, the Slovak Republic and Switzerland.

With respect to ozone, the reductions in precursor emissions will lead to a reduction of about 25% in AOT40 levels for crops (Figure 3.4.13). Despite the considerable efforts in emission reductions, the long-term objective of 6 000 µg/m^3.h will only be reached in the north-west outskirts of Europe (Ireland, Scandinavia). The target value of 16 000 µg/m^3.h will still be exceeded in seven EU Member States.

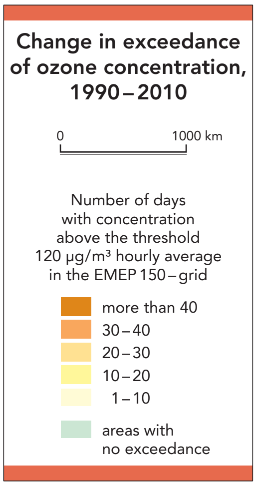
The reduction in the number of days with ozone above the health-related threshold of 120 mg/m^3 varies over Europe (Map 3.4.8). Under the assumption of the most unfavourable meteorological conditions, the number of days above the health-related threshold falls from 67 in 1990 to 49 in 2010. There is however, a shift in location: in 1990 the highest numbers of exceedances were found in southern Italy; in 2010 the highest number are found in the more densely populated north-western part of EU (the Netherlands, Belgium, and northern France).

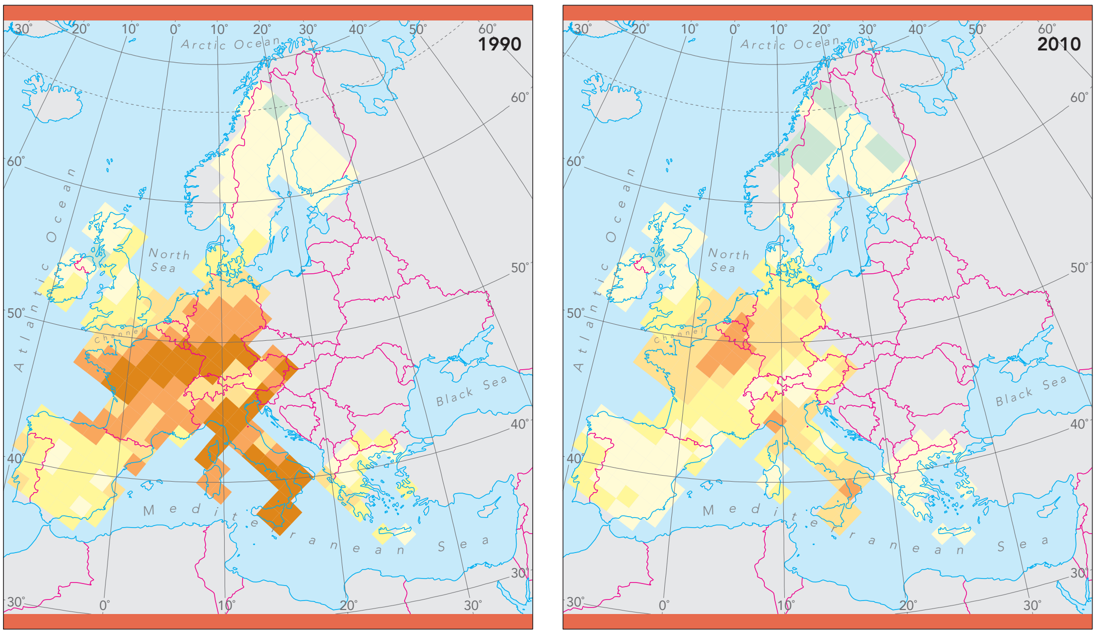
Reduction in exposure of crops in 2010 in EU compared with the situation in 1990

Figure 3.4.13



Source: EMEP





Map 3.4.8
Number of days the WHO criterion is exceeded for emissions in 1990 and for projected emissions in 2010. Calculations represent the maximum of the three-year moving averages for the five-year period considered

Souce: European Commission, 1999

7. Future acidification and summer smog policies

7.1. Emission-oriented policies

An optimal emission-reduction strategy requires coordination of SO_2, NO_x, NH_3 and VOC emission controls. At present, environmental problems are treated separately, so that acidification-related strategies emphasise reduction in SO_2 and nitrogen emissions, ozone-related strategies prioritise NO_x and VOC measures, while eutrophication strategies suggest the importance of NH_3 emission reductions. The focus on acidification abatement is presently on nitrogen compounds. NO_x emissions are major contributors to the acidification and eutrophication of ecosystems and are at the same time a precursor of ground-level ozone. This implies that any emission reduction scenario should combine the evaluation of the consequences on health and vegetation due to ozone exposure together with their impacts in acidification.

Both the EU and UNECE have been working since 1997 on a combined acidification/eutrophication/ozone abatement strategy, seeking cost-effective solutions to minimise the gap between critical load/level and ambient levels. With the use of the new AAE concept to calculate average accumulated exceedance to critical loads, significant and cost-effective reductions appear possible.

The analysis of all these effects combined increases the demand for further NO_x reductions, while the requirements on SO_2 and VOC controls are somewhat relaxed and the requirements for ammonia emission reductions remain almost unchanged (Amann *et al.*, 1998).

There is a – sometimes complex – relation between precursor emissions and environmental quality. If a target on environmental quality is set, such as full protection of all ecosystems from acidification, emission targets are implicitly set. So far, this interrelation has been included in the development of EU policies using expert judgements. Only recently have both the EU and UNECE adopted a broad approach which should help to abate the problems of acidification, eutrophication, as well as those of photochemical oxidants. This approach will seek to establish national emission ceilings for the relevant components that take into account the effect of the emission reduction in the various problem areas and the costs involved in emission abatement. For the first time, agreements on abating NH_3 emissions will be made at an international level.

7.2. Air quality, deposition standards, and target levels

For the air pollutants causing acidification and summer smog, the WHO has recommended air quality guidelines for protection of human health and ecosystems (WHO, 1995 and 1996 a, b). These recommendations are applied to policy use in the European Union as well as the UN-ECE. At present the EU Council of Ministers has agreed on a common position on the proposed daughter directives on ozone, PM10, SO_2, NO_2 and other pollutants in the framework of the Air Quality Framework Directive

(European Community, 1996). Once adopted, this will lead to more stringent air quality targets.

For ambient SO_2 and NO_2 concentration, targets have been set both for protection of human health and to avoid damage to ecosystems. Generally, the requirements on emissions reduction to meet the deposition targets are more stringent than reductions needed to meet the concentration targets. However, close to sources, high concentrations may occur, such as in an industrial area or in a very busy street (see Chapter 3.12). Current air quality thresholds for the EU are defined in the Ozone Directive (92/72/EC). In 1999, a new ozone daughter directive was proposed by the Commission. A similar situation to the case with acidification abatement (section 5 of this chapter) evolved in defining an ozone-abatement strategy in the EU. To attain ambient ozone concentrations at a level below which adverse effects on human health and ecosystems are unlikely: European-wide emission reduction of 80% or more will be needed. Even with major improvements in current technologies, this will hardly be achievable and large changes in societal behaviour would be needed. Therefore, interim target values have been defined, taking into account realistic options for emission abatement.

A monitoring strategy is defined in the Air Quality Framework Directive (European Community, 1996) and the proposed daughter directive on ozone. This strategy is designed to assess the current ozone levels relevant for human health and ecosystems but it can only partially answer other important questions:

- Is the ozone situation improving? Trends in ozone concentrations are obscured by the large year-to-year variations caused by different weather conditions. To detect a possible trend, long-term measurements of high quality are needed.
- Is there compliance with agreed emission reductions? Ozone is a secondary pollutant, in the sense that it is formed by chemical processes from other substances emitted to the environment. Information on its precursor levels cannot be detected by monitoring ozone. Moreover, there is a strong non-linearity between ozone levels and precursor emissions: for a certain reduction in ozone levels, at least a threefold reduction in precursor emissions is needed. Monitoring of NO_x and VOC in combination with ozone monitoring is needed to follow the implementation of abatement measures.

8. Emerging Issues

8.1. Global tropospheric ozone

During the summer, there is a general blanket of medium to high ozone levels over Europe at least twice as high as during the 1850s (EEA, 1998). These background levels frequently exceed the concentrations at which damage to vegetation is expected. Model calculations indicate that the increase in these tropospheric background concentrations will continue. The steady growth in ozone is caused by increases in background levels of nitrogen oxides, carbon monoxide, as well as methane (see for example Berntsen *et al.*, 1997).

Ozone precursors may be transported over distances of hundreds to thousands of kilometres, resulting in ozone formation far from its source. An abatement policy at European level is therefore a key issue. Long-range intercontinental scale ozone formation and transport in the lower troposphere has also been postulated (Parrish *et al.,* 1993; Collins *et al.*, 1998): fringes of ozone leaving the east coast of North America spread out over the North Atlantic towards Europe; the European ozone plumes stretch out eastwards over the continent and join with the ozone peaks over the densely populated areas in Asia. It might be that the global background increase partly reverses the advantages of a European reduction program. The overall success of pan-European abatement policies will depend on actions on a hemispheric scale, a European scale and an urban scale.

On a global scale, production and use of fossil fuels are important sources of methane and CO emissions. Biomass burning, waste treatment and intensive cattle breeding are additional sources. An overview of global emissions is presented in Table 3.4.7.

Calculations using global-scale models (Collins *et al.,* 1998) indicate that ozone concentrations within Europe are more or less stable. The reduced ozone formation caused by reduction in NO_x emissions within Europe appears to be just enough to counterbalance the increased ozone input from the global background. Actions on a global scale, in particular aiming at reductions of

Table 3.4.7.	Global emissions in 1990 (Tg)			
	Methane	CO	NO_x (1)	VOC (2)
Fossil fuel production and combustion	94	263	72	69
Biofuel	14	181	5	31
Industrial processes	0.8	35	5	34
Land use/waste treatment	211	496	20	44
Total anthropogenic	320	974	102	177.5
European contribution (%)[2]	25	15	26	21
Natural emissions	160	70-280	23-131	1100

(1) in Tg NO_2
(2) incl. Newly Independant States (of former USSR)

Source: Olivier et al., 1996; IPCC, 1996; EEA, 1995

emissions of CO, methane and NO_x will be necessary to control ozone concentrations in Europe.

Ozone is also a greenhouse gas. The increase in tropospheric ozone has potentially important consequences for radiative forcing (See Chapter 3.1).

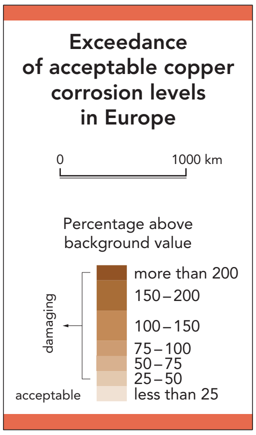
8.2. Is our cultural heritage more in danger than our ecosystems?

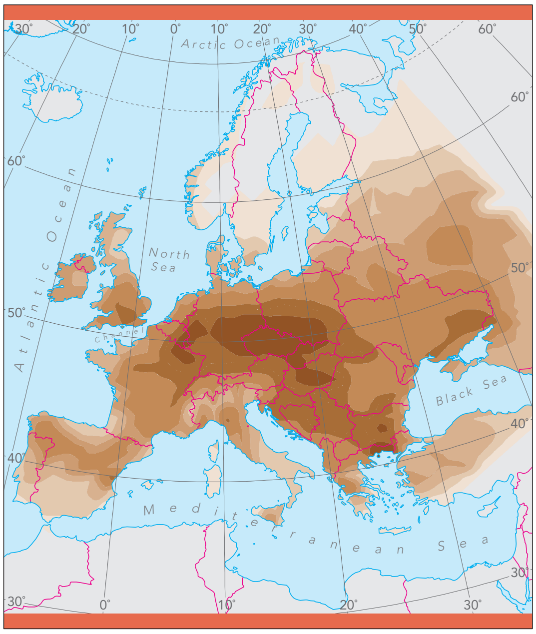
Exposure to acidifying and photo-oxidant air pollution increases the corrosion rate of materials. Gaseous SO_2 has been considered to be the main explanatory factor for corrosion damage to buildings and building materials. Ozone also affects materials such as natural and synthetic rubbers, coatings and textiles. Recently, synergistic effects of ozone in combination with the acidifying components SO_2 and NO_2 have been reported to lead to increased corrosion. This affects in particular the materials most widely used in our cultural heritage, such as marble, calcareous stone and rendering, medieval glass, copper, bronze and most construction metals.

Recent results (ETSU, 1996) indicate that the average cost of material damage is approximately 1 130 euros per tonne SO_2 emitted, which implies a total damage cost of 13.5 billion euros per year for the EU in 1995. This probably underestimates the cost of the damages if the enhanced corrosion levels resulting from the combined exposure to O_3 and acidifying compounds were to be considered. There are two main reasons for this expected underestimation. First, the combination of SO_2 and O_3 increases the actual corrosive attack on materials. Second, the geographical distribution of potential corrosion is expected to change when synergetic effects are considered. Introducing the effect of ozone will probably enhance the corrosion levels in southern Europe, that is, in areas with an extensive cultural heritage where the impact of corrosion will cause more damage.

The distribution of copper corrosion rates illustrates well the above-mentioned geographical effect of the combined exposure to SO_2 and O_3 air concentrations. Copper corrosion has been calculated from 1996 European levels of SO_2, NO_2 and O_3. The actual corrosion levels have been compared to the corrosion caused by exposure to background air concentration. Corrosion rates approximately 25% higher than background corrosion are considered acceptable, above this corrosion levels are considered damaging. Acceptable corrosion rates are exceeded all over Europe (Map 3.4.9), and decay rates are doubled in most central European regions. The substantial emission reductions during recent years have reduced corrosion damage in Scandinavia. In central Europe we still see the effects of high levels of SO_2 pollution in areas of Germany, Poland and the Czech Republic where the corrosion rate still is more than three times the general background for Europe. In southern Europe the increased corrosion rate is mostly generated by the high ozone level, although SO_2 may still contribute in some areas.

Comparing the geographical distribution of exceedances of acceptable corrosion rates





Map 3.4.9
Note that the calculation will underestimate the total corrosion in the larger cities.

Source: NILU

and the distribution of exceedances of critical loads for acidification and eutrophication brings the focus towards southern and eastern Europe. This introduces new elements in the discussion of the harmful effects of transboundary air pollution that will be worth analysing in the future.

References

Amann, M. *et al.*, (1997) Cost-effective Control of Acidification and Ground-Level Ozone. Second Interim Report, IIASA, A-2361 Laxenburg Austria.

Amann, M. *et al.*, (1998) Cost-effective Control of Acidification and Ground-Level Ozone. Fifth Interim Report, IIASA, A-2361 Laxenburg Austria

AMAP (1997) Arctic Pollution Issues. A state of the Arctic Environment Report. AMAP, Oslo, Norway.

Beck J.P., Krzyzanowski M. and Koffi B. (1998) Tropospheric ozone in the European Union. *'The consolidated Report',* European Commission Brussels. Also available at http://eea.eu.int.

Berntsen, T.K. *et al.* (1997) Effects of anthropogenic emissions on tropospheric ozone and its radiative forcing. *J. Geophys. Res.* 102, 28101-28126

Brasseur, G.P. *et al.*, (1998) European scientific assessment of the atmospheric effect of aircraft emissions. *Atmospheric Environment* 32, 2329-2418.

Collins W.J., Stevenson D.S., Johnson C.E., and Derwent R.G. (1998) The European regional ozone distribution and its links with the global scale for the years 1992 and 2015, to be published.

De Leeuw F., Sluyter R. and van Zantvoort E. (1997) Air pollution by ozone in the European Union; exceedances of ozone threshold values in 1996 and summer 1997. EEA Topic Report 7-1997. EEA, Copenhagen.

de Leeuw and de Paus, 1998. Air Pollution by ozone in Europe; 1997 - summer 1998. EEA Topic Report in press, EEA, Copenhagen.

EEA (1995) Europe's Environment: the Dobris Assessment. Copenhagen.

EEA (1998) Europe's Environment: the Second Assessment. Copenhagen.

EMEP/MSC-W, Report 1/98. Transboundary Acidifying Air Pollution in Europe. DNMI, Norway.

ETSU (1996) Economic evaluation of the draft directive on incineration of non-dangerous waste;. report to EC-DGXI.

European Commission (1997), Community Strategy to combat acidification COM(97)88 European Commission, Brussels.

European Commission, 1999 (forthcoming). *Economic Assessment of Priorities for a European Environmental Policy Plan (working title).* Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environment, Nuclear Safety and Civil Protection).

European Commission (1999b), *draft Ozone Directive*, 1998 (to complete).

European Community (1996) *Council Directive 96/62/EC on Ambient Air Quality Assessment and Management.*

Hjellbrekke A.G. (1997) Ozone measurements 1995. EMEP/CCC-report 3/97, NILU, Kjeller, Norway

Hlobil, P. and Holub, J. (1997) Conference on the Black Triangle. In Economy Press May 1997.

Hov, Ø. and Flatøy (1997) Convective redistribution of ozone and nitrogen oxides in the troposphere over Europe in summer and fall. *J. Atm. Chem.* 28, 319-337.

IPCC, (1996). *Second Assessment Climate Change 1995, Report of the Intergovernmental Panel on Climate Change. The Science of Climate Change, Contribution of Working Group I.* WMO, UNEP. Cambridge University Press.

Klap J.M., de Vries W., Erisman J.W. and van Leeuwen E.P. (eds.) (1997) Relationships between forest condition and natural and anthropogenic stress factors on the European scale; pilot study. SC Report 150, DLO Winand Staring Centre, Wageningen.

Lindskog, A., *et al*. EUROTRAC-2 Tropospheric Ozone Research, TOR-2. Full proposal. (1998) IVL, Göteborg, Sweden

Millan, M.M., Salvador, R., Mantilla, E., Kallos, G. (1997) Photooxidant dynamics in the Mediterranean basin in summer: results from European research projects. *J. Geophys. Res.,* **102**, 8811-8823.

Müller-Edzards C., de Vries W. and Erisman J.W. (eds.) (1997) Ten years of monitoring forest conditions in Europe. Federal Research Centre for Forestry and Forest Products, Hamburg.

NILU, Exceedances of acceptable copper corrosion levels in Europe due to the combined effect of SO_2, NO_2 and ozone concentrations in air (to complete).

Olivier J.G.J., Bouwman A.F., van der Maas C.W.M., Berdowski J.J.M., Veldt C., Bloos J.P.J., Visschedijk A.J.H., Zandveld P.Y.J. and Haverslag J.L. (1996) Description of EDGAR, version 2.0. Report 771060 002, RIVM, Bilthoven.

Parrish D.D. *et al.*, (1993) Export of North American ozone pollution to the North Atlantic Ocean. *Science*, 259, 1436-1439.

PORG (1997), Ozone in the United Kingdom. Photochemical Oxidant Review Group, DOE, London.

Posch, M., Hettelingh, J.P., de Smeet P.A.M., Downing, R.J. (eds.) (1997) Calculation and mapping of critical thresholds in Europe. Status report 1997. Coordination Center for Effects. Report 259101007, RIVM, Bilthoven, the Netherlands.

Simpson, D. *et al.*, (1997) Photochemical oxidant modelling in Europe: multi-annual modelling and source-receptor relationships. EMEP/CCC-Report 3/97, DNMI, Oslo, Norway.

Simpson, D. *et al.* (1999) Inventorying emissions from nature in Europe. *J. Geophys. Res.* in press.

Slanina, J. *et al.* (1998) Biogenic and anthropogenic volatile organic compounds in the atmosphere. SPB Academic Publishing, Amsterdam, the Netherlands.

Tonneijk, A.E.G. *et al.*, (1998) Economische aspecten van het effect van luchtverontreiniging op de gewasteelt in Nederland. Report 90, AB-DLO, Wageningen, the Netherlands.

Tsyro, S. and Berge, E. (1997) *The contribution of ship emission from the North Sea and the north-eastern Atlantic Ocean to acidification in Europe.* EMEP/MSC-W Note 4/97, DNMI, Oslo, Norway.

UN-ECE (1998) 1998 Joint report of the international co-operative programmes and the mapping programme. EB.AIR/WG.1/1998/4.

UN-ECE (1998). *Convention on Long-Range Trans-boundary Air Pollution*, Internet web site (http://www.unece.org/env/lrtap_h.htm), UN-ECE, Geneva.

Valks, P.J.M. and Velders, G.J.M. (1999) The present-day and future impact of NO_x emissions from subsonic aircraft on the atmosphere in relation to the impact of NO_x surface sources. Annales Geophysicae (in press).

WHO (1995). Update and revision of the Air Quality Guidelines for Europe. Meeting of the Working Group 'Classical' Air Pollutants. Copenhagen: World Health Organization: 1995.

WHO (1996a) Update and revision of the WHO air quality guidelines for Europe. Classical air pollutants ; ozone and other photochemical oxidants. European centre for environment and health, Bilthoven, the Netherlands.

WHO (1996b) Update and revision of the WHO air quality guidelines for Europe. Ecotoxic effects, ozone effects on vegetation. European centre for environment and health, Bilthoven, the Netherlands.

3.5. Water Stress

Main findings

- Water stress is caused by activities in two sectors identified as priorities under the Fifth Environmental Action Programme, namely, agriculture and industry, and also by the household sector. Most progress has been achieved in the industrial sector, with some improvement for households, but little progress has been made by the agricultural sector.
- EU countries are, on average, abstracting around 21% of their renewable freshwater resources each year which is regarded as a sustainable position, although significant water loss occurs in southern countries – around 18% of the resource is lost each year in irrigation. Water abstraction will increase very slowly in the EU. Water pricing to promote conservation, re-use and leakage control is now an important consideration in the development of water policy.
- There are fewer heavily-polluted rivers due to reductions in organic matter discharges, phosphate-free detergents and improved waste-water treatment; implementation of the Urban Waste-water treatment Directive and upgrading of discharge can achieve further reductions of phosphorus and organic matter discharges but the quantity of contaminated sludge will increase accordingly. The concentration of nitrate in EU rivers has been approximately constant since 1980 leading to eutrophication in coastal areas. Nitrate contamination of aquifers also remains a problem, due to diffuse nutrient loads from agricultural areas.

1. Focus on major water stress problems

Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. It frequently occurs in areas with low rainfall and high population density or in areas where agricultural or industrial activities are intense. Even where sufficient long-term freshwater resources exist, seasonal or annual variations in the availability of freshwater may at times cause stress.

Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.). Such deterioration can result in health problems and have a negative influence on ecosystems.

At European level, various policy responses have been taken to address water stress and prevent the deterioration of water quality. Sustainable use of water is among the key objectives of the EU's Fifth Environmental Action Programme (5EAP), and is the subject of policy initiatives including the Groundwater Action Programme and Directives on Urban Waste-water treatment, Nitrate, Drinking-water and Bathing Waters. In February 1997, the European Commission adopted a Proposal for a Water Framework Directive, pursuing a generic approach to water management and providing a framework for the protection of water resources. Table 3.5.1 lists the EU objectives, targets and actions achieved in relation to water resources. Water stress is also affected by sectoral policies, notably the Common Agricultural Policy and its reform.

Water resources and water quality in Europe are affected mainly by the activities in three sectors: agriculture, industry and households. This chapter focuses on the influence these sectors have on the availability and demand for water and on water quality problems caused by discharges of organic matter, phosphorus and nitrogen into water bodies. Europe's water bodies are affected by many other factors creating water stress (see Table 3.5.2) but the issues selected for analysis in this chapter are the most prominent on a European scale. In addition, the relatively high amount of good quality information available on these issues provides a sound basis for analysis at European level.

Table 3.5.1. **EU objectives, targets and actions in relation to water resources**

	Objectives	EC targets up to 2000	Actions achieved (achievements by 1998)
Quantitative aspects *Groundwater and surface fresh water*	Sustainable use of freshwater resources: demand for water should be in balance with its availability.	Prevent permanent overdraft. Integrate resource conservation and sustainable use criteria into other policies, including agriculture, planning and industry. Marked reduction in pollution of water bodies.	The approach on sustainable water use is now developed in the Water Framework Directive (1997/8 proposal, probable adoption 1999) which sets target of good ecological status (including minimum water flow conditions where relevant) for surface water, and good quantitative status for groundwater. These together define the sustainable limits for abstraction, and the Directive requires Member States (MS) to ensure that abstraction does not exceed this. This requires MS to integrate these constraints into controls on agriculture, industry and any other activity which could affect them.
Qualitative aspects *Groundwater*	To maintain the quality of uncontaminated groundwater. To prevent further contamination of contaminated groundwater. To restore contaminated groundwater to a quality required for drinking-water production purposes.	To prevent all pollution from point sources and to reduce pollution from diffuse sources according to best environmental practices (BEP) and best available technology (BAT).	The main groundwater pollution problems were identified and legislated on in 1991 – nitrate (Directive on Protection of waters against nitrate pollution from agriculture) and pesticide contamination (Directive 91/414). Implementation of the Nitrate Directive has been unsatisfactory in the majority of Member States and proceedings have been initiated against those MS that have not yet complied. Progress on 91/414 has been glacially slow – seven years after adoption analysis is complete on only one active substance out of approximately 800. The BEP and BAT measures are set out in the Groundwater Action Programme (GWAP, 1996) and implemented in the Water Framework Directive (1997/8 proposal, probable adoption 1999). They enforce existing quality objectives for pesticides, nitrate and biocides, and add two elements: a requirement to ensure that the quality is sufficient to support connected surface ecosystems; and a requirement to reverse increasing pollution trends.
Qualitative aspects *Surface fresh waters*	To maintain a high standard of ecological quality with a biodiversity corresponding as much as possible to the unperturbed state of a given water.	Quality improvements towards a better ecological quality and safeguard of high quality where it exists.	The overall purpose of the proposed Water Framework Directive is to establish a framework for protection of water bodies to prevent further deterioration, and to protect and enhance the status of aquatic ecosystems and those terrestrial ecosystems directly dependent upon them. It requires the achievement of good surface water status by 2015 unless it is impossible or prohibitively expensive. The Nitrate and Urban Waste-water treatment Directives address surface water pollution. Implementation of the Nitrate Directive is described above. Implementation of the Urban Waste-water treatment Directive since 1991 has been patchy but considerable investment programmes are in place in all Member States.

2. How much water is available?

2.1. Renewable resources

The total renewable freshwater resource of a country is the amount of water flowing in rivers and aquifers, originating either from precipitation over the country itself (internal water resources), or from water received from neighbouring countries in transboundary rivers and aquifers (external water resources). In the EU, the average internal water resource is estimated to be approximately 1 190 km^3/year (EEA, 1999a), equivalent to 3 200 m^3/cap/year. Although this is significantly lower than the global average of 7 300 m^3/cap/year (WMO, 1997), EU countries appear to have sufficient water resources since average abstractions are estimated at 660 m^3/cap/year.

However, these resources are not evenly distributed. There are substantial imbalances between different regions. Map 3.5.1 illustrates the wide spatial variability of freshwater resources, with annual average runoff (water resource per unit of area) ranging from over 3 000 mm in western Norway to 100 mm over large areas of Eastern Europe and less than 50 mm in southern and central Spain.

Transboundary river flows make up a significant share of the resources in many countries. In Hungary, freshwater originating from upstream countries accounts for as much as 95% of the total resource. In the Netherlands and the Slovak Republic this proportion is over 80%; whilst Germany, Slovenia and Portugal all rely on imported water for over 40% of their resources. Although there are international agreements

Other Water stress related factors — Table 3.5.2.

Water Stress Factor	Reference to Chapter
Acidification	(no direct description of surface water acidification in *Chapter 3.4)* *Chapter 3.11* Acidification from sulphur and nitrogen polluted depositions
Biodiversity	*Chapter 3.11* Includes some description of biodiversity in relation to freshwater
Climate change	*Chapter 3.1* Vulnerability to climate change in Europe *Chapter 3.11* Foreseen impact of climate change by 2050 by habitat-type (running water, bogs, marshes and fens)
Desertification	*Chapter 3.6* Main impacts on resources
Eutrophication of coastal and marine waters	*Chapter 3.14* Environmental conditions in regional seas
Heavy metals	*Chapter 3.3* Heavy metals losses during production, use and waste treatment
Pesticides	*Chapter 3.3* Organochlorines dispersal in soil, groundwater and some global scale problems
Radiation	(No direct description of radiation in surface waters in *Chapter 3.8)*
River flooding	*Chapter 3.8* Occurrence of major floods
Soil-phosphorus	*Chapter 3.6* Analysis of phosphorus surplus
Sludge from waste-water treatment plants	*Chapter 3.7* Case study: Sewage sludge – a future waste problem?
Water management (urban areas)	*Chapter 3.12* Box: Water management in Europe: the pricing issue and Case study : Water flows in Barcelona
Water stress in mountain areas	*Chapter 3.15* Mountains are the water towers of the lowlands
Wetlands	*Chapter 3.11* Wetlands: where all environmental pressures meet
Sectors	
Aquaculture	*Chapter 3.14* Developments in aquaculture
Agriculture	*Chapter 2.2* Trends in agriculture (livestock, fertilisers and pesticides)

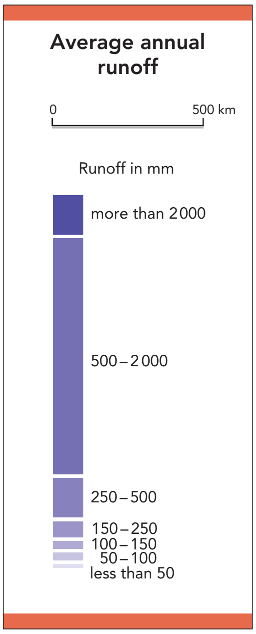
to control the quantity and quality of imported water, tensions inevitably can arise, especially where total water availability in the upstream country is less than in the downstream country.

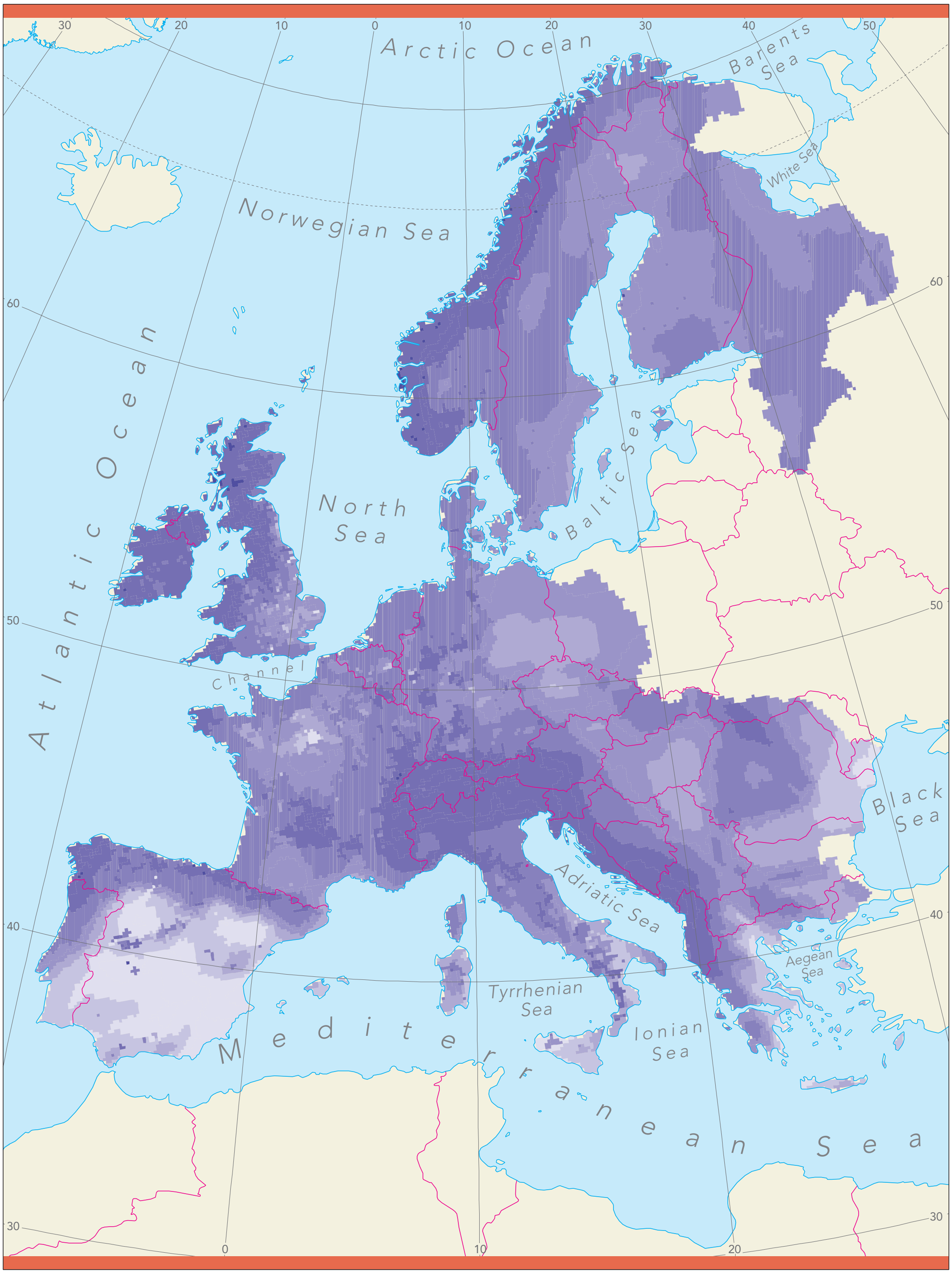
2.2 How much water is being used?

Fortunately, in most European countries the amount of water available is far greater than demand. In the EU, EFTA and Accession Countries (excluding Cyprus), total internal resources amount to 1897 km^3/year, out of which 296 km^3/year are abstracted (16%) and 89 km^3/year consumed (5%).

With total abstraction at around 240 km^3/year (in 1995), the EU is using, on average, only 21% of its renewable resources (EEA, 1999a) which can be regarded as a sustainable position (OECD, 1998). The most stressed countries with respect to water quantity (highest ratios of abstraction per total resources) are Belgium and Luxembourg with high water stress and more than 40% of resources being abstracted and Germany, Italy and Spain, with medium-high water stress and values between 30% and 35% (Figure 3.5.1). Such country averages, however, may conceal enormous regional and temporal differences in the sustainability of usage within the country.

In order to meet their total needs for water for all purposes, most European countries rely more on surface water than on groundwater (EEA, 1998). For example, Finland, Slovenia and Lithuania take more than 90% of their total supply from surface waters, although groundwater is the predominant source in some countries, such as Denmark





Map 3.5.1

Source: EEA, 1998

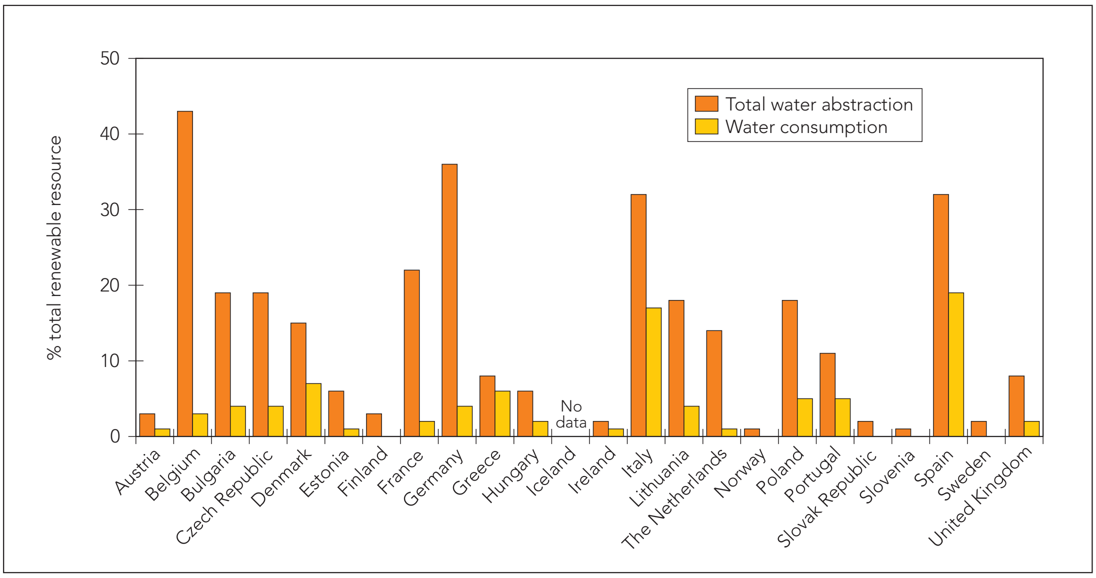
and Iceland, where it satisfies practically the entire demand. In many countries, groundwater is the main source for drinking-water supply, due to its easy (and low-cost) availability and its high quality (EEA, 1999a). It can, however, be an expensive and time-consuming resource to restore once it has been polluted or depleted, hence vigilance and regular monitoring are required.

2.3. Sectoral water use

On average, 14% of total water abstraction in the EU is used for public water supply, 30% in agriculture, 10% in industry (excluding cooling water) and 46% as cooling water, mainly for power generation (EEA, 1999a). Mediterranean agriculture is the biggest water user: irrigation accounts for about 80% of total water demand in Greece, 60% in Spain, 52% in Portugal and more than 50% in Italy (the average figure in northern Europe is under 10%). For the Accession Countries, industry is the biggest user (Figure 3.5.2).

Most of the water abstracted is not consumed but returned to the water cycle, being

Intensity of water abstraction and water consumption as a percentage of total renewable freshwater resources in the EU — Figure 3.5.1



Source: ETC/IW

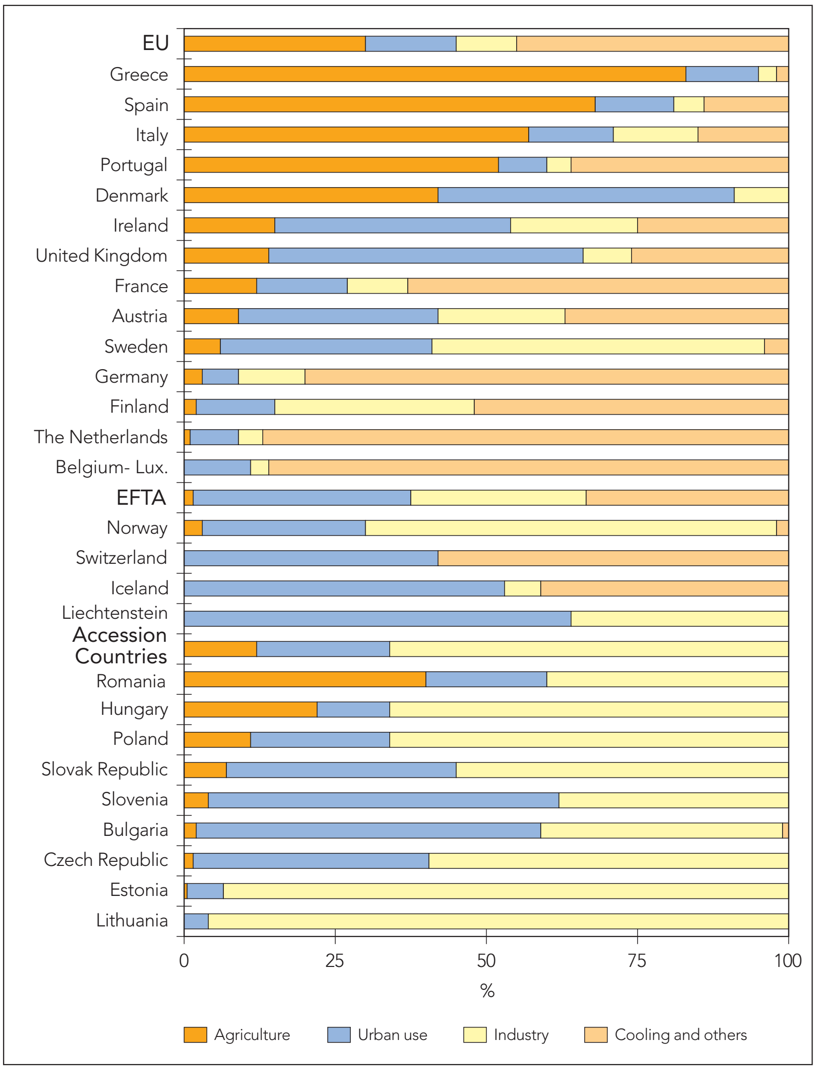
available, after proper treatment or natural purification, for subsequent use (see Box 3.5.1). Water consumption (principally evapotranspiration) in the EU is estimated to be 77 km^3/year, or around 32% of total abstractions, with 80% attributable to agriculture (mainly irrigation water), 20% to urban and industrial use and 10% to cooling and other uses.

The major water consumers are the Mediterranean countries, where irrigation is much greater than in central and northern Europe. Also, the highest levels of total water demand per capita occur in countries with agriculture systems which heavily depend on irrigation (e.g. Italy, Spain).

Box 3.5.1: Definitions of water use

Various concepts are used to describe the diverse aspects of water use. *Water abstraction* is the quantity of water physically removed from its natural source. *Water supply* refers to the share of abstraction which is supplied to users (excluding losses in storage, conveyance and distribution), and *water consumption* means the share of supply which in terms of a water balance actually is used (as evaporation) whilst the remainder is reintroduced into the source of abstraction. The term *water demand* is defined as the volume of water requested by users to satisfy their needs. In a simplified way it is often considered equal to water abstraction, although conceptually the two terms do not have the same meaning.

Sectoral water use in Europe — Figure 3.5.2



Source: EEA, 1999a

2.3.1. Public water supply

Public water supply (PWS) includes a wide range of users, most notably households, small industry, agriculture, commerce and public services. PWS is the major user in many western European and Nordic countries, but has a lower share in Mediterranean countries (see Figure 3.5.2).

Within public water supply, households tend to dominate, accounting for 44% of the total urban demand in the UK (DOE, 1999), 57% in the Netherlands, and 41% in Hungary (ICWS, 1996).

Large variations in PWS per capita are found in Europe, ranging from 50 m^3/capita/year in Germany to 140 m^3/capita/year in Italy, and from 30 m^3/capita/year in Romania to over 200 m^3/capita/year in Bulgaria. Iceland has the largest PWS volume supplied (310 m^3/capita/year).

Urban water demand rose steadily between the 1980s and 1990s in most countries, owing to growing population and the increased use of domestic appliances such as dishwashers (see also Chapter 3.12). Predictions indicate that population will continue to increase moderately over the next 15 years in most countries of the EU, with the total population reaching around 390 million in 2010, although the number of households is projected to increase, as household size declines (see Chapter 2.2). Pricing mechanisms and incentives to encourage improved efficiencies in water use by households will be important influences on future demand for PWS, and it is expected that future water demand for PWS will decline slightly in the EU (ETC/IW, 1998b).

Table 3.5.3. **Leakage rates in various European countries**

Country	Leakage rate (%)
Austria[1]	10
Denmark[2]	10
Czech Replublic[1]	33
France[1]	30
Italy[1]	15
Slovak Replublic[1]	23
Spain[1]	20
UK (England and Wales)[3]	28

[1] EEA, 1999a
[2] Danmark Statistik, 1998
[3] OFWAT, 1997

Loss of water from leakage in the distribution networks (still substantial in many countries) could be reduced by improved maintenance of the water distribution network. Comparisons of average leakage rates for eight countries (Table 3.5.3) shows that between 10% (for Austria and Denmark) and 33% (for the Czech Republic) of supplied water never reaches the final user. Individual cities and water companies can experience higher losses, for example, Bilbao and Thames Water report losses of up to 40% and 34% respectively (EEA, 1999a; DOE, 1999).

2.3.2 Industrial water use

The biggest industrial water users are the chemical industry, the steel, iron and metallurgy industries, and the pulp and paper industry, although in most European countries industrial abstractions have been declining since 1980. In western Europe this is due, primarily, to economic restructuring with closures in water-using industries such as textiles and steel, and a move towards less water-intensive industries. Technological improvements in water-using equipment and increased recycling and re-use have also contributed to the decline. In eastern Europe, abstractions seem to have diminished due to the serious decline in industrial activity across the whole sector.

Generally, pricing mechanisms have been used more extensively to encourage water use efficiencies in the industrial sector, where firms will adopt water-saving technologies if costs can be reduced, than in the household and agricultural sectors. Also charges for the discharge of contaminated water into the sewerage network are an important incentive for industries to improve process technologies and to reduce the amount of water used and discharged. Industrial sectors with the largest water needs are the chemical industry, steel, iron and metallurgy industries, and the pulp and paper industry.

In general, the quantities of water abstracted for cooling are far in excess of those used by the rest of industry (e.g. 95% of all industrial water use in Hungary is for cooling). However, cooling water is generally returned to the water cycle unchanged, apart from an increase in temperature and some possible contamination by biocides.

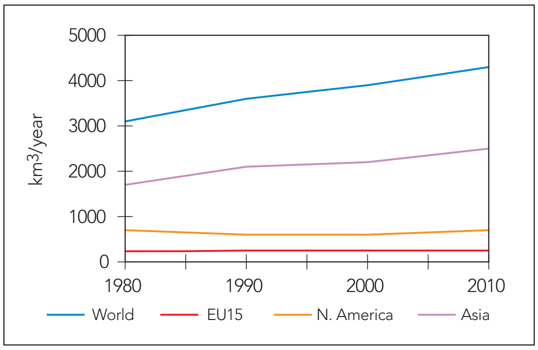
Forecasts of industrial water use in Europe are generally downwards because of increased efficiency in industrial processes, greater water re-use and the decline of resource intensive industries in Europe (ETC/IW, 1998b).

2.3.3. Agricultural water use
Over the past decades the trend in agricultural water use has, in general, been upwards, due to increasing use of water for irrigation. However, during recent years in several countries the rate of growth has slowed down. In Spain for example, the area under irrigation expanded from 1.5 to over 3 million hectares during the period from 1950 to 1980 and since then the irrigated area has been roughly stable.

In southern European countries, irrigation is necessary to secure crop growth each year whereas in central and western Europe it is only a means to maintain production in dry summers. The major irrigated areas in EU are in the Mediterranean countries and Romania and Bulgaria in the Accession Countries.

Reforms of Common Agricultural Policy (CAP – see Chapter 3.13) will lead to changes in types of crop being cultivated, the area irrigated and the amount of water used. In principle, two trends can be distinguished. On the one hand, if production is reduced, the demand for production inputs, such as water, is logically bound to diminish. On the other hand, there might be a switch towards more profitable crops, which at least in southern climates frequently require irrigation.

Total water demand – trends and projections Figure 3.5.3



Source: ETC/IW, 1998b; Shiklomanov, 1998

Unlike in the industrial sector, there remains scope for further improvements in the efficiency of water use by agriculture. Much of the improvement could be realised through changes in practice and behaviour, e.g. by undertaking irrigation more sparingly and when evaporation is less likely to occur, encouraged by the use of price mechanisms and other instruments.

2.3.4. The overall demand for water in the future
It is estimated, considering the present and future water demand sector by sector, that the total water demand in the EU will remain relatively stable until 2010 (Figure 3.5.3), although further growth is projected for other regions of the world, due to economic development and increased irrigation (Box 3.5.2).

Box 3.5.2: The challenge of water resources in Mediterranean countries

Water resources in the Mediterranean basin area, under increasing pressure, are about to be a major challenge regarding development and security over the next decades. Various figures on exploitation of the resources, analysed against the fast-growing population rate, notably in urban and coastal areas (see Chapter 3.14), lead to an estimate that around 50% of the population may face a water shortage of less than 500 m^3/cap/year available. According to a prospective analysis of water resources issues in the countries bordering the Mediterranean Sea (Blue Plan, 1996) it is projected that in 2025 more than 13 countries will be abstracting more than 50% of their renewable water resources and 6 countries more than 100%.

In this context, one should note that waters in the Mediterranean region are naturally of various qualities which hamper their exploitation; for instance, salinity in some places prevents the use of water for human consumption and irrigation in many southern countries. In addition, large pollution discharges and local overexploitation further degrade the quality. Every year, about 15 billion m^3 of discharges within the catchment area occur, a large part of which is not treated; 75% of these discharges come from northern Mediterranean countries. Loss of water resources, due to poor management, might represent 47% of the present demand (mainly from agriculture). Reversing that situation would contribute to 90% of the additional demand foreseen to 2010.

In spite of measures and actions, recourse to non-conventional sources of water is therefore expected to contribute to the challenge. Re-use/recycling of waste water, mainly for agriculture, is a key development; it is expected, in Cyprus, to triple the rate of re-use by 2010. Desalinisation is already in use in most islands but the high production costs limit production for human consumption and even for industrial processes. However, these non-conventional sources are estimated to account for less than 5% of water supply in the area by 2025.

Source: MAP/Blue Plan; Environment Institute, Cyprus

A similar analysis of the expected evolution of the total water demand in several regions of EU also shows only a slight increase of demand for water in all regions. This is because the rate of growth of the main driving forces is expected to slow and the efficiency of water use is expected to improve, as national water conservation policies and actions have an increasingly positive impact.

Such forecasts are best estimates based on current knowledge, and should be interpreted with caution. This is clearly demonstrated by the fact that the growth rates of water demand registered in some EU countries during the past decade were much lower than the forecasts made in the 1960s and 1970s and to bring the forecasts in line with reality they were on several occasions corrected downwards (Figures 3.5.4 and 3.5.5).

Figure 3.5.4 **Forecasts and actual growth of total water demand in Spain**

Source: Spanish Ministry for the Environment, 1998

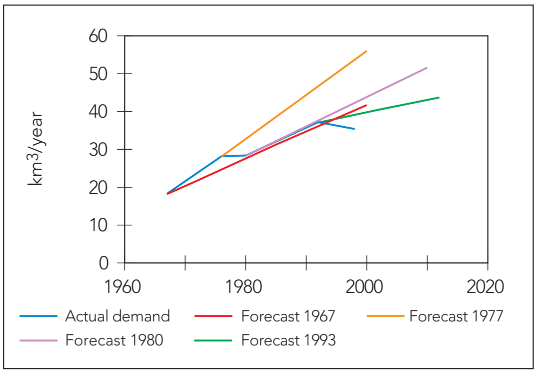
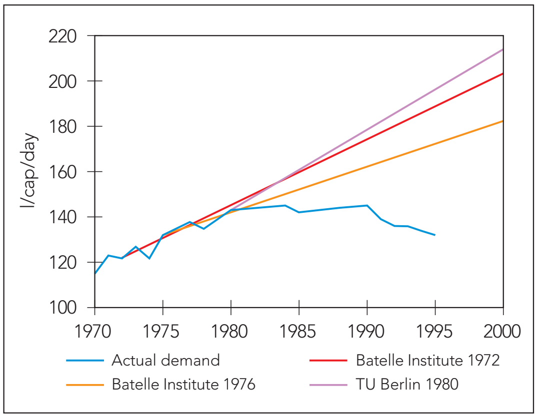


Figure 3.5.5 **Domestic water use per capita in the Federal Republic of Germany – projections and trends (per capita)**

Source: Gundermann, 1993



2.4. Water shortages

Long-term water resources assessments do not take into account their irregular distribution in time. Even where there are sufficient long-term resources in an area, the seasonal or year-to-year variation of the resource will, at times, result in problems of water stress. For water resource planners, decisions on water supply are frequently based on the resource they can expect in dry periods and low river flow.

Recent years have shown how vulnerable countries can be to low precipitation. In several (mainly southern) European countries periodic droughts are a major environmental, social and economic problem (Box 3.5.3).

Extended or recurrent periods of drought can intensify the desertification process, which is caused by over-use of soil and water (see Chapter 3.6) leading to deterioration in the natural vegetation cover. The result is a reduction of infiltration into the soil and increased surface flow; furthermore the soil is unprotected and the risk of erosion becomes greater.

Semi-arid Mediterranean countries are the most susceptible to the effects of desertification because of – for example – their mountainous morphology with steep slopes (see Chapter 3.15), rainfall with considerable erosion capacity and over-exploited systems due to the imbalance between resources and abstractions (EEA, 1997).

Intensive exploitation of aquifers can give rise to over-exploitation problems. Aquifer over-exploitation mainly depends on the balance between abstraction and renewable resources. In Mediterranean countries the over-exploitation commonly arises from excessive abstraction for irrigation. The resulting increase in productivity and change in land use can establish a cycle of unsustainable socio-economic development within an irrigated region. Additional resources are exploited to satisfy the increased demand from the population and agriculture, exacerbating the already fragile environment by reducing groundwater levels and, in some circumstances, accelerating the desertification processes (EEA, 1997). Wetlands or wet ecosystems are also damaged when the aquifer water table drops (Box 3.5.4). It is estimated (EEA, 1999b) that about 50% of major wetlands in Europe have 'endangered status' due to groundwater over-exploitation (see also Chapter 3.11).

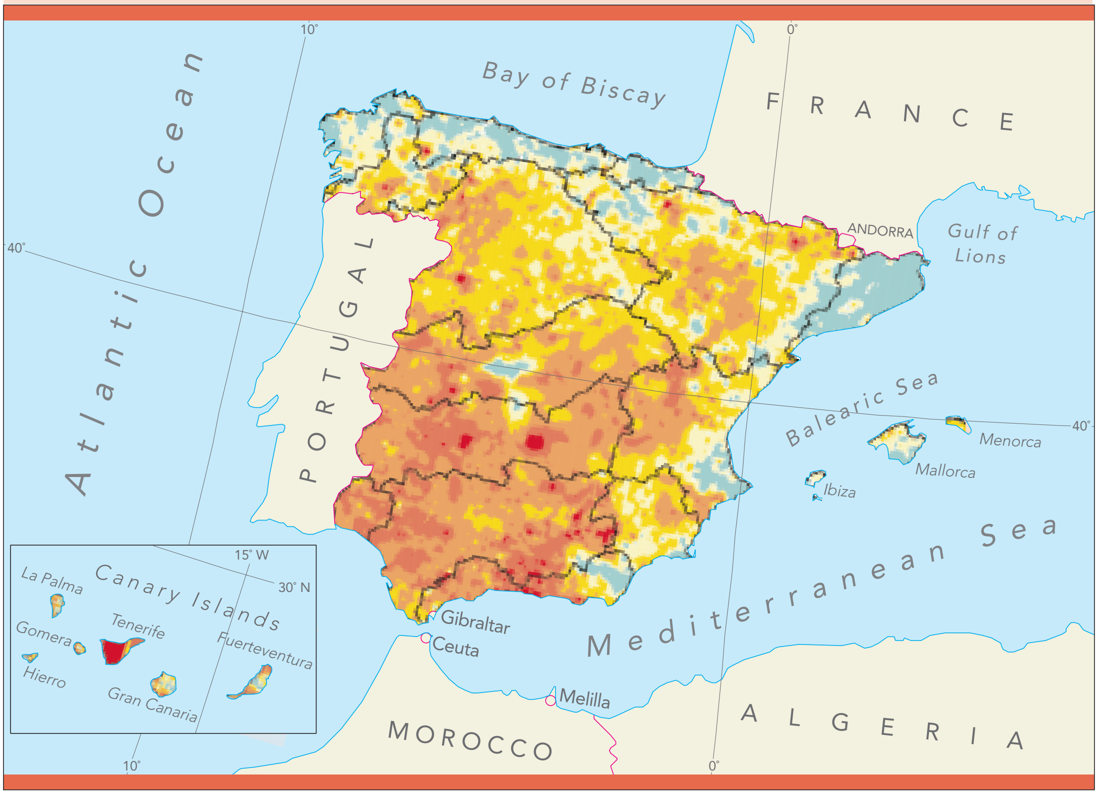
Box 3.5.3 Droughts in Cyprus and Spain

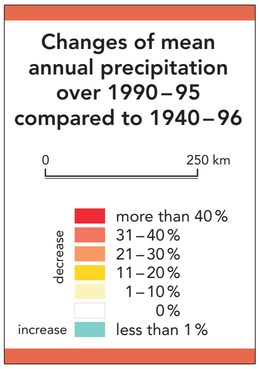
Cyprus
In Cyprus, water scarcity is creating serious problems and constraining infrastructural development, not only of agriculture, but more significantly of other activities, including tourism, a water- intensive activity. In recent years annual precipitation has fallen well below its historical average. The country is suffering the third-worst three-year drought period of this century, and water in the reservoirs is down to only 10% of total capacity. As a result, and despite many resources being invested in water storage capacity, the quantities of water available for drinking and irrigation purposes have not been adequate.

The present water situation is not sustainable. Development of conventional surface water resources in the past two decades has proved insufficient to respond successfully to the extreme climatic conditions of the past three years.

The 1990-95 drought in Spain
Low rainfall during 1990-95 led to a significant reduction in run off and to a spectacular decrease in most of the country's water reservoirs. This adversely affected aquatic life and landscapes in many regions (dry rivers, impact on ecosystems, deterioration of water quality, etc.). Although the drought struck almost the entire territory, it especially increased the problems related to water stress in regions where water resources were already under pressure (Map 3.5.2).

The strategies to confront the situation included a variety of emergency measures to develop new sources of supply (increased use of groundwater, water transfer, use of water of poor quality). The increased use of existing groundwater resources was a major source of additional supply. In total 270 new wells with a pumping capacity of more than 16 m^3/s were opened during the period 1990-95. Also a number of measures aimed at reducing demand were applied (information campaigns, assignment of priorities, restrictions of urban supply). At one time during the period 1990-95, 25% of the population in Spain, especially in the south of the country, was suffering restrictions of domestic water supply.





Map 3.5.2

Source: ETC/IW

Salt-water intrusion in aquifers can result from groundwater exploitation along the coast, where urban, tourist and industrial centres are commonly located. The intrusion of salt water is a problem in many coastal European regions, but especially along the Mediterranean, Baltic and Black Sea coasts (EEA, 1995).

3. Just using water pollutes it

3.1. Agriculture
Over the past 50 years, more intensive farm management practices, have meant that the use of commercial inorganic fertilizer has increased dramatically. Increased livestock densities have resulted in the production and application of greater loads of manure to cultivated land. Together these trends have contributed to excessive amounts of nutrients, in particular nitrogen, being applied to the soil. Under these conditions, the nutrient load can exceed the removal capacity of the crops and of the soil and leaching of nutrients to water bodies may increase.

In many areas, much of the agricultural land has been drained to enhance production.

Box 3.5.4 An example of wetland deterioration

Maintenance of wetlands is dependent on a natural hydrological regime (see Chapter 3.11). In Spain, for the past two or three decades, the 'la Mancha Occidental' aquifer (5 500 km^2) has been exploited for irrigation purposes. The abstraction, made by private farmers, has established more than 100 000 ha of new irrigation land. This abstraction (more than 600 M m^3/year a few years ago) was higher than the recharge (between 200 and 500 M m^3/year, depending on the meteorological year) and had two consequences: economic development of the region and the exploitation of the aquifer.

The decline of the aquifer water level produced serious ecological impacts on some wetlands of La Mancha Humeda, the most important in the National Park "Las Tablas de Daimiel".

The Spanish administration declared the aquifer provisionally over-exploited in 1987, and in 1995 the administration produced its final declaration of over-exploitation. Together with this measure, the administration designed a programme to plan the abstractions. In 1993 a five-year programme was established to compensate for the loss of farmer's income (PCR) when reducing their abstractions. A large part of the compensation (75%) came from the EU. The PCR programme gave rise to the 'Groundwater Users' Community' (the farmers receive compensation through this organisation) and had the effect of reducing the abstractions, but the economic impact was negative for the region, with a loss of jobs in agriculture and small industries (Llamas, 1996).

However, as a result, many of Europe's marshes, wetlands, ponds and lakes have disappeared. This has considerably reduced the capacity of freshwater ecosystems to store and remove many pollutants including nitrogen.

3.1.1. Nitrogen load

Agriculture is the main source of nitrogen loading to water bodies. High inputs of nitrogen to water bodies can cause significant ecological changes, especially in coastal areas. At excessive concentrations nitrate in drinking-water is considered to be a human health problem (see Chapter 3.10).

In the five areas (Figure 3.5.6) with the largest nitrogen export coefficient (i.e. Poland, the European part of the Mediterranean basin, Danube basin, North Sea basin and western European countries) there are only small differences in the percentage of arable and total agricultural land. The marked increase in load, i.e. from 6.5 kg N/ha in Poland to around 28 kg N/ha in the western European countries, can generally be explained by more intensive agricultural production, here illustrated by higher nitrogen fertiliser application.

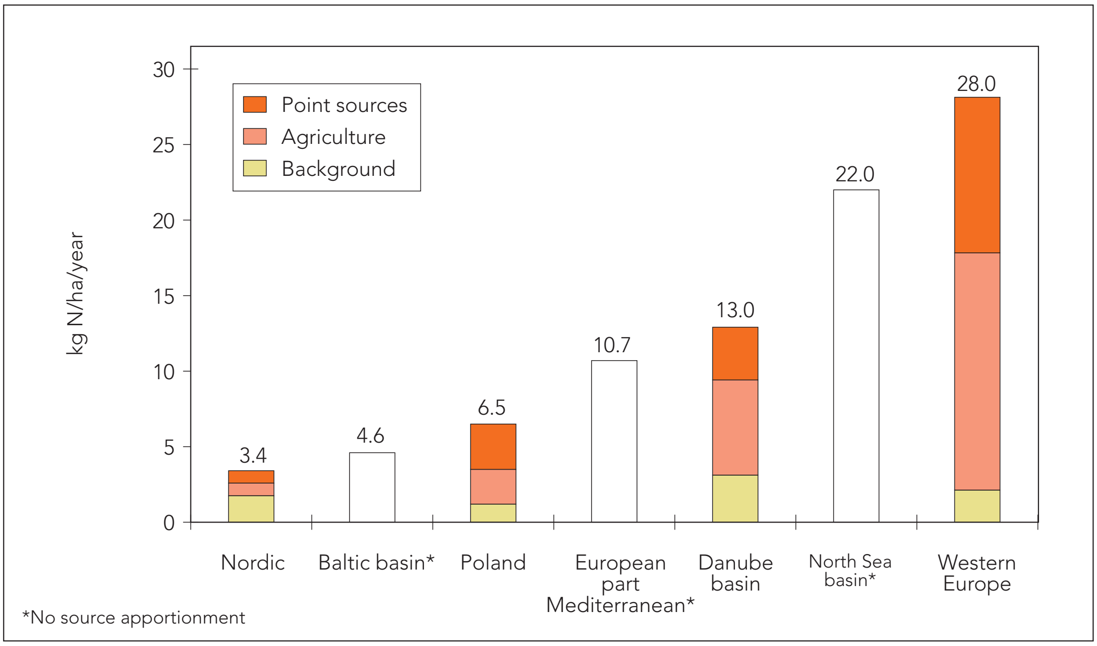
3.1.2. Nutrient surpluses are highest in regions with intensive livestock production

Despite documented decreases in fertiliser use, livestock numbers and manure production (Chapter 2.2), European agriculture still adds much more nitrogen to the soil than is

Figure 3.5.6 **Sources of N in selected larger areas (> 300 000 km²)**

Annual nitrogen load per hectare (export coefficient) compared with the percentage of agricultural land, and the application of fertilisers per hectare of *total land* area. No source apportionment for the Baltic Sea catchment, the European part of the Mediterranean catchment and the North Sea. *Nordic:* Norway, Sweden, & Finland. *Eur. Medd.:* European part of the Mediterranean basin *W. Europe:* Germany, the Netherlands, Flemish part of Belgium, Denmark, & Austria.

Source: ETC/IW based on 12 different sources



required for crop growth. When this surplus of nitrogen leaches out of the soil and reaches a water body it can create pollution problems. Field balance studies show that countries in north-western Europe generally have the largest nitrogen surplus. In the Netherlands and Belgium the country average nitrogen surplus is around 300 and 180 kg N/ha of agricultural land, respectively, while in Luxembourg, Germany, Denmark and the United Kingdom the surplus is around 100 kg N/ha (Figure 3.5.7). In southern countries, the country average surplus is generally less than 50 kg N/ha.

Even in countries with a relatively low average nitrogen surplus, there may be regions where the surplus is high; they are generally also the regions with high concentration of intensive livestock production (in particular pigs and poultry).

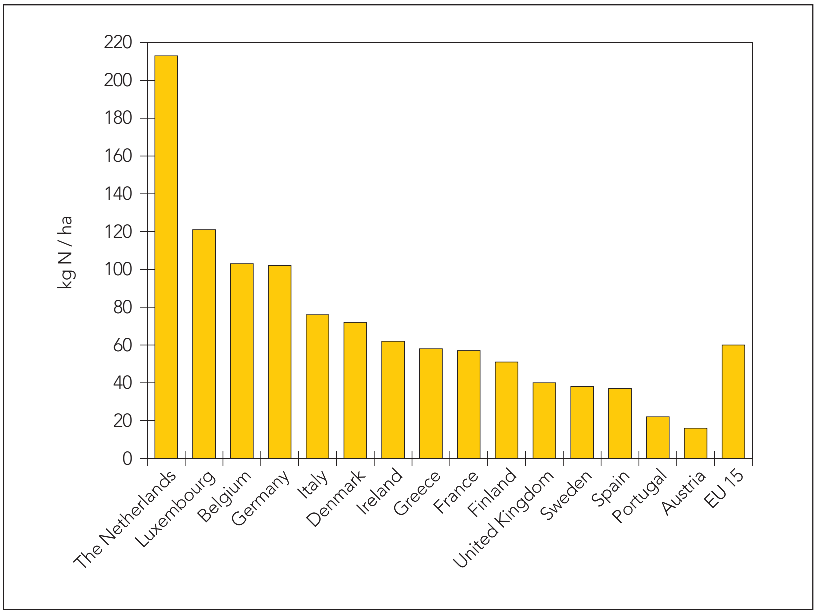
3.2. Marked reduction in discharge from industry
Only a small part of the European industrial sector is responsible for the majority of organic matter and nutrients in waste water, in particular the pulp and paper, food processing and fertiliser industries.

Over the past 25 years, emissions of oxygen-consuming substances from the pulp and paper industry have been radically reduced because of the introduction of new techniques and various measures to clean processes. In Sweden and Finland, which account for 60% of the EU production of woodpulp for paper production, the organic matter load has been reduced by around 75% during over the past 15 years, even though production has increased by 20%.

Similarly, because of improved technology there has been a marked reduction in industrial phosphorus discharges in many western European countries. In the Netherlands, the industrial phosphorus discharge was reduced from 14 to 3 ktonnes between 1985 and 1993 (RIVM, 1995) mainly due to discharge reductions at fertiliser plants in Rotterdam harbour.

The phosphorus emission from two major European fertiliser companies (Hydro and Kemira) fell from 15.6 ktonnes in 1990 to 2.6 ktonnes in 1996 (Figure 3.5.8). For comparison, the total annual discharge from Denmark is around 5 ktonnes. In the same period the phosphorus discharged from the pulp and paper industry in Sweden and Finland was halved from 1.2 to 0.6 ktonnes.

Average nitrogen surplus (difference between input by atmospheric deposition, fertiliser and manure and output by harvested crops) Figure 3.5.7



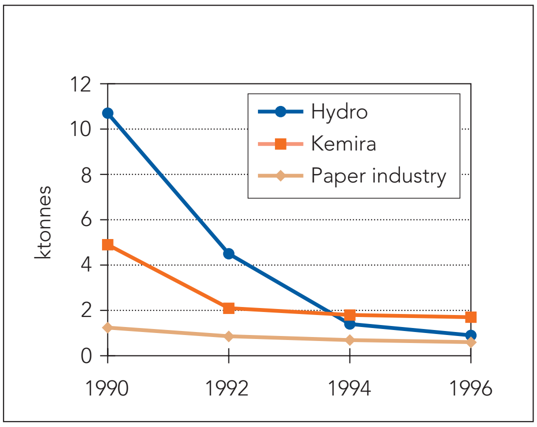
Source: Eurostat

3.3. Phosphorus loads

3.3.1. Regional loads
Excessive input of nutrients to water bodies can result in eutrophication. Households and industry are the most important contributors to phosphorus pollution (Figure 3.5.8). Agricultural activities also contribute to phosphorus loading. In Nordic countries the contribution from uncultivated land and forested areas is proportionally high as inputs from other sources are low.

With increasing population density and human activity phosphorus loading from the area increases. In the Baltic Sea catchment area, for instance, the phosphorus export

Phosphorus emissions from large industries Figure 3.5.8



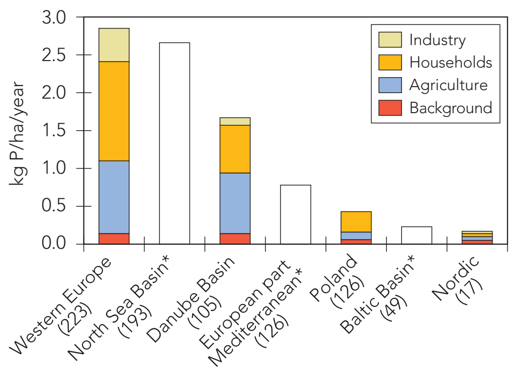
Source: Hydro, 1995, 1996; Kemira, 1996; Wahlström, 1996; Statistics Sweden 1990; 1996

Figure 3.5.9

Sources of phosphorus discharges in selected larger areas (> 300 000 km²)

Annual phosphorus load per hectare (P export coefficient) compared with population density (inhabitants per km²). No source apportionment for the Baltic, the European part of the Mediterranean catchment and the North Sea. *Nordic*: Norway, Sweden, and Finland; *Eur. Med.*: European part of the Mediterranean basin; *W. Europe*: Germany, the Netherlands, Flemish part of Belgium, Denmark, and Austria.

Source: ETC/IW based on 12 different sources



*No source apportionment

coefficient is 0.23 kg P/ha per year, increasing to 2.7 kg P/ha per year in the North Sea catchment area. The results can be related to increasing population density from less than 50 persons per km² in the Baltic Sea catchment to around 200 persons per km² in the North Sea catchment area.

If there were no human activity (the background level at Figure 3.5.9), phosphorus loads would only be 5% to 10% of the current loads in densely populated areas. In densely populated areas, 50 to 75% or even more of the phosphorus load to surface waters is derived from households and industry, while agricultural activity generally accounts for the remainder. In these densely populated areas, municipal sewage discharge generally accounts for the major part of the point source discharge. However, in some countries, e.g. the Netherlands (because of fertiliser production) and Finland and Sweden (because of the pulp and paper industry), industrial effluents may account for most of the point sources discharge. Diffuse phosphorus loads from agriculture are in some countries quite significant. In the UK, for example, the agricultural contribution is as high as 43% (Environment Agency, 1998), in Germany 46% (Umweltbundesamt, 1997), in Switzerland 50% (Siegrist and Boller, 1999) and in Denmark 38% (Danmarks Miljøundersøgelser, 1997). In Norway, fish farms account for around half of the total phosphorus discharged (see Box 3.5.5).

3.3.2. Phosphate-free detergents have reduced the phosphorus produced per capita

The organic matter and nutrient content of waste water is primarily determined by excreta from humans, by phosphorus from detergents and by the type of industries connected to sewers. Over the past 10-15 years the most marked change in the phosphorus content of waste water in many European countries has been due to nationally imposed reductions in the phosphate content of detergents. Today, in many countries phosphate-free detergents constitute the majority of detergents being sold.

The downward trend in consumption of detergents containing phosphate occurred especially from the late 1980s to 1992/93 with a more than 50% reduction in the use of phosphate in detergents in many countries. In 1992, the average detergent-phosphorus consumption per capita was between 0.1-0.4 kg P/year. Phosphate-free detergents are used much less in the Accession Countries (Ijjas, 1996).

The marked reduction in the phosphorus content of detergents is also reflected in the waste water flowing to waste-water treatment plants. In Denmark, Finland and Switzerland, for instance, the phosphorus being produced per person was reduced from around 1.2-1.7 kg P/year in the 1980s to less than 1 kg/year in the 1990s. Much smaller changes have occurred in the per capita production of organic matter and nitrogen.

4. Waste-water treatment

Industry and households produce waste water containing all sorts of pollutants including organic matter and nutrients (mainly phosphorus). The extent to which the pollutants in waste water are discharged into surface waters depends on the waste-water treatment facilities available. Similarly, agricultural activities lead to the discharge of a variety of pollutants to water bodies, the most important being nitrogen resulting from the excess application of artificial fertilisers and manure. At a local level, the accidental spills of oxygen consuming liquid manure and silage juice to small streams can severely threaten the natural fauna dependent on good oxygen conditions in the water thus reversing the improved conditions resulting from waste-water treatment.

Box 3.5.5: Fish farms: one of the fastest-growing food industries

From 1984 to 1996, the production in Europe's fish farms increased by more than 250%, making it one of the fastest-growing food production activities. In Europe, about 5% of all fish production in 1995 was attributable to fish farms. Yet this industry's contribution to the human diet is actually greater than the numbers imply. Whereas a proportion of the conventional fish catch is used to make fishmeal and oil, virtually all farmed fish is used as human food.

Salmon from west – carp from east
Europe's fish farms fall into two distinct groups: in western Europe the fish farms grow high-value species such as salmon and rainbow trout, frequently for export, whereas in central and eastern Europe the fish farms grow lower-value species such as carp that are mainly consumed locally (Figure 3.5.10).

In the period 1984 to 1996, European production of Atlantic salmon increased 15 fold (Figure 3.5.11). Since 1987 the growth has been 40 to 60 ktonnes per year, except for a period of consolidation in the early 1990s, because of problems of marketing and control of parasites and diseases. In 1984 the production of rainbow trout was five times the salmon production, and has nearly doubled over the last 13 years. The production of common carp was nearly constant between 1984 to 1991 and declined thereafter by 35%. The reduction was most significant in Romania and Hungary (60-70%).

As currently practised, fish farming also causes environmental damage. The farmed fish need artificial feeding and in many cases treatment with chemicals; these and the surplus of food and the faeces may be discharged to the surrounding waters. It is inevitable that fish escape from fish farms. The escapees may be of completely different genetic stock from native and the long-term effects on native stocks are unknown.

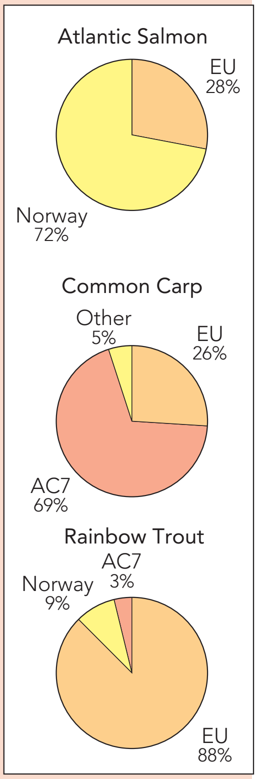
Chemicals in fish farming
Chemicals, particularly formalin and malachite green, are used in freshwater farms to control fungal and bacterial diseases. In marine farms antibiotics are used for disease control but amounts have been drastically reduced in the past years following the introduction of vaccines.

Fish farms' discharge is equal to untreated waste water discharge from five million persons
In marine areas the fish are reared in large cages or net enclosures in sheltered coastal areas. When they are fed, the situation is the same as it would be if a farmer threw some of his fertiliser or manure straight into the water. Inland fish are generally reared in artificial ponds, from which outflows of organic matter and nutrients are easier to control. Annually, around 3 to 8 ktonnes of phosphorus and 30 to 60 ktonnes of nitrogen are discharged from European fish farms. The amount of nutrients being discharged is equal to untreated waste water from five million persons.

The comprehensive development of the feed composition and the feeding technology have over the past years resulted in reduced load of nutrients from fish farms, calculated per tonne of fish produced. The effect of the technology improvement on the total nutrient loading has partly been halted by the marked increase in production.

Big production increase still expected
In the long term, there is a real possibility that production of farm fish will still continue to increase. This will probably result in rising discharges of nutrients, organic matter and chemicals. The choice of technology for fish farms will be one factor that affects the extent of the increase. Fish farms should increasingly take account of pollution problems. In addition, the concept of integrated coastal management and planning provides an appropriate framework for assessing environmental effects of fish farms.

Fish-farming by European regions in 1996 Figure 3.5.10

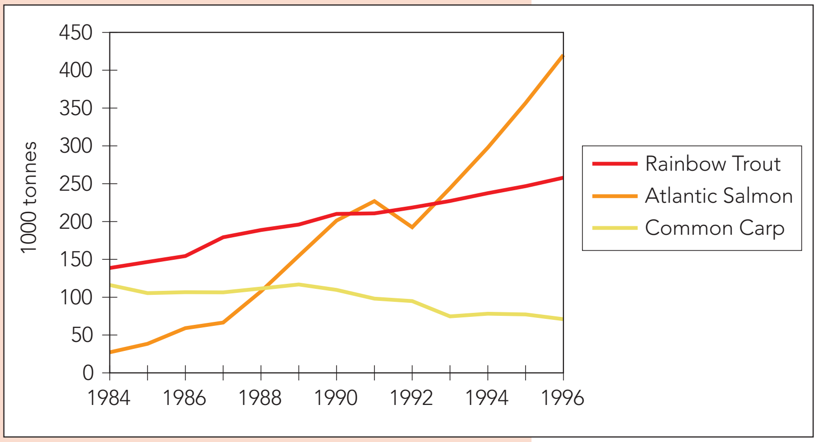


Total Atlantic salmon, rainbow trout and common carp production are 420 258 and 71 ktonnes, respectively.

Source: FAO Aquacult PC, 1998

AC7: Bulgaria, Czech Rep. & Slovak Rep. (Czechoslovakia), Hungary, Poland, Slovenia & Romania.

Main fish-farming productions, 1984-96 Figure 3.5.11



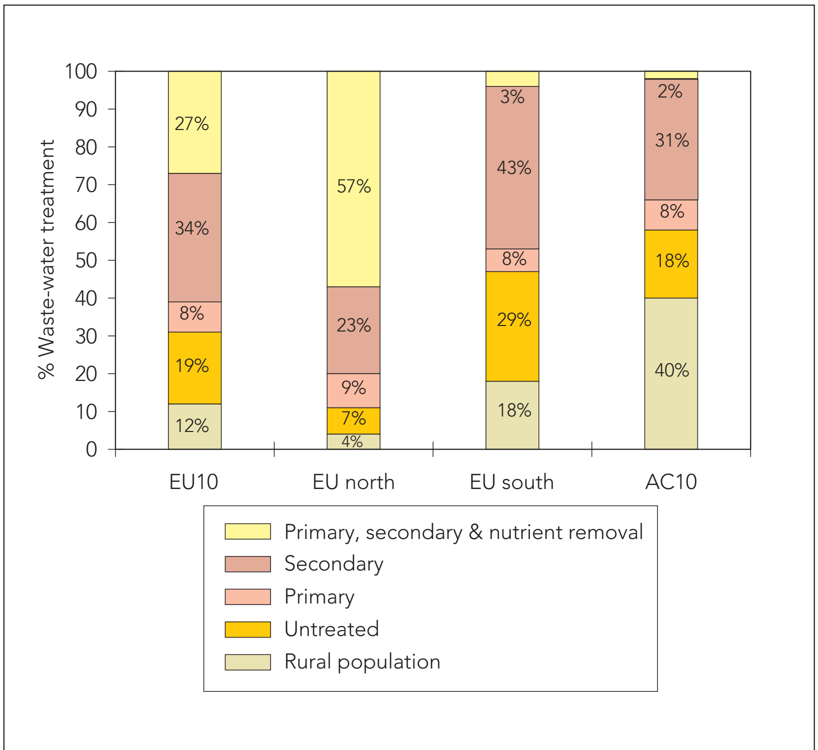
Source: FAO Aquacult PC, 1998

4.1. Better waste-water treatment in Northern Europe

Around 90% of the EU population is connected to sewers and around 70% to municipal waste-water treatment plants (Figure 3.5.12). However, some regional differences do exist. In northern countries generally more than 90% of the population is connected to waste-water treatment plants, while the percentage in southern Europe varies between 50% and 80%. The absence of a sewer connection does not necessarily imply inadequate sewage treatment, because rural populations not connected to sewers may have efficient individual treatment systems.

The more advanced waste-water treatment is found in the northern Member States with 57% of the waste water treated in plants with nutrient removal (tertiary treatment) and a further 23% treated in plants with biological removal of organic matter (secondary treatment). Tertiary treatment is found in the Nordic countries, Austria, Germany and the Netherlands, while most of the waste water in the United Kingdom and Luxembourg is treated in plants with secondary treatment.

Figure 3.5.12 **Population served by different treatment levels in three European regions**



Rural population is the population not connected to sewers; EU north: DE, FI, NL, LU, UK; EU south: FR, IT, GR, ES, PT; AC10: Accession Countries minus Cyprus

Source: Compiled on basis of information from European Waste Water Group (1997) and other sources (ETC/IW, 1998a).

In the southern Member States 29% of waste water is discharged without any treatment and only 43% of the waste water is treated in secondary treatment plants. Here the highest level of treatment is generally found in France and Italy, where more than half of the waste water was secondarily treated.

In the Accession Countries (excluding Cyprus; AC10) 40% of the population is not connected to sewers and from 18% the waste water is discharged without any waste-water treatment (untreated). The remaining 42% of the waste water receives treatment before being discharged into surface waters, with most waste water receiving secondary treatment.

In many areas of Europe, but in particular in AC10, many of the sewer systems are old, overloaded and leaking, potentially affecting groundwater quality. In addition, many sewer systems have an inflow of groundwater, diluting the waste water and resulting in more water going to treatment plants. At many of the waste-water treatment plants operational problems and low level of efficiency are frequent problems and some are heavily overloaded.

4.1.1. Marked improvement in waste-water treatment

Over the past 15 years marked changes have occurred in the proportion of the population connected to waste-water treatment as well as in the waste-water treatment technology involved (Figure 3.5.13).

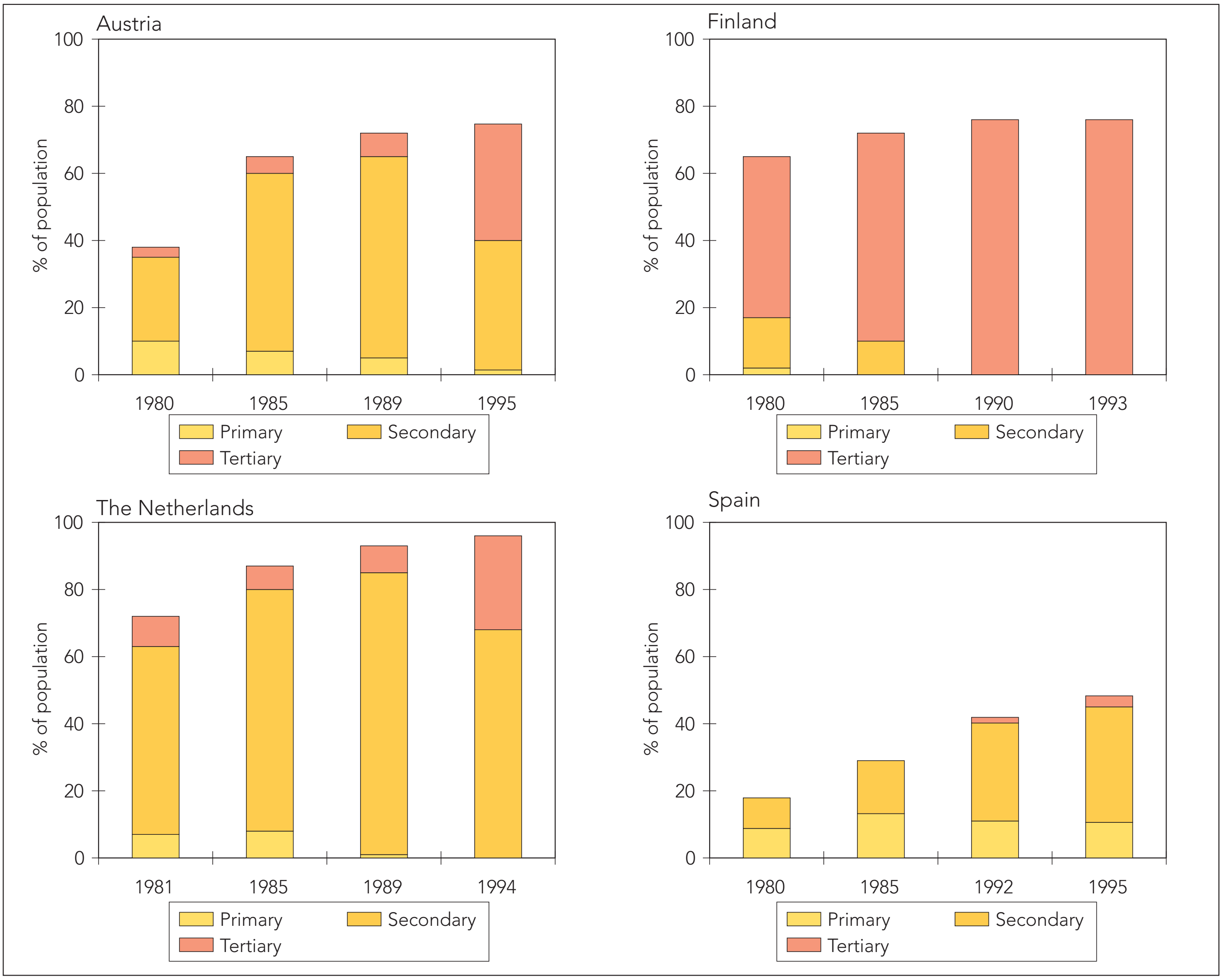
There has been a dramatic increase in sewer connections in those EU countries where the connection rates were comparatively low: in Austria and Spain, it has nearly doubled over the past 15 years. However, there is still some way to go: in 1995 only half of Spain's population had their waste water treated in treatment plants, and some of the waste water going to sewers was discharged untreated.

In the late 1980s and in the 1990s many of the western countries constructed treatment plants with nutrient removal, e.g. there was a marked increase in tertiary treatment in Austria and the Netherlands from 1990 to the mid-1990s.

4.1.2. Marked reductions in emissions from urban waste-water treatment plants

Over the past 15 years reductions of 50-80% in organic matter discharges and 60-80% in phosphorus discharges have been observed

Development in waste-water treatment in selected EU countries — Figure 3.5.13



Only data for untreated waste water for the last year

Source: OECD 1997

in many of the northern EU countries. Part of the reduction in phosphorus discharges can be explained by the shift to use phosphate-free detergents (see above).

Compared to the marked reduction in discharges of organic matter and phosphorus, there have only been small reductions in the discharge of nitrogen. Only a few countries have upgraded their waste-water treatment plants to include nitrogen removal: for instance in Denmark 73% of the waste water is treated in plants with nitrogen removal and current nitrogen emissions from waste-water treatment plants are around 40% of the discharges in the mid-1980s.

4.2. Future waste-water treatment

4.2.1. EU Member States

Under the baseline scenario, the existing waste water facilities in 10 EU Member States, covering 90% of the EU population, are assumed to have been upgraded fully to implement the requirements of the Urban Waste-water treatment Directive (UWWT, see Box 3.5.6). The scenario is based on results reported by national contacts to the European Waste Water Group (1997).

Full implementation of the UWWT Directive, which is expected before 2010, should halve the population not connected to sewers (from 64 to 29 million persons). This would mean that 95% of the total waste water is discharged to sewers (Figure 3.5.14).

With a marked upgrading in waste-water treatment, most waste water would either receive secondary treatment or secondary treatment plus nutrient removal. Sweden and Denmark currently have most of their waste water treated in plants with nutrient removal, while major upgrading of the waste-

Box 3.5.6 Urban Waste-water treatment Directive (UWWTD)

The UWWTD obliges Member States to provide all agglomerations of more than 2 000 population equivalents (p.e.) with collecting systems, and secondary treatment (i.e. biological treatment) for all agglomerations of more than 2 000 population equivalent (p.e.) discharging into fresh waters and estuaries and for all agglomerations of more than 10 000 p.e. discharging into coastal waters.

Member States have to identify water bodies as sensitive areas in accordance with the criteria of the Directive (eutrophication, high concentration of nitrates in surface waters intended for abstraction of drinking water, areas where further treatment is necessary to fulfil other directives). In sensitive areas and catchment of sensitive areas Member States have to ensure the provision of more advanced treatment.

For agglomerations smaller than those described above and which are equipped with a collecting system the treatment must be appropriate, which means that the discharge allows the receiving waters to meet the relevant quality objectives.

The deadline for the implementation of these collection and treatment systems is 31 December 1998, 31 December 2000 or 31 December 2005, depending on the size of the agglomeration and the identification of the receiving waters.

Member States have to ensure that by 31/12/1998 the disposal of sludge from urban waste-water treatment plants is subject to general rules or registration or authorisation in order to minimise the adverse effects on the environment. The disposal of sludge to surface waters has to be phased out by this deadline.

The Directive also contains requirements concerning the discharge of biodegradable industrial waste water from plant representing 4000 p.e. or more. The deadline for this application is 31 December 2000.

water treatment plants is planned in Austria, Belgium and Ireland.

Some countries, such as Spain, Italy, Portugal and the UK, have decided that most waste water should receive secondary treatment, while in the other EU countries most of the water bodies have been classified as sensitive and the waste-water would therefore be treated in plants with nutrient removal.

With full implementation of the UWWT Directive, the discharge of organic matter after implementation of the UWWT Directive is expected to fall from 3.4 to 1.2 Mtonnes BOD_5, a reduction of 65% from current levels. In addition, phosphorus and nitrogen discharges should decrease by 31% and 21% respectively; from 210 to 145 ktonnes P, and from 1030 to 810 ktonnes N.

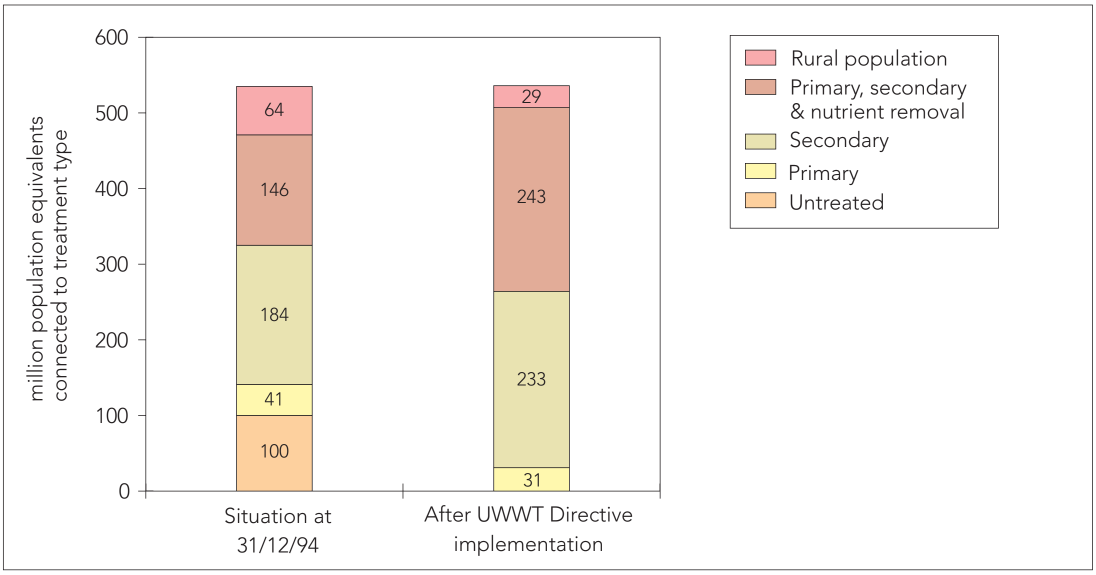
The investment cost of implementing the UWWT Directive in the EU has been estimated at 140 EUR per capita for waste-water treatment alone and 300 EUR per capita for waste-water treatment and collecting systems together. Beside, the intensification of waste-water treatment will increase the quantity of contaminated sludge generated by the treatment process (see Chapter 3.7).

Construction of waste-water treatment plants will be concentrated in the catchment areas of heavily polluted rivers, and so the improvement in water quality should be even greater than suggested by the emission reductions. Thus, the number of river stretches heavily polluted by organic matter should be mark-

Figure 3.5.14 **Development in the number of population equivalents connected to different types of waste-water treatment (EU10)**

Person equivalents (p.e) EU10: DE, ES, FI, FR, GR, IT, LU, NL, PT, UK.

Source: Compiled from European Waste Water Group, 1997



edly reduced, especially in southern and eastern parts of the EU, where the current waste-water treatment level is low.

Reduced discharges of nutrients from point sources are also expected to reduce eutrophication effects, especially in water bodies with current high concentrations. For these and other water bodies, nutrient concentrations will be largely determined by the diffuse loads from agricultural activities.

The baseline scenario, with full implementation of the UWWT Directive, has been applied to estimate the downstream concentration of nutrients in large EU rivers (European Commission, 1999). The results demonstrate that overall river phosphorus concentrations could decrease by 0.1-0.2 mg P/l in the period 1990 to 2010, while the nitrate concentrations are likely to remain unchanged in most rivers. In many rivers in north-western Europe, phosphorus concentrations have already decreased by around 0.1 mg P/l during the first half of the 1990s.

4.2.2. Accession Countries
Similar baseline scenarios have also been developed for the implementation of the UWWT Directive in the AC10. In these countries around 40% of the population is not currently connected to sewers. Thus the effect of implementation of the Directive will depend significantly on the development of sewerage in the coming years. Three possible 'what if' scenarios for the period 1995 to 2010 have been assessed (EEA, 1999):

A: Moderate development of sewerage and waste-water treatment as a requirement for normal areas (secondary treatment);
B: High effort on sewerage development and waste-water treatment as a requirement for normal areas (secondary treatment);
C: High effort on sewerage development and waste-water treatment as a requirement for sensitive areas (secondary treatment plus nutrient removal).

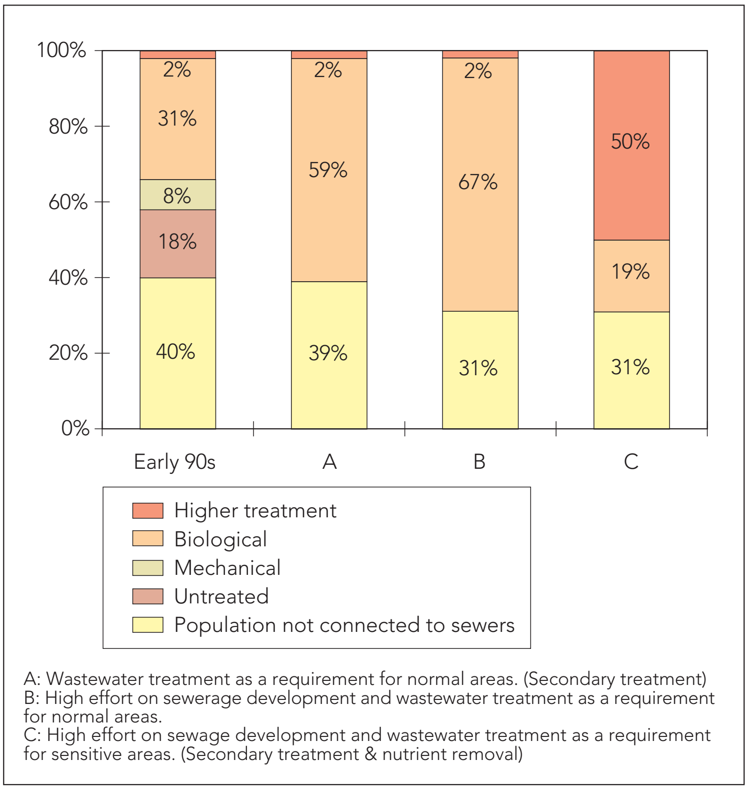
The predicted changes in waste-water treatment are illustrated in Figure 3.5.14. The proportion of the population not connected to waste-water treatment is expected to decrease from the current 40% to around 31% under scenarios B and C.

Waste-water treatment will also improve. Currently most discharges are untreated or mechanically treated. In the future waste water will be either treated biologically, as in scenarios A and B; or biologically with nutrient removal, as in scenario C. Scenario C is similar to the expected situation in the present EU following implementation of UWWT Directive, except that the proportion of population not connected to sewers is higher in the Accession Countries.

Under scenarios A and B, the extent of biological treatment of waste water is expected to increase from the current 31% to 59% and 67%, respectively by 2010. If realised, this should result in a reduction of organic matter being discharged from the current value of 1.1 Mtonnes to around 0.45 Mtonnes, that is a 60% reduction (Figure 3.5.16). Implementation of scenario C should result in a small additional reduction (5%) in the amount of organic matter discharged to about one third of the current loads.

Only small changes are expected in the future amount of nutrients discharged under the two first scenarios, namely a reduction of 12% and 10% for phosphorus and nitrogen respectively. In scenario C with half of the waste water being treated in

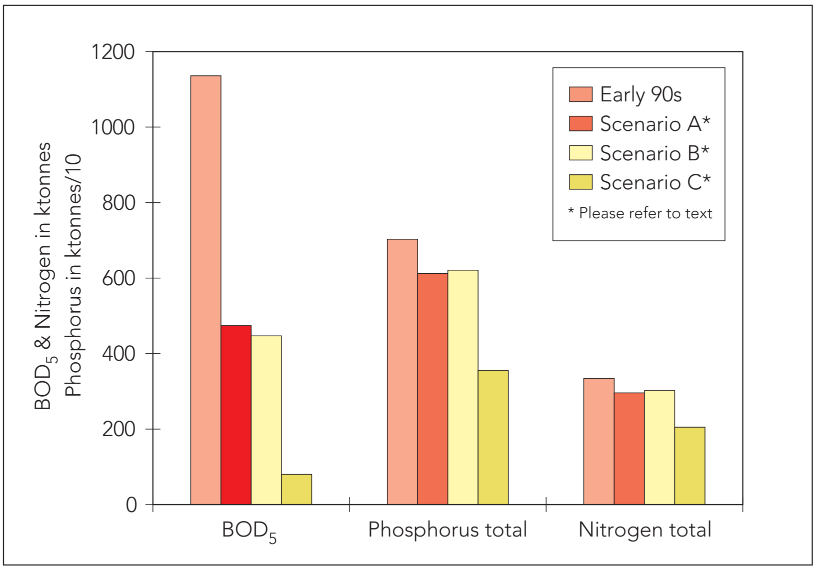
Development in waste-water treatment in the Accession Countries (excluding Cyprus) — Figure 3.5.15



Source: EEA, 1999

Figure 3.5.16

Change in emissions from urban waste-water treatment plants as result of three scenarios, Accession Countries



Phosphorus discharges should be divided by 10

Source: EEA, 1999

plants with nutrient removal, a 50% reduction in phosphorus discharges and a 40% reduction in nitrogen discharges would be expected by 2010 compared to the current loads. This would potentially reduce the nitrate and phosphorus loading from rivers in the Accession Countries to both the Baltic and Black seas by around 15% and 28% respectively.

The cost for the most radical implementation of the UWWT Directive in the Accession Countries as in scenario C is estimated at 9 billion EUR (around 100 EUR per capita), for the construction of treatment plants (van Driel, 1998); this does not include costs of additional sewer construction and sludge treatment and disposal.

5. Trends in quality

5.1. Improvement in oxygen conditions and river quality

5.1.1 Organic pollution, a success story

The most important sources of the organic waste load are: household waste water, industries such as the paper industry or food processing industry, and silage effluent and slurry from agriculture. Severe organic pollution may lead to rapid deoxygenation of river water and disappearance of fish and aquatic invertebrates.

Increased industrial and agricultural production coupled with more of the population being connected to sewerage meant that the discharge of organic waste into surface water increased in most European countries from the 1940s onwards. Over the past 15-30 years however, biological treatment of waste water has increased, and the organic loading has consequently decreased in many parts of Europe. The result is that many rivers are now well oxygenated.

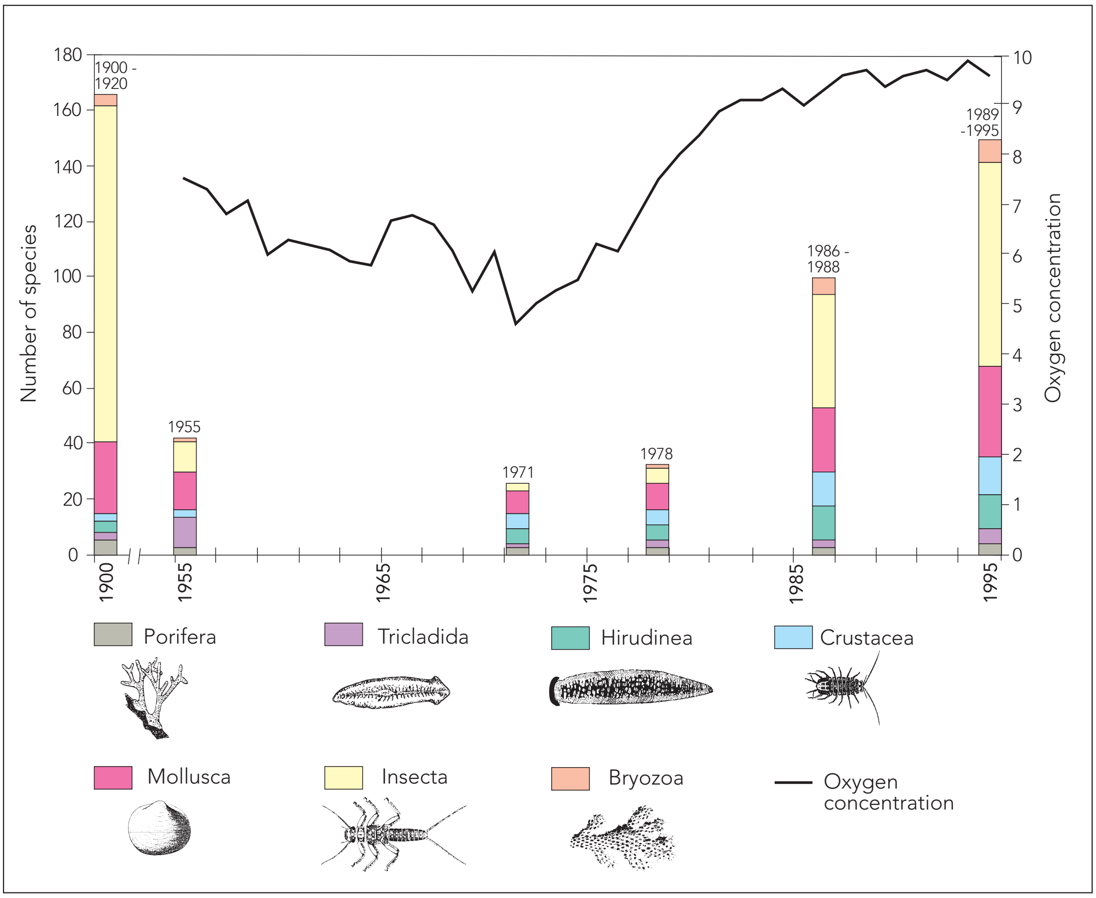
The changes in the river Rhine is an illustrative example (Figure 3.5.17). Up to the early 1970s, the Rhine was polluted with such excessive amounts of organic matter that the oxygen depletion was so serious in the central and lower reaches that the river was virtually dead. Since then, the oxygen conditions have markedly improved, and as a result the number of invertebrate species has nearly reached the numbers observed early this century.

Information from about 1 000 river sites across Europe shows that in the mid-1990s, 35% of the sites had an annual average concentration of organic matter measured as BOD (Biochemical Oxygen Demand) below 2 mg O_2/l (the typical value for unpolluted rivers) while 11% were heavily polluted and had an average BOD greater than 5 mg O_2/l. Rivers with high BOD levels are generally subject to high human and industrial use. In the Nordic countries and western Europe less than 10% of the rivers have BOD levels higher than 5 mg O_2/l, while around 25% of the rivers in southern and eastern Europe are heavily polluted with organic matter (Figure 3.5.18).

Generally, the concentration of organic matter in European rivers has fallen over the past 10 to 20 years, particularly in the most polluted rivers. In western Europe there has since the late 1970s been a marked decrease in the number of heavily polluted rivers from 24% in the late 1970s to 6% in the 1990s, while the decrease in southern and eastern Europe started in the 1980s and are less significant. The decrease reflects improvements in the treatment of domestic sewage and industrial waste water.

Improvements in the oxygen conditions of European rivers are consistent with the reduction in concentrations of organic matter. The oxygen concentration in the river Rhine has, for instance, increased from an annual average value around 5 mg O_2/l in the 1970s to current values around 10 mg O_2/l (see Figure 3.5.17).

Development of biotic community of the Rhine (selected animal groups) and oxygen concentration (at Bimmen) — Figure 3.5.17



Source: German Federal Ministry of the Environment, 1998

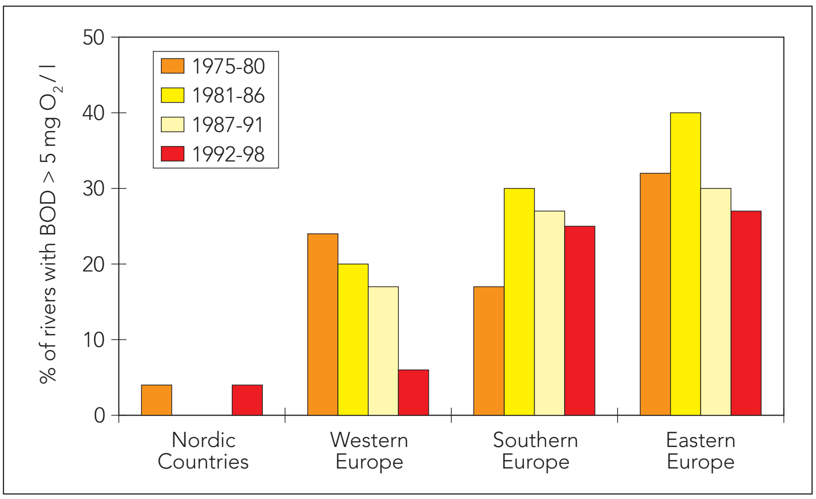
5.1.2. Ecological impacts

The oxygen consumption caused by organic matter pollution has a strong impact on the riverine fauna. Heavily polluted rivers have a low biodiversity and an invertebrate fauna dominated by species tolerant to low oxygen concentrations. Many European countries use either biochemical organic pollution indicators (e.g. oxygen levels, BOD and ammonium concentrations) or invertebrate indices for classification of river quality.

In general, most of the countries classify 80% to 95% of the river stretches as having good and fair quality. However, in some countries such as Belgium, Bulgaria, the Czech Republic, Denmark, Lithuania and Poland more than 25% of the river stretches surveyed have been classified as poor or bad quality. The rivers with poor or bad quality are generally rivers polluted by waste-water discharges and are in regions of high population density and intensive farming.

An illustration of the bad quality of some of the rivers in eastern Europe, also to illustrate that the measures to improve quality are

Percentage of heavily polluted rivers (i.e. rivers with BOD concentration levels greater than 5 mg O_2/l) — Figure 3.5.18



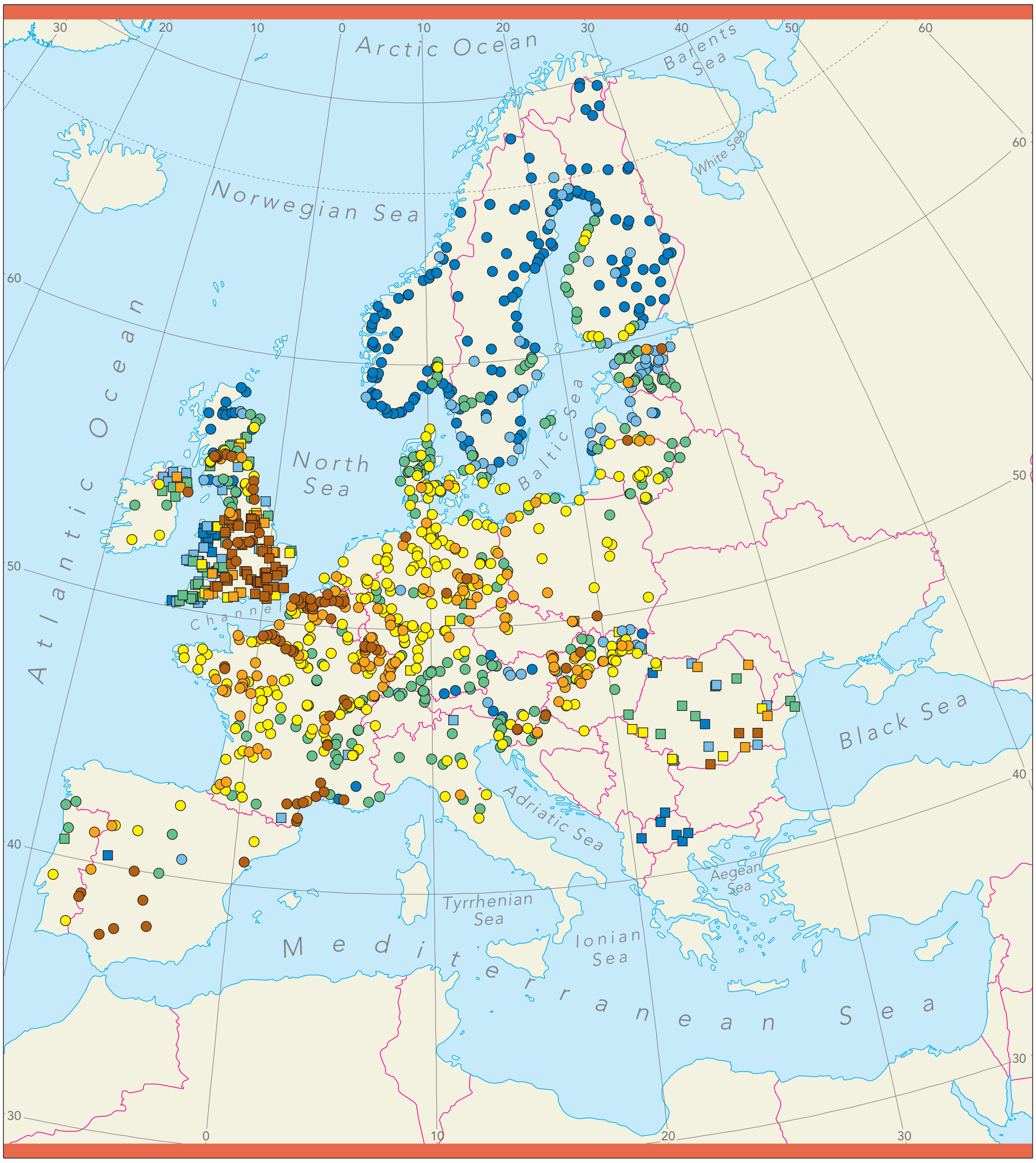
Source: ETC/IW

rather straightforward, could be the situation in the river Elbe after the reunification of Germany in 1990. Here it proved necessary to introduce a new water quality class ‘ecologically destroyed’ to describe the water quality of some stretches of the river. In 1995, because of the closure of major industries and the construction of new waste-water treatment plants, especially in the New Länder and the Czech Republic, water quality in the Elbe has markedly improved. In the catchment area of the Elbe more than 125 waste-water treatment plants are being built at a cost of DM 14 billion (German Federal Ministry of the Environment, 1997).

5.2. Phosphorus levels are declining in rivers and lakes

Information from about 1 000 river stations in Europe shows that 90% of the stations had a mean concentration of total phosphorus exceeding 50 µg/l (Map 3.5.3). The concentration in rivers unaffected by human activities are for comparison generally less than 25 µg/l. The lowest concentrations are found in the Nordic countries, whereas the river stations in a band stretching from southern England across western and central Europe to Romania have relatively high concentrations.

The phosphorus concentration in European lakes and reservoirs is similar to the state of the rivers. In the Nordic countries more than half the lakes have a concentration below 10 µg/l, whereas in most other countries, a large proportion of the lakes have phosphorus concentrations far exceeding a near natural state, in this context considered as below 25 µg/l.



Map 3.5.3

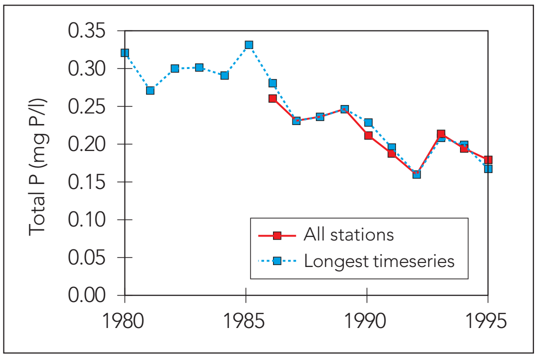
Source: ETC/IW

The concentration of phosphorus in EU rivers has decreased since the mid-1980s, particularly in the most polluted rivers. The long time-series available for some river stations reported under Council Decision (77/795/EEC) on Exchange of Information, indicates roughly a 25% reduction of the concentrations (Figure 3.5.19), from the early 1980s the early 1990s. The changes have been most pronounced in the previously most polluted rivers.

Similar changes have been observed in many lakes (e.g. lake Constance; Figure 3.5.20). Here the phosphorus level increased in the 1960s, but since the mid-1970s, when measures were taken to reduce the phosphorus load, the lake phosphorus concentration has decreased. Although the phosphorus level of European lakes has decreased markedly, water quality in many lakes in large parts of Europe is still poor and below that of lakes in good ecological state.

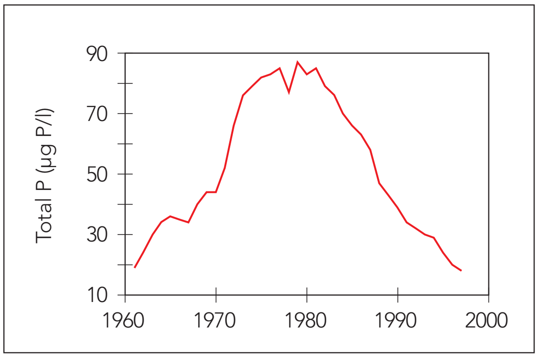
The declining concentrations of phosphorus results from improved waste-water treatment and reduced content of phosphorus in detergents. Having reduced the pollution from the point sources it may, in many cases, also be necessary to take measures to reduce the diffuse load of phosphorus from agricultural areas, particularly where the absorption capacity of the soil may be exceeded, for example, in parts of Ireland, where such measures are being introduced.

Development in river phosphorus concentration in 126 large river stations – median of annual averages — Figure 3.5.19



Source: Codling and Bøgestrand, 1998

Development in lake Constance phosphorus concentration — Figure 3.5.20



Volume-weighted annual averages of phosphorus (in epilimnion)

Source: IGBK, 1998

5.3. Nitrate in European waters

5.3.1. Why worry about nitrate?

Nitrate in drinking-water is considered to be a public health problem because nitrate rapidly reduces to nitrite in the body. The major effect of nitrite is that it reduces the capacity of the blood to transport oxygen. This phenomenon has only been observed at nitrate levels significantly above the 50 mg/l level therefore this level delivers sufficient protection against this occurring. In addition, nitrite reacts with compounds in the stomach to form products which have been found to be carcinogenic in many animal species, although the link to cancer in humans is at the moment suggestive. Nevertheless, these two factors together totally justify a precautionary approach being taken in the establishment of this parameter.

5.3.2. Drinking water

In Europe, most people are served with drinking-water taken from groundwater sources (EEA, 1999b). Most groundwater supplies in the EU are generally from deep wells not affected by high nitrate levels, although private and small communal supplies are usually derived from shallow groundwater sources, and if these are contaminated with nitrate the population is at risk.

In the EU, the concentration of nitrate in drinking-water has been regulated since 1980 by the Drinking-water Directive. This establishes a guide level of nitrate of 25 mg/l and a Maximum Allowable Concentration (MAC) of 50 mg/l. No complete overview of nitrate in drinking-water exists in the EU, only information from selected national surveys. A study of more than 5 000 samples from private well waters throughout Belgium has shown that 29% exceed the MAC of 50 mg NO_3/l (Verbruggen, 1997). Thirteen percent of the Finnish population has water supply from private wells, of which 12% has a nitrate content exceeding 25 mg NO_3/l (Wahlström *et al.*, 1996).

Nitrate levels were evaluated at more than 3 000 sampling sites in France in 1992-93 (IFEN, 1996). The sampling sites were mainly abstraction points for supplying drinking-water from both groundwater and surface water. In all, water in 25% of the sampling sites had nitrate concentration over 40 mg/l. In addition, the nitrate concentration exceeded 50 mg NO_3/l at 12% of the water abstraction points sampled. The most serious situation was observed in regions where intensive livestock and arable farming takes place (e.g. Brittany, Paris basin, and Rhone valley).

In many countries the main measure to combat the nitrate problem has been closing the nitrate-affected shallow wells and taking groundwater from deeper wells. Taking water supplies from deeper aquifers is a short term solution and is not sustainable in the long run. A reduction in the pollution of groundwater and surface waters can only be achieved if there is a substantial reduction in the nitrogen surplus in the agricultural sector and hence in nitrogen inputs to water.

In the Accession Countries agricultural activities are generally less intensive compared to the EU, however, some regions are affected by high nitrate levels. This is especially of concern because of the relatively high proportion of rural population in the AC10. The rural population is more at risk because of the use the more heavily polluted shallow wells for drinking water. In 10 different regions in Bulgaria, an average of 35-45% of the population is exposed to elevated nitrate levels (OECD, 1993). In Lithuania in 1996, 37% of samples from private groundwater water supplies contained concentrations of nitrate exceeding the MAC (EEA/WHO, 1999). Elevated nitrate levels are also found in local water supplies in all but two of the 41 districts of Romania. According to a 1990 survey of water supplies in the countryside, 7% were above 200 mg NO_3/l, 10% were between 100-200 mg NO_3/l, and a further 19% were between 45-100 mg NO_3/l (OECD, 1993).

5.3.3. Nitrate in rivers and coastal areas

Apart from Nordic rivers, 68% of the river stations (Map 3.5.4) had mean nitrate concentrations exceeding 1 mg/l. The concentration in unaffected rivers is 0.1-0.5 mg/l. The highest concentrations were found in rivers in the intensive agricultural regions in the northern part of western Europe. In the Nordic countries, concentrations are low, 70% of the sites have levels below 0.3 mg/l.

The concentration of nitrate in EU rivers has been approximately constant since 1980 (Figure 3.5.21) and there is no overall indication that the reduced application of nitrogen fertilisers to agricultural land (see Chapter 2.2) has resulted in lower levels of nitrate in the 1990s.

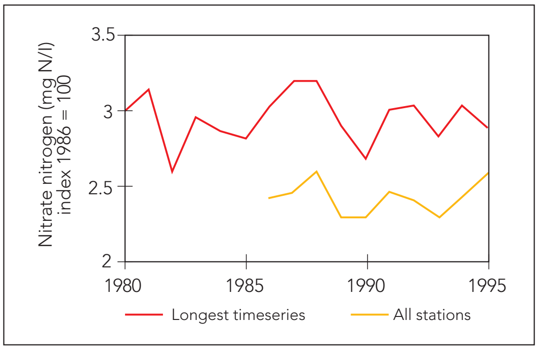
The impact of nitrate is more significant in coastal and marine waters than in inland surface waters. In many coastal areas enhanced nitrogen loading leads to increased growth of annual macrophytes and in some cases mass occurrence of filamentous algae. At even higher nitrogen loading the amount of phytoplankton (algae) increases markedly, and the water becomes turbid. In enclosed or semi-enclosed marine waters (for instance the Baltic Sea), large amounts of phytoplankton will sediment out and oxygen consumption will consequently increase, possibly resulting in oxygen deficits and kills of animals unable to escape the area affected by low oxygen content (see chapter 3.14).

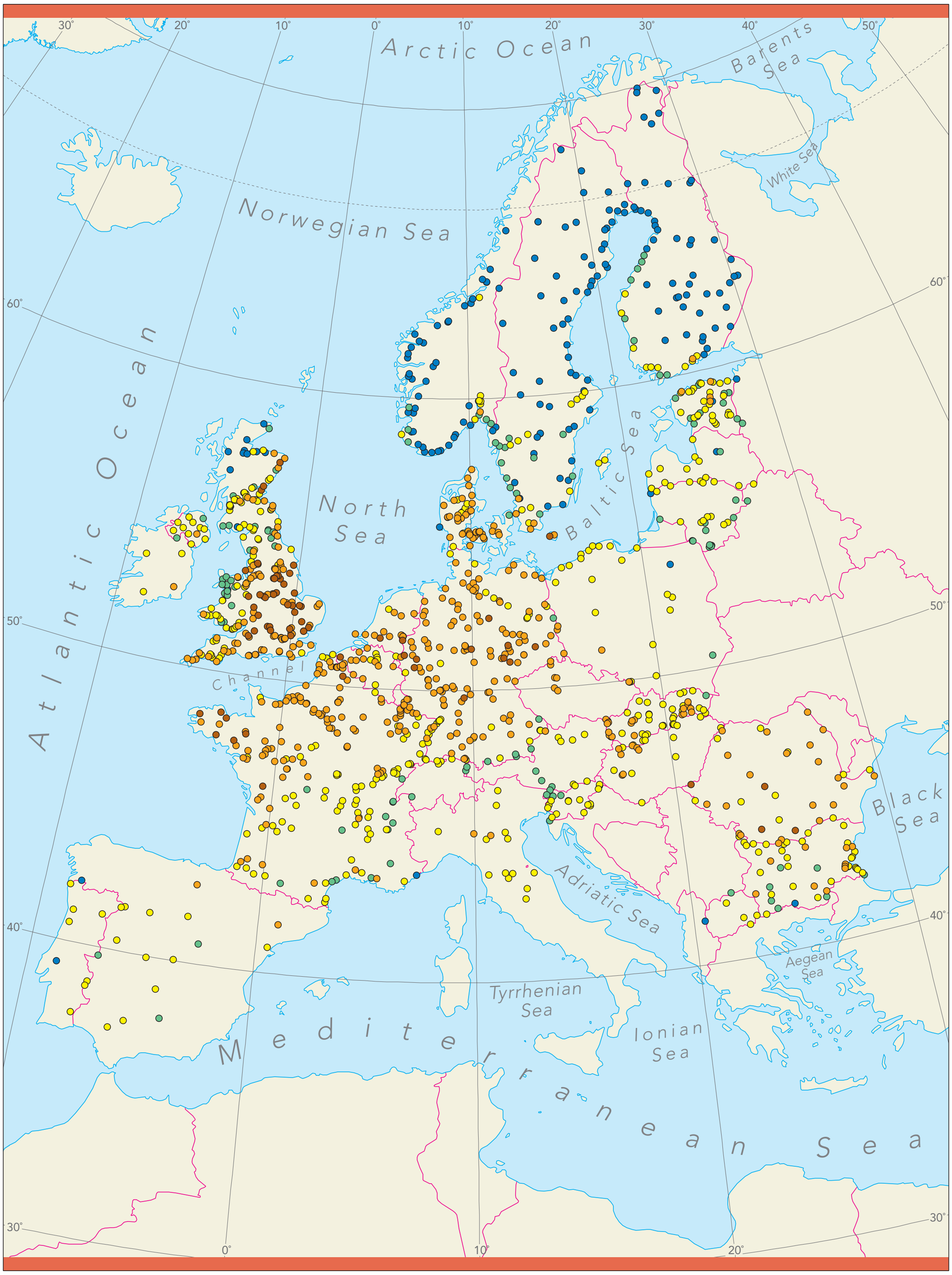
6. Policy responses to alleviate water stress

Over the past 25 years, the EU has developed and adopted a number of directives concerning water quality, aimed at specific processes or industries (e.g. chlor-alkali, titanium, dioxide), specific substances (e.g. dangerous substances, nutrients) or specific uses of water (e.g. drinking water, fish, bathing). The majority of these Directives have been transferred to national law, and their application is leading to improvements in many areas. In contrast to the many initiatives on water quality in the European Union, there has been much less activity concerning water quantity, and until recently there has been no policy in place, which integrated water quality and quantity.

Figure 3.5.21 **Development in river nitrogen concentration in 126 large river stations – median of annual averages**

Source: Codling and Bøgestrand, 1998





Annual average nitrate concentration in rivers

0 — 500 km

Nitrate in mg N/l
Average of annual means
1994–1996

- more than 7.5
- 2.5–7.5
- 0.75–2.5
- 0.3–0.75
- less than 0.3

Map 3.5.4

Source: ETC/IW

The proposed Water Framework Directive (see below) seeks to address these deficiencies by an integrated approach covering all aspects of water management (including groundwater) under one framework document. It is also intended to integrate conservation and sustainable use criteria into other policy areas, such as agriculture, land-use planning, industrial production processes and economic development.

Another initiative towards an integrated management of water resources is the EU groundwater action programme, which establishes objectives related to groundwater quality and the over-exploitation of aquifers. However, these initiatives are relatively recent and there are no parameters yet available to measure the progress in pursuing the targets established.

The EU regulation 2078/92 on agri-environmental measures (see Chapter 3.13) has co-funded actions for the protection of rivers and water extraction areas. The expansion of agri-environmental measures is the central element of a strategy to integrate environmental considerations into agricultural policy. However, the pace and extent of integration will need to be considered in future adjustments of the CAP.

6.1 Water quality: what do the trends tell us about the effectiveness of current policies?

The assessments in this chapter illustrate that the measures to reduce pollution and hence improve water quality have been implemented with varying degrees of success. Organic matter and phosphorus discharges into surface waters have been reduced markedly in several areas over the past 20 years and have lead to lower concentrations. In contrast, nitrate levels in rivers have remained high. For groundwater no firm conclusions about state and trends of pollution can be drawn. This is partly due to a lack of comparable data on groundwater pollution and to the fact that the time lag for pollutants to reach groundwater may be up to 20 to 30 years.

Although many large rivers have improving quality, there is little evidence that this trend is being observed in smaller rivers, to which national regulatory authorities often give a lower priority in terms of monitoring and improvement measures. Small rivers and headwaters are ecologically important, providing diverse habitats for aquatic biota. For example, they provide important spawning grounds for many fish species. Because of their physical size, and often low flows, providing only limited dilution of pollutants, they are particularly susceptible to human pressures and activities. Channel modifications, discharges of inadequately treated sewage and run-off from agricultural land are all important pressures on small rivers.

Generally, control of discharges has been most effective for point sources such as urban waste water and industrial effluents, and in the case of pollutants like phosphate from detergents, where the use has been restricted or completely banned. Nevertheless, control of point source discharges varies, and most Member States have room for improvement. In the Accession Countries, the construction and upgrading of waste-water treatment plants to north-western European standards would result in considerable reductions in pollutant discharges.

In the case of diffuse sources, such as nitrate runoff from agriculture, effective control has rarely been achieved. Today, the use of fertilisers and the load of nutrients spread in manure has decreased compared to maximum levels in the 1980s. This is mainly because of the effect of the CAP reform (decoupling of payments from production aids to direct aids linked to farming area with price reductions), and a reduction in cattle livestock, but also due to economic recession in the AC10. However, the nutrient input from agriculture is still too high. In addition, when agriculture in the AC10 regains some of its former production levels, major problems with diffuse source pollution may occur in this region.

The implementation of the Nitrate Directive has been unsatisfactory in the majority of Member States (European Commission, 1998) and proceedings have been initiated against those Member States that have not yet complied. Implementation of the Urban Waste-water treatment Directive has likewise been patchy and slow but considerable investment programmes are in place in all Member States to comply with the Directive's objectives. Achievement of these objectives should have a great impact on the future state of the EU's waters.

6.2 Water quantity – supply-side and demand-side strategies

6.2.1. Supply-side

Supply-side strategies, which focus on measures (reservoirs, new wells, water transfers, etc.) that increase or assure supply, have traditionally been used for addressing the water quantity problems associated with water stress.

At present about 3 500 major reservoirs with a total gross capacity of approximately 150 km^3 are in operation in the European Union (EEA, 1999c). The greatest storage capacities exist in Spain (52 km^3), Sweden (21 km^3) and Finland (18 km^3). Despite its large reservoir storage capacity, Spain still experiences periods of severe drought, indicating that more than just supply-side measures are needed for efficient water resource management. Reservoirs are expensive to build and can cause problems like sedimentation, eutrophication, reduction of the biodiversity downstream, interruption of fish migration, etc. The establishment of a common policy for ecological quality and minimum flows to be guaranteed by reservoir management is a key question, for instance, in order to maintain the aquatic biodiversity (EEA, 1999c).

Water transfer schemes are used (for example in France, Spain and Greece) to overcome the uneven geographical distribution of resources, and they constitute an essential element of water resource planning. Water transfer can, however, have several disadvantages, such as the need for major investment in construction works, losses through leaks and evaporation and possible negative environmental impacts, for example through the introduction of alien species. Water quality problems can also arise because of mixing of water from different sources during a water transfer.

Increasingly, non-conventional sources such as desalination and water re-use are playing an increasingly important role in Mediterranean areas which face acute problems of water stress (see Box 3.5.7).

6.2.2. Demand-side

Demand-side strategies focus on water conservation and waste prevention measures. In general, demand-management measures tend to be especially promising under circumstances where either water is very scarce or environmental consciousness very high.

In order to achieve reduction or prevention of water stress by demand-based strategies, policy must rely on economic principles and particularly on pricing (Box 3.5.8). Nowadays prices do not always cover the full cost of water services and therefore users do not pay the real cost of the water they use. One aim of a future water policy could be to implement the (full) cost recovery principle (CRP). The main question is to determine which services and costs have to be covered by each particular tariff system and how it impacts on the economic situation of users. The main consequence of the implementation of the CRP is that most subsidies will be removed and the revenues will have to be provided by higher tariffs, which should tend to reduce water demand. This type of policy can produce negative impacts on some regions where water is crucial for their economic or social development. As a benefit, the CRP implementation will reflect the “real value” of water, and the need for efficient management of water resources.

6.3. The Water Framework Directive – a new approach?

Pressure for a fundamental rethink of EU water policy came to a head in mid-1995. There was a need for a more global and coherent approach to water policy to replace what many saw as a piecemeal and sometimes inconsistent approach that had been put into place. As a result the requirements of the proposed directive on the ecological quality of surface waters were incorporated into a proposed framework directive that aimed to be the cornerstone of a new water policy. This proposed Water Framework Directive will rationalise the Community’s water legislation by replacing six of the ‘first generation’ directives. The aims of these directives will be taken into in the Framework Directive, allowing them to be repealed.

The overall purpose of the proposed Directive is to establish a framework for the protec-

Box 3.5.7 The role of non conventional water resources in Europe

Desalination

Initially sea-water desalination technologies were based on distillation and hence energy consumption was very high. The development of more efficient technologies (such as inverse osmosis) has reduced the cost of desalination considerably (below 1 EUR/m^3). However, this technique still tends to be considerably more expensive than supply from conventional (surface water and groundwater) sources. Desalination of sea water or brackish groundwater is therefore mainly applied in places where no other sources are available.

Sea-water desalination in Spain accounts for about 0.22 km^3/year. Although this volume is small in comparison to the country’s total renewable water resources (111 km^3/year), it represents a significant share of resources in the areas where this technology is applied (mainly the Canary and Balearic Islands). In Greece five desalination plants are in operation, all of them on islands.

Water re-use

The term ‘water re-use’ refers to supplying wastewater for a secondary use. The main applications of this technique are irrigation in agriculture, parks, recreational areas, golf courses, etc. Usually, simplified water treatment is carried out, in order to guarantee minimum quality standards of the water to be re-used. Few studies and data about the re-use of waste-water are available, and further research is needed to assess the long-term effects of irrigation with treated waste-water on soils and agriculture.

In France, waste-water re-use has become a part of regional water resources management policies. It is practised mostly in the southern part of the country and in coastal areas, compensating local water deficiencies.

In Portugal it is expected that by the year 2 000 the volume of treated waste-water will be around 10% of the water needs for irrigation in dry years. It is estimated that between 35 000 and 100 000 ha could be irrigated with treated waste-water.

In Spain, the total volume of waste-water reclaimed amounts to 0.23 km^3/year, being used mainly for irrigation in agriculture (89%), recreational areas and golf courses (6%), municipal use (2%), environmental uses (2%) and industry (1%).

Box 3.5.8 Water prices and subsidies

A study being carried out (Planistat, 1998) for the European Commission shows what is the current situation of pricing in four different European basins and what have been the main obstacles for the implementation of the cost recovery principle (CRP). The basins that have been studied are: the Adour-Garonne in France, the Henares in Spain, the Tavy in UK and the whole territory in the Netherlands.

In England and Wales, the costs of providing public water supplies are covered solely by the charges that the water companies make on their customers. These charges are under the control of an independent regulator who conducts periodic reviews of the price limits which apply to each company. These reviews are conducted with full consultation and the outcome is available for public scrutiny, subject only to genuine needs for commercial confidentiality. Water abstraction charges, whether by water companies or other abstractors such as irrigators, are limited to recover only the costs the Environment Agency incurs in managing water recourses.

In the Netherlands, the collective water supply is self-financing. There are not known government grants for collective drinking-water services. There is no collective irrigation thus no tariffs are applicable. As in the UK, problems of data availability have been found when trying to assess how the CRP is implemented.

In the Spanish Henares basin, different rates of cost recovery have been found, depending on the high, medium or low section along the river. In the highlands, the tariff system applied for the regulation and distribution of water result in a low rate of cost recovery (46% for agriculture and 58% for urban use). In the middle and low section, the rate is close to the CRP, varying between 99% and 74%, depending on the approach used for assessing the revenues to be got from the tariff system.

In the French Adour-Garonne basin the drinking-water supply is almost entirely self-financing (about 98%), but the irrigation tariff only covers from 30% to 40% of the total cost of the services.

tion of inland surface water, transitional waters, coastal waters and groundwater in order to prevent further deterioration, and to protect and enhance the status of aquatic ecosystems and those terrestrial ecosystems directly dependent upon them;

- It requires the achievement of ‘good’ surface water and groundwater status by 2015 unless it is impossible or prohibitively expensive.
- It also promotes the concept of sustainable water use based on the long-term protection of available water resources and also contributes to mitigating the effects of floods and droughts. The Framework Water Directive will, therefore, contribute to the provision of a supply of water of the quality and in the quantity needed, for sustainable, balanced and equitable use of the resource.
- It supports the protection of transboundary, territorial and marine waters and the achievement of the objectives of international agreements to prevent and eliminate pollution of the marine environment.
- The proposal also stimulates the progress reduction of pollution by hazardous substances.

A key feature of the proposed Directive is that it requires Member States to manage and co-ordinate administrative arrangements at the River Basin level (or, where appropriate, e.g. in the case of small River Basins) to aggregate into River Basin Districts. This applies to groundwater as well as surface waters. The more integrated approach to protect the aquatic environment together with integration of environmental considerations into sectoral policies should help to alleviate water stress in the future.

References

Blue Plan, 1996. *Water in the Mediterranean region. Situations, perspectives and strategies for sustainable water resources management.* Euro-Mediterranean Conference on local water management. Marseilles, 25-26 November 1996.

Codling, I.D. and Bøgestrand, J., 1998. *Quality of surface fresh water. – Common procedure for the Exchange of Information – 1993-1995.* Synthesis Report to the European Commission, Brussels.

Danmarks Miljøundersøgelser, 1997. *Vandmiljøplanens Overvågningsprogram.Ferske vandområder – vandløb og kilder.* Faglig rapport fra DMU, nr. 214. (in Danish)

Danmarks Statistik, 1998. *Miljøstatistik.* Copenhagen. (in Danish).

DOE, 1999. Personal Communication, Department of Environment, UK.

EEA, 1995. *Europe’s Environment. The Dobris Assessment.* D. Stanners and P. Bourdeau (Eds). Office for Official Publications of the European Communities. European Environment Agency, Copenhagen.

EEA, 1997. *Water resources problems in Southern Europe – An overview report.* Topic Report 15, Inland Waters. European Environment Agency. Copenhagen.

EEA, 1998. *Europe’s Environment. The Second Assessment.* Office for Official publications of the European Communities & Elsevier Science Ltd.

EEA, 1999a. *Sustainable Water Use in Europe – Sectoral Use of Water.* Topic Report 1, Inland Waters. European Environment Agency. Copenhagen.

EEA, 1999b. *Groundwater quality and quantity in Europe.* Environmental Issues Series,. European Environment Agency. Copenhagen. (in press).

EEA, 1999c. *Lakes and reservoirs in the EEA area.* Topic Report 2, Inland Waters. European Environment Agency. Copenhagen. (in press).

ETC/IW, 1998a. *Nutrient discharges from point (industry and consumers) in the 10 Accession countries.* Technical Report to the EEA from the European Topic Centre on Inland Waters. December 1998.

ETC/IW, 1998b. *Contribution from the European Topic Centre on Inland Waters to RIVM's study on priorities, Water demands in Europe*. European Topic Centre on Inland Waters. Report for European Environment Agency.

EEA (forthcoming), 1999. Environment and European enlargement - Appraisal of future trends: *Implementation of the Urban Waste-water treatment Directive*. Scenarios and projects n° 3. Environmental issues n°. 8. European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EEA/WHO, 1999. *Water resources and human health in Europe*. Environmental Issues Series (in press).

Environment Agency, 1998. *Aquatic eutrophication in England and Wales. A proposed management strategy.* Environmental Issues Series, UK Environment Agency.

European Commission, 1998. *The implementation of Council Directive 91/676/EEC concerning the Protection of Waters against Pollution caused by Nitrates from Agricultural Sources.* Report of the Commission to the Council and European Parliament. COM(97) 473 final.

European Commission, 1999 (fortcoming). *Economic assessment of priorities for a European Environmental Policy Plan (working title).* Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (environment, nuclear safety and civil protection).

European Waste Water Group, 1997. *Urban waste-water treatment in the EU*. Report from the European Waste Water Group.

FAO Aquacult PC, 1998. AQUACULT PC – *Time Series of Aquaculture and Capture Fishery Production*. http://www.fao.org/WAICENT/FAOINFO/FISHERY/statist/fisoft/AQUACULT.HTM

German Federal Ministry of the Environment, 1997. *Towards Sustainable Development in Germany*.http://www.bmu.de/englisch/index.htm

German Federal Ministry of the Environment, 1998. *Water Resources Management in Germany*. http://www.bmu.de/englisch/index.htm

Gundermann, H., 1993. *An estimate of the future demand for water in a region – Forecasting techniques*, in La economía del agua, Sociedad General de Aguas de Barcelona (ed.).

Hydro, 1995-1996. *State of the Environment report 1995, & 1996.* Http://www.hydro.com/

ICWS, 1996. *Long range study on water supply and demand in Europe – Integrated Report*, International Centre of Water Studies. Amsterdam, the Netherlands, Report 96.05 to the EC Forward Studies Unit.

IFEN, 1996. *Environmental Performance Indicators in France – 1996-1997 edition*. Report from the French Institute for the Environment (IFEN).

Ijjas, I., 1996. *Removal of Phosphate from Detergents in the Danube Basin. Executive Summary*. Report from PHARE Project No: EU/AR/205/91, Contract No: 95-0036.00.

IGBK, 1998. *Langjährig Entwicklung chemischer Parameter im Bodensee-Obersee*. Internationale Gewässerschutzkommission für den Bodensee Bericht 48.

Kemira, 1996. *State of the Environment report*. http://www.kemira.com/environment.html

Llamas, M.R., M. Casado, A. de la Hera, J. Cruces and L. Martinez, 1996. *El desarrollo sostenible de la cuenca alta del río Guadiana: aspectos socio-económicos y ecológicos.* Medio Ambiente. Páginas 66-74. Sept.-Oct. 1996.

OECD, 1993. *Environmental Action Programme (EAP) for the Central and Eastern European Countries*. Document endorsed by the Ministerial Conference 'Environment for Europe', 28-30 April 1993 in Lucerne, Switzerland http://www.oecd.org/env/eap/docs/eap-cont.htm

OECD, 1997. *OECD Environmental Data – Compendium 1997*. Paris.

OECD, 1998. *Towards sustainable development – Environmental indicators*. Paris.

OFWAT, 1997. *1996-97 Report on leakage and water efficiency*. Office of Water Services. Birmingham.

PLANISTAT, 1998. *A study on water economics – Integrated Report.* A study for the European Commission – DG XI.B.1. September 1998.

RIVM/NTUA/IIASA, 1998. *Integrated environmental assessment of the baseline scenario for the EU state of the environment 1998 report*. Report prepared for EEA.

RIVM, 1995. *Milieubalans 95*. Http://www.Milieubalans.rivm.nl/body.htm.

Shiklomanov, I., 1998. *World water resources – A new appraisal and assessment for the 21st century.* UNESCO.

Siegrist, H. and M. Boller, 1999. *Auswirkungen des Phosphatverbots in den Waschmitteln auf die Abwasserreinigung in der Schweiz.* Korrespondenz Abwasser 46: 57-65.

Spanish Ministry for the Environment, 1998. *Spanish White Paper on Water.* Madrid.

Statistics Sweden, 1990. Naturmiljön I siffror – tredie udgave 1990. Report from Statistics Sweden (in Swedish).

Statistics Sweden, 1996. *Naturmiljön i siffror – femte udgave 1996*. Report from Statistics Sweden (in Swedish).

Umweltbundesamt, 1997. *Daten zur Umwelt, Der Zustand der Umwelt in Deutschland*. Erich Schmidt Verlag.

van Driel, 1998. *Costs for upgrading waste-water treatment to EU standards in ten Accession Countries*. Draft, RIZA, the Netherlands.

Verbruggen, A., 1997. *Report on the Environment and Nature in Flanders 1996*. Report from the Flemish Environment Agency, Ostende.

Wahlström E., E.-I. Hallanaro, & S. Manninen, 1996. *Miljöns framtid i Finland*. Report from Edita & Finlands Miljöcentral.

WMO, 1997. *General evaluation of world freshwater resources.* Stockholm Environment Institute (ed.). World Meteorological Organisation. 1997.

3.6. Soil degradation

Main findings

The main problems for soils in the EU are irreversible losses due to increasing soil sealing and soil erosion, and continuing deterioration due to local contamination and diffuse contamination (acidification and heavy metals). The incremental loss and deterioration of Europe's soil resource will continue, and will probably increase as a result of climate change, land-use changes and other human activities.

Soil degradation is mainly caused by urbanisation and infrastructure development (in western and northern Europe) and erosion (in the Mediterranean region). There is a significant risk of water erosion mainly in southern and central Europe and the Caucasus region; at present, this risk is high to very high in one-third of Europe.

In the EU, policies are in place to prevent an increase in local soil contamination, which is high in areas with heavy industries and military bases. However, the problem of existing contamination remains and there is a danger of further contamination in the Accession Countries.

Diffuse contamination is particularly significant in areas with intensive agriculture. Southern Europe is increasingly affected due to increased industrial activity, urban expansion, tourism and agricultural intensification, while soils in northern Europe are prone to the effects of acid deposition.

Strategies for soil protection, and systems for monitoring of soil, are not adequately developed at European or national level, as compared with air and water for which monitoring, assessment and policy frameworks are already in place. A policy framework is needed which recognises the environmental importance of soil, takes account of problems arising from the competition among its concurrent uses (ecological and socio-economical), and is aimed at maintaining its multiple functions.

1. Why are Europe's soils degrading?

1.1. The issue

Soil must be considered as a finite, non-renewable resource since its regeneration through chemical and biological weathering of underlying rock requires a long time. In humid climates, for example, it takes 500 years on average for the formation of only 2.5 cm of soil (The Tutzing Project, 1998).

Notwithstanding the limitations of available information (see detailed discussion in Chapter 4.2), it is clear that the damage to soils caused by human activities is increasing, and manifested for instance in rates of erosion 10-50 times higher than the rates of naturally induced erosion. Pressure on soils results from agricultural intensification (including consolidation of small fields into larger units) (see Chapters 3.13 and 3.14), and population growth coupled with increasing urbanisation (see Chapters 2.3 and 3.12).

Soil is affected in terms of "loss" or "deterioration" of its functions (Box 3.6.1). A variety of economic sectors all play a part in contributing to soil degradation. As a consequence, approaches to solving soil problems must be based on multi-layered and integrated measures (Figure 3.6.1).

Some of the problems and their consequences are irreversible, such as soil losses, mainly due to erosion and soil sealing. Others can be improved with adequate measures, such as clean-up and remediation plans set up to eliminate local contamination.

1.2. Assessing the impacts of economic activities – on soil

The capability of soil to provide a support to life and ecosystems can be expressed through its ecological and socio-economic functions (Box 3.6.1).

Competition in terms of space exists between the ecological and the socio-economic functions, as well as among concurrent uses of soil within each group of functions.

For example, the use of land for infrastructure construction – irreversible in relation to several generations time scale – makes soil unavailable to ecological functions. Meanwhile the "over-intensive use of soils by modern farming imposes too heavy a burden on the buffer, filter, transformation, and gene-protection functions, resulting in contamination of the food chain and/or groundwater, as well as the destruction of plant and animal species." (Blum, 1990).

The concept of multiple soil function and competition is crucial in understanding current soil-protection problems and their multiple impact on the environment (Figure 3.6.1). Accordingly, a conceptual assessment framework has been developed applying the DPSIR approach to soil issues (Figure 3.6.2). This of course requires development of indicators for soil degradation and loss of soil functions (see also chapter 4.2).

Soil quality and functions are of great importance for the environment. They are interrelated with other key environmental issues such as (see Figure 3.6.1):

- acidification: particularly affecting sensitive, poorly buffered soils (see Chapter 3.4);
- climate change (Box 3.6.2): leading to soil degradation, but it is also influenced by soils and vegetation (see Chapter 3.1);
- biodiversity: including gene reserve and protection, biomass production, protection of landscapes (see Chapter 3.11);
- water stress: soil has a filtering/buffering capacity, but there are threats from contamination, salinisation and eutrophication (see Chapter 3.5);
- dispersion of hazardous substances, due to run-off or leaching (see Chapters 3.3 and 3.5).

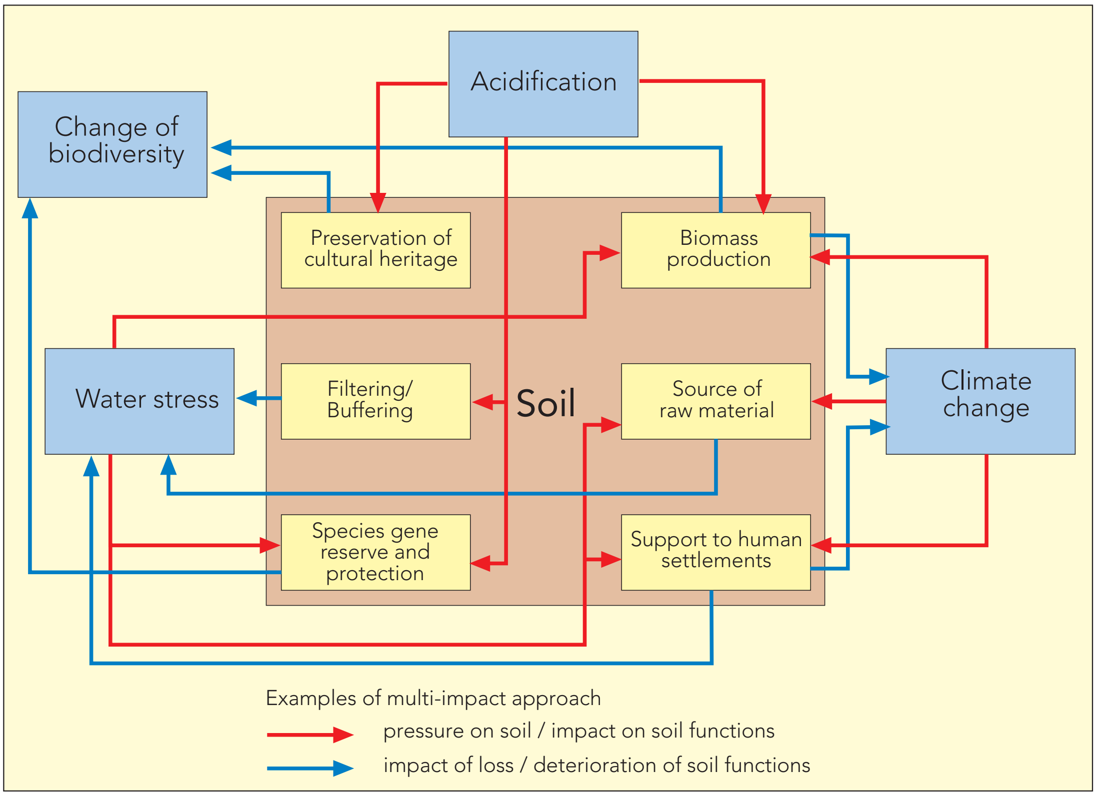
1.3. Driving forces and pressures affecting soil from main economic activities

1.3.1. Land development, transport and tourism
Pressures on land use are particularly associated with urban sprawl (see Chapters 2.3, 3.12 and 3.13), increasing mobility (see chapter 2.2) and tourism (see Chapters 3.14 and 3.15).

A predicted 5% increase in the urban population between 1990 and 2010 will, according to present trends, require an

Figure 3.6.1 **Multi-function/Multi-impact approach (examples)**

Source: EEA



Box 3.6.1. Soil and soil functions

Many different definitions of soil exist, according to the particular context, purpose, and point of view from which soil issues are approached. This report, which considers soil with its multiple functions and impacts as having a fundamental role in Europe's Environment, requires a broad definition such as that adopted by the Council of Ministers of the Council of Europe in 1990:

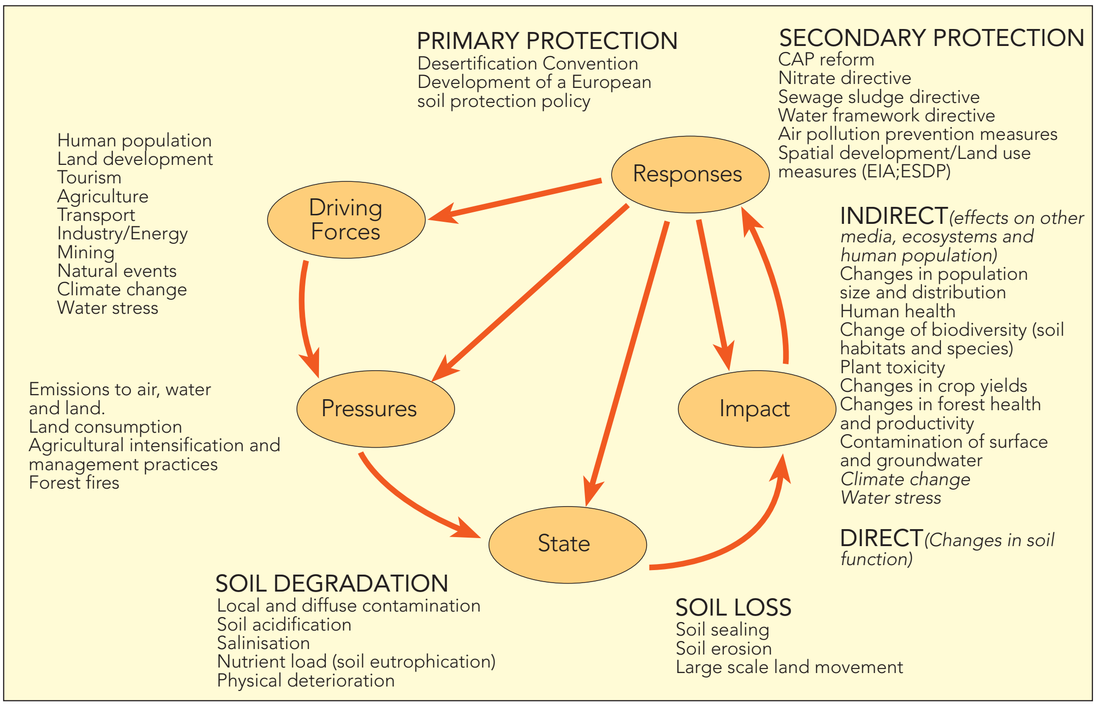
" Soil is an integral part of the Earth's ecosystems and is situated at the interface between the Earth's surface and the bedrock. It is subdivided into successive horizontal layers with specific physical, chemical and biological characteristics and has different functions. From the standpoint of history of soil use, and from an ecological and environmental point of view, the concept of soil also embraces porous sedimentary rocks and other permeable materials together with the water which these contain and the reserves of underground water." (Council of Europe, 1990).

Ecological functions	Production of biomass	Soil produces food and fodder, providing nutrients, air, water. It provides a medium in which plants can penetrate with their roots.
	Filtering, buffering and transforming	This function enables soils to deal with harmful substances, mechanically filtering organic, inorganic and radioactive compounds; adsorbing, precipitating or even decomposing and transforming these substances - thus preventing them from reaching the groundwater or the food-chain.
	Gene reserve and protection of flora and fauna	Soil protects numerous organisms and micro-organisms which can live only in soil.
Socio-economic functions	Support to human settlements (housing and infrastructure, recreation) and waste disposal	Soil provides ground for the erection of houses, industries, roads, recreational facilities and waste disposal.
	Source of raw materials, including water	Soil provides resources of numerous raw materials, including water, clay, sand, gravel and minerals, as well as fuel (coal and oil).
	Protection and preservation of cultural heritage	Soil, as a geogenic and cultural heritage, forms an essential part of the landscape and is a source of paleontological and archeological evidence, relevant for the understanding of the evolution of earth and mankind.

Source: Blum, 1990, 1998

Soil degradation means loss or deterioration of its functions. For the purpose of this report, it includes both soil loss and soil deterioration. Soil losses due to sealing and erosion can be considered in large part as irreversible in relation to the time needed for soil to form or regenerate itself. Soil deterioration due to local and diffuse contamination can be reversed, if adequate measures are taken, such as clean-up and remediation plans.

The DPSIR Framework applied to soil Figure 3.6.2



Source: EEA

Box 3.6.2. An emerging issue: the relationships between soil and climate change

The Kyoto Protocol recognises the need to consider additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the categories of agricultural soils, land-use change and forestry. So far only activities related to forestry (afforestation, reforestation and deforestation) since 1990 have been regulated. Reliable and transparent methodologies, and guidelines on how to take into account additional sources/sinks still need to be developed (see Chapter 3.1; UNFCCC, 1998)

Soil can act as a carbon sink. This also has implications for the bio-availability and mobility of metals in soils, and has potentially harmful effects on both human, plant and animal health.
Soil can also act as a carbon source, as well as a source of other greenhouse gases. The direct application of agro-chemicals in the industrial agricultural sector, and other related management practices, can promote micro-organism activity in soils, and result in increased emissions of nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) to the atmosphere, hence contributing to climate change (see Chapter 3.1).

In boreal soils, reduction in the extent and depth of permafrost due to global warming could lead to an additional flux of CO_2 into the atmosphere, and contribute to the release of CH_4 stored in the soil (IPCC, 1996).

Desertification and climate change

Desertification is "land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities" (UNCCD, 1997). Some southern parts of the EU, including Spain, Greece, Portugal, Italy and France (Corsica) are affected (EEA,1998).

The modified patterns of precipitation, consequent to climate change, will probably induce greater risks of soil erosion, depending on the intensity of rain episodes (IPCC, 1998).

Desertification is likely to become irreversible if the environment becomes drier and the soil becomes further degraded through erosion and compaction (IPCC, 1996).

equal increase in the uptake of urban land (see Chapter 2.3).

Some EU, national and regional policies seem to encourage these sprawling trends: for instance, over the next decade, it is planned to extend the length of railways by approximately 12 000 km, of which 10 000 km is high-speed track and the road network by over 12 000 km (implementation of the TENs; see Chapter 2.2).

The major impacts of these developments on soil are its irreversible loss: through surface sealing, affecting the most productive agricultural and forest land; together with soil erosion, due to destruction of plant cover; local contamination due to waste accumulation; and salinisation caused by the abstraction and use of marine water in coastal areas.

Expansion of transport infrastructure and traffic emissions are also affecting soil in terms of diffuse contamination (heavy metals, soil acidification), while road spills and facilities connected to the transport sector (petrol stations and car-repair facilities) contribute to the generation of local soil contamination.

The consequences are observable in nearly all big cities and urban agglomerations in the EU, such as London, Paris and the Ruhr area (see Chapter 3.12, Box 3.12.6). Tourism affects mainly the Alps, Mediterranean coastal areas (which account for 30% of the total tourist arrivals in the EU), and sub-tropical islands (Canaries, Madeira).

1.3.2. Agriculture

There are marked regional imbalances in the EU between agricultural intensification – changes largely driven by the implementation of the CAP – and economic pressures on marginal farms. The latter causes land abandonment, which may accelerate soil degradation, and, in areas with a dry climate, may lead to desertification.

Intensive industrial agriculture gives rise to severe (and increasing) pressures on agricultural soils, which represent approximately 40% of the EU's total soil resource (see Chapter 2.2).

The major impacts on soil are (German Advisory Council of Global Change, 1994):

- increased susceptibility to wind and water erosion as a consequence of agricultural practices (long exposure of ploughed soil, loss of organic matter, cultivation on steep slopes, etc.);
- loss of grazing cover and erosion due to overgrazing;
- loss of fertility due to deep ploughing, elimination of crop residues, monoculture and elimination of mixed cultivation/animal farming;
- soil compaction by heavy machines, with increased run-off.

These problems, initially focused on zones with fertile soils in Europe, are now widespread at continental level, as industrial agriculture has spread to regions with less fertile and more vulnerable soils, such as the Mediterranean area.

1.3.3. Industry, energy and mining
These sectors are affecting soils both in terms of local contamination, mainly due to inadequate waste management and production processes, and diffuse contamination, due to emission and transport of pollutants via air, water and earth often in regions far from the original source (Box 3.6.3).

Local soil contamination most frequently occurs at waste-disposal sites, gas works, oil refineries, metal-processing industries, chemical industries and other production facilities.

The extraction of minerals, metals and construction materials can be another source of pollution, leading to: local contamination; destruction of arable land; changes in morphology and consequently erosion and hydrological disruption; and compaction, surface sealing and soil loss.

Box 3.6.3. The causes of local contamination

Contaminated sites are mostly due to industrial activities and waste disposal.

Waste disposal addresses most sectors, namely industry, households and consumers but also tourism.

The transport sector contributes to local soil contamination due to road spills and the huge number of repair and maintenance facilities.

Abandoned military bases pose a very serious problem in most of the Accession Countries, especially those of the former Soviet army forces. Local soil contamination at military bases is mostly due to air strips, vehicle repair and maintenance facilities, production of warfare agents, storage of chemicals and fuels, and shooting ranges.

The energy sector contributes to the problem with gas works and caloric power stations.

Industry	direct	chemicals industry, petrochemical/oil industry, steel industry and other
Energy	direct	gas works, petrochemical/oil industry
Transport	direct and indirect	accidents (road spills), maintenance of transport vehicles, inadequate interim storage of hazardous chemicals
Household/ Consumers	indirect	production of waste
Tourism	indirect	production of waste
Military	direct	military bases: production of war fare agents, shooting ranges, stocks, air strips, car-repair shops

2. What is the current state of Europe's soils?

Although soil degradation at European level is generally recognised as a serious and widespread problem, its quantification, geographical distribution and total area affected are only roughly known.

The most recent assessment of soil conditions in Europe is an evaluation of the current state of human-induced soil degradation, derived by ISRIC in 1993 from the world map on the status of human-induced soil degradation (GLASOD) (Maps of soil degradation in Europe, prepared by ISRIC, are published in EEA, 1998). There is a need for better, and more detailed information. Validation of the maps through the EIONET is ongoing.

2.1. Soil loss by urbanisation and infrastructures
The rates of real soil loss due to surface sealing through urbanisation and infrastructure construction in the EU are consistent. Since 1970, the increase of length of motorways has been significant in most of the countries. Occupation of land by infrastructure is high in Belgium, Germany and the Netherlands, and is increasing in Greece, Portugal and Spain (see Chapter 2.2, Table 2.2.1).

There is a lack of consistent data on the amount of soil loss through surface sealing at the EU level. Data on the total amount of built-up areas is only available for a limited number of countries, and is not comparable since countries use different methodologies. Within these limitations, existing data shows that since 1990 the growth of built-up areas has been consistent in Belgium, France and Germany, where it reached about 50 and 70 ha/day over the period 1990-1995 in Belgium and France respectively, and exceeded 120 ha/day over the period 1993-1997 in Germany (Table 3.6.1, Figure 3.6.4).

Built-up areas have grown at the expenses of agricultural land in France, Germany, the Netherlands, Poland and Iceland – where forest areas have also decreased in the period 1990-1995 (Figure 3.6.3).

Soil loss rates through land development and infrastructures may exceed those due to

Table 3.6.1. **Growth of built-up areas in selected countries in the period 1990-1995**

(1) All countries except Germany, Land area: FAO at 16/06/98
(2) All countries except Germany, Built-up area: For EEA18 - Agricultural yearbook, 1995 and ENVSTAT/LUQ1 at 12/03/98. For others - General Questionnaire (NFP)
(3) For Germany: Flachennutzung in Deutschland 1997, Statistisches Bundesamt
(4) Population: World Population Prospects: the 1996 Revision (United Nations, New York)
(a) Figure for "built-up area" refers only to Belgium
(b) Data for Germany refers to the period 1993-1997
(c) data for the Netherlands refers to the period 1989-1993
(d) land area is referred to year 1995
(e) built-up area is referred to most recent figure
(f) population is an average over the selected period

Sources: EEA data elaboration

country	land area (km²) (1) (d)	built-up area (km²) (2) (e)	built-up (% of land area) (e)	built-up area increase (ha/day)	population (1000's) (4) (f)	built-up area increase (m²/person/year) (4)	increase of built-up area over the period as % of land area
Belgium/ Luxembourg (a)	32 820	5 960	18.2	49	10 039	18	2.7
Bulgaria	110 550	8 356	7.6	-6	8 614	-2	>-0.1
France	550 100	29 549	5.4	72	57 411	5	0.2
Germany (3) (b)	349 166	42 128	12.1	122	81 392	5	0.5
Iceland	100 250	1 353	1.3	6	262	79	0.1
Liechtenstein	160	12	7.4	<0.1	30	5	0.4
Netherlands	33 920	5 609	16.5	9	15 063	2	0.4
Poland	304 420	23 087	7.6	21	38 338	2	0.1
Slovak Republic	48 080	1 290	2.7	2	5 297	1	>0.1

Figure 3.6.3 **Changes in built-up areas vs. other land uses in selected countries in the period 1990-1995 as a % of total land area**

Source: EEA data elaboration (see Table 3.6.1 for data sources)

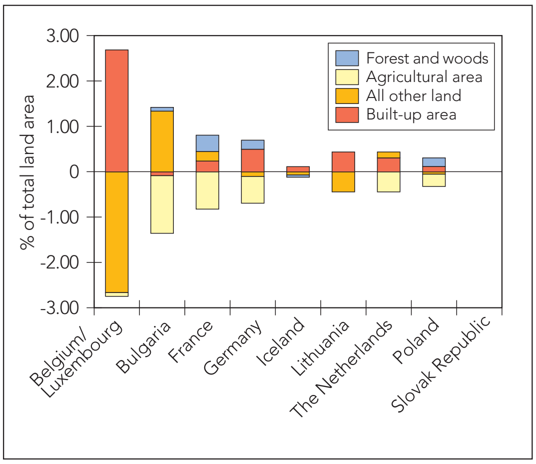
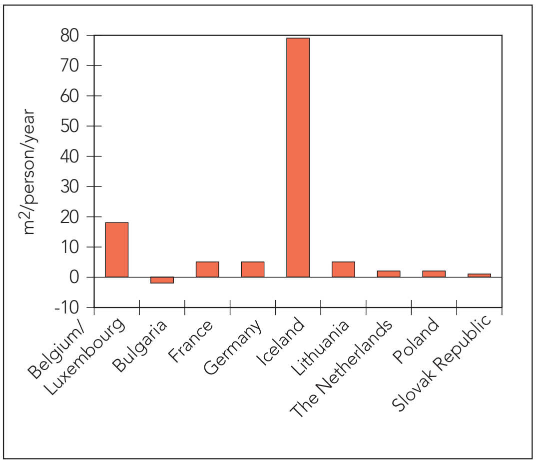


Figure 3.6.4 **Increase of built-up areas in selected countries during in the period 1990-1995 in m²/person/year**

Source: EEA data elaboration (see Table 3.6.1 for data sources)



soil erosion in many EU countries, with the likely exception of some countries in Southern Europe (see Table 3.6.3).

2.2. Soil erosion

Soil erosion in Europe is mainly due to water and to a lesser extent to wind. The major causes are unsustainable agricultural practices and overgrazing. Soil erosion reduces the ecological functions of soil: mainly biomass production, crop yields due to removal of nutrients for plant growth, and soil filtering capacity due to disturbance of the hydrological cycle (from precipitation to runoff).

The loss of plant nutrients and organic matter *via* eroded sediment reduces the fertility and productivity of the soil. This leads to a vicious cycle whereby farmers apply more fertilisers to compensate for the loss of fertility. Soil, once eroded, tends to be more susceptible to further erosion, and thus the cycle intensifies. The loss of applied nutrients in this way, represents an enormous cost to the agricultural community.

It has been calculated that in Austria, potential loss of organic matter in agricultural soil due to erosion could be more than 150 000 tonnes per year, while potential loss of nutrients, such as nitrogen and phosphorous, could be more than 15 000 and 8 000 tonnes per year respectively (Stalzer, 1995).

2.2.1 How much soil is being eroded?

Soil erosion causes irreversible soil loss over time-scales of tens or hundreds of years and is an increasing phenomenon in Europe (Blum, 1990). In parts of the Mediterranean region, erosion has reached a stage of irreversibility and in some places soil erosion has practically stopped through lack of soil. With a very slow rate of soil formation, any soil loss of more than 1 t/ha/year can be considered irreversible within a time span of 50-100 years. Losses of 30-40 t/ha in individual storms that may happen once every one or two years are measured regularly in the EU, with losses of more than 100 t/ha in extreme events (Van Lynden, 1995).

The amount of soil loss from erosion in the EU is not known. The area affected by water erosion and yearly amounts of soil loss for selected countries in the period 1990-1995 are shown in Tables 3.6.2 and 3.6.3. Figure 3.6.5 shows distribution of loss per land-use class in the same period.

Soil losses are high in Spain, where loss of soil in agricultural land reached a peak of an average 28 t/ha/year, in the period 1990-1995, while the total area affected was 18% of the total land in 1995. Substantial losses have been calculated for Austria, where an average of more than 9 t/ha/year in agricultural land losses affected an area of approximately 8% of the total land.

2.2.2 Where in Europe?

Although it has always been considered as a severe and increasing problem in southern Europe, soil erosion, especially due to water, is becoming increasingly relevant in northern Europe. The area with the greatest severity of soil loss for both wind and water erosion is the Balkan Peninsula and the countries surrounding the Black Sea. Some central European Countries such as the Czech Republic and the Slovak Republic, also suffer from extremely serious soil erosion problems (EEA, 1998).

The EU Mediterranean countries have severe soil erosion problems, which can reach the ultimate stage and lead to desertification. At present rates of erosion, considerable areas in the Mediterranean and the Alps, currently not at risk, may reach a state of ultimate physical degradation, beyond a point of no return within 50-75 years. Some smaller areas have already reached this stage (Van Lynden, 1995).

2.2.3 Outlooks: the effects of climate change in agricultural areas - changes in water erosion risk

Water erosion risk is, under current climate and land cover, high to very high in one-

Area affected by water erosion in selected countries in the period 1990-1995 — Table 3.6.2.

Country	Total area affected (ha)	Agricultural land	Forest land	Dry open land with vegetation	Dry open land
Germany	2 400 000	2 400 000			
Spain	9 161 000	6 477 000	255 000	2 024 000	405 000
Austria	625 000	625 000			
Iceland	6 800 000	1 500 000			5 300 000

Source: OECD-Eurostat joint 1996 questionnaire; for Austria: Östat & UBA,1998; EEA

Soil loss due to water erosion in selected countries in the period 1990-1995 — Table 3.6.3.

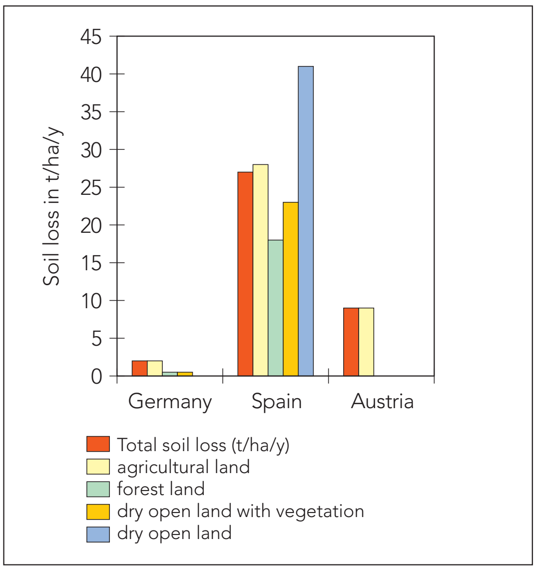
Country	Total soil loss (t/ha/y)	Soil loss in agricultural land	Soil loss in forest land	Soil loss in dry open land with veg.	Soil loss in dry open land
Germany	2	2	0.4	0.4	
Spain	27	28	18	23	41
Austria	9 (a)	9 (a)			
Iceland	n.a.	n.a.	n.a.	n.a.	n.a.

n.a.: the unit (t/ha/yr) is not applicable to Icelandic conditions

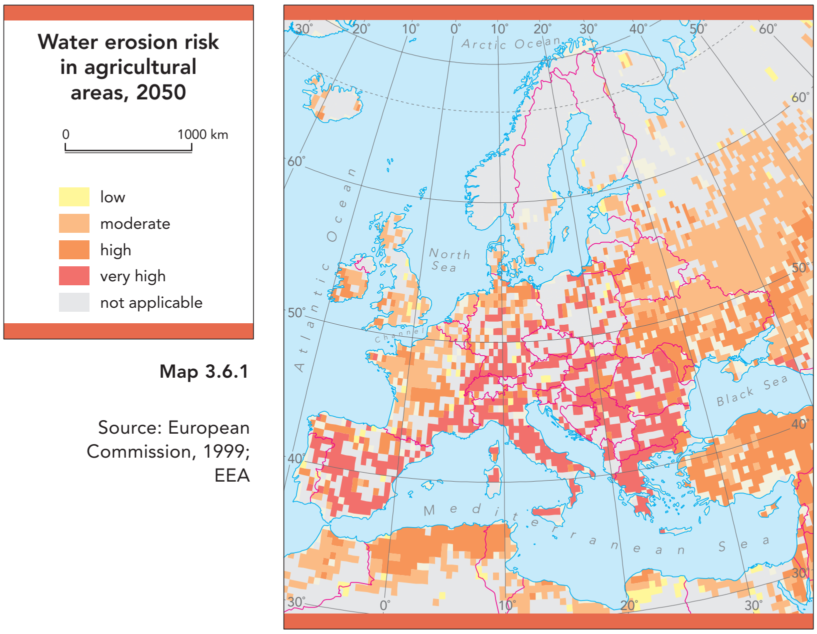
(a) The value for Austria refers to an average loss for agricultural land covered by corn, potatoes, sugar beet and spring grain

Source: OECD-Eurostat joint 1996 questionnaire; for Austria: Östat & UBA, 1998; EEA

Soil loss due to erosion in selected countries in the period 1990-1995 — Figure 3.6.5

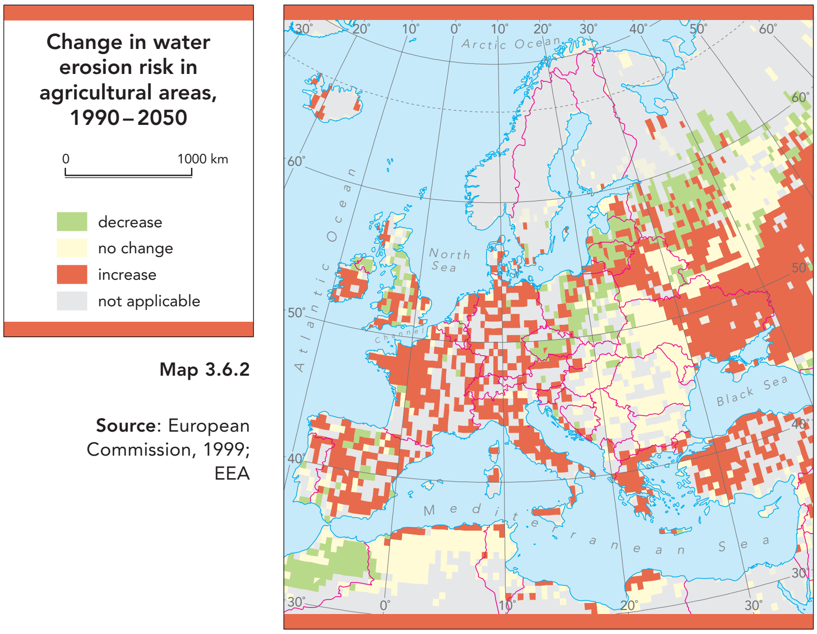


Source: OECD-Eurostat joint 1996 questionnaire; for Austria: Östat & UBA, 1998; EEA



Map 3.6.1

Source: European Commission, 1999; EEA



Map 3.6.2

Source: European Commission, 1999; EEA

third of the European land area. Areas with such high risk are dominantly located in southern and central Europe and the Caucasus area. In the remaining parts of Europe the risk is low to moderate.

Under the baseline scenario, the water erosion risk is expected to increase by 2050 in about 80% of the EU agricultural areas, as an effect of climate change. It remains the same in 10% of the areas and decreases in the remaining 10%. The areas with highest increase in erosion risk are mainly located in the western part of central Europe, in the Mediterranean area, and in the north and south of the Black Sea. Areas with 10% or more decrease in risk can be found across the EU (parts of UK and Spain), but are mainly located in the areas south or south-east of the Gulf of Bothnia (Maps 3.6.1 and 3.6.2).

2.3. Local contamination

Local contamination is a characteristic of regions where intensive industrial activities, inadequate waste disposal, mining, military activities or accidents pose a special stress to soil. If the natural soil functions of buffering, filtering and transforming are overexploited, a variety of negative environmental impacts arise, the most problematic of which are water pollution, direct contact by humans with polluted soil, uptake of contaminants by plants and explosion of landfill gases.

2.3.1. How many contaminated sites are there in Europe?

There is no European-wide monitoring of contaminated sites. Monitoring exits only on a country-by-country basis. Countries are at different levels of progress and apply different methodologies and definitions.

Several countries have initiated national inventories. However, data on the number of contaminated sites based on national inventories is not currently comparable, since it is based on different national approaches. Therefore, national totals do not represent the scale of the problem, but give only an indication of the efforts made by each country.

Information available for 20 European countries reveals that the estimated total of sites which are definitely or potentially contaminated exceeds 1.5 million and that these are mostly located in 13 EU Member States (Table 3.6.4).

2.3.2 Where in Europe?

Land contamination usually affects areas with a high density of urban agglomeration and with a long tradition of heavy industry, or in the vicinity of former military installations. However, a single site may pose a major threat to a large population group or to a vast area, as for the mine of Aznacóllar (Andalusia, Spain), where an accident occurred in April 1998 and provoked the contamination of an area of about 4 500 ha, threatening the national park of Doñana (Box 3.6.4).

The largest and most affected areas are located in north-west Europe, from Nord-Pas de Calais in France to the Rhein-Ruhr region in Germany, across Belgium and the Netherlands. Other areas include the Saar region in

Germany; northern Italy, north of the river Po, from Milan to Padua; the region located at the corner of Poland, the Czech Republic and the Slovak Republic, with Krakow and Katowice at its centre; and the areas around all major urban agglomerations in Europe.

In order to identify 'hot-spots' for local contamination, an integrated inventory of pollution sources to air, water and land is needed.

2.3.3 What is being done? Investigation and remediation of contaminated land in Europe.

Identification of sites posing a potential risk to human health and ecosystems (identification of potential contamination through the screening process), verification that a contamination exists, and assessment of the risks involved are the first steps in the management of contaminated land before any remediation activity can take place.

Progress in the identification of contaminated sites in some European countries is summarised in Figure 3.6.6. In Denmark, for instance, screening has been completed for 93% of suspected sites and risk assessment for 26% of the definitely contaminated sites; in Austria, the percentages are 9% and 35% respectively. It is not possible at present to make a more comprehensive assessment of progress in the management of contaminated land in the EU, because the available information is far from complete.

Many countries have developed special funding tools for the clean-up of contaminated sites, such as tax systems, new land-use incentives or the prevention of new contamination. Public expenditure on clean-up and remediation of contaminated sites for selected countries is illustrated in Table 3.6.5.

In the EU, policies now in place reflecting the precautionary principle will help to avoid contamination in the future. Thus expenditure on the clean-up of contaminated sites will stabilise or even decline, except in countries which have only recently begun to address the problem. Monitoring activities will increase; many countries have only recently started to set up a monitoring system.

At EU level the programmes of the European Regional Development Fund provide some support for the clean-up of local soil contamination (Table 3.6.6).

Many Accession Countries have enacted legislation for contaminated sites, started inventories and set up specific funding tools. Hungary and the Czech Republic can be regarded as the most advanced in this respect. The Slovak Republic and Slovenia are working on a new regime including financing models. Lithuania, Latvia, Hungary and the Czech Republic have started to set up inventories, while all Accession Countries have made assessments of the costs of remedial measures for former military bases. Co-operation with the EU is increasing.

2.4. Diffuse contamination

Soils are often used for the disposal of industrial and urban waste products. Contaminants from flowing water over soil or eroded soil itself can pollute surface waters such as rivers, streams and reservoirs. Leaching of contaminants through channels in the soil via preferential flow is a large source of chemicals in groundwater (see Chapter 3.3).

Soil characteristics play a major role in the movement of chemicals within the soil. Movement of chemicals that adsorb to mineral or organic soil particles is governed mainly through erosion mechanisms, whereas transport of soluble chemicals tends to be via water flow either through the soil or as surface runoff. Many chemicals exhibit both partial adsorption and solubilisation, making predictions of their fate, behaviour and environmental impacts difficult (see Chapter 3.3).

The soil function most affected by diffuse contamination is its buffering, filtering and transforming capacity. When the buffering capacity of soil with respect to a certain substance is exceeded, the substance is released to the environment. This delayed release of pollutants is very dangerous and renders the soil a "chemical time-bomb".

The most relevant problems posed by diffuse contamination and treated here are soil acidification, soil contamination by heavy metals and chemicals, and surplus nutrients.

2.4.1 Soil acidification

Soil acidification occurs as a result of emissions from vehicles, power stations, other industrial processes and natural biogeochemical cycles, re-depositing onto the soil surface mainly via rainfall and dry deposition (see Chapter 3.4).

Exceedances of critical loads of acidification and eutrophication are at present mostly dominated by nitrogen deposition. The

Table 3.6.4. **Available data on the number of potentially and definitely contaminated sites, for selected categories and countries**

ab = abandoned;
op = operating:
n.i. = no information

screening process = identification of sites with a potential for contamination

risk assessment process = verification of the contamination and assessment of the risks involved

Potentially contaminated site: a location where as a result of human activity an unacceptable hazard to human health and ecosystems might exist

Contaminated site: a potentially contaminated site where an unacceptable hazard to human health and ecosystems does exist, on the basis of the results of risk assessment

Source: EEA-ETC/S, 1998

	Industrial sites		Waste sites		Military sites	Potentially contaminated sites		Contaminated sites	
	ab	op	ab	op		identified (screening completed)	estimated total	identified (risk assessment completed)	estimated total
Albania	•	•	•	•		n.i.	n.i.	78	n.i.
Austria	•	•	•	•	•	28 000	~80 000	135	~1 500
Belgium (Flemish region)	•	•	•	•	•	5 528	~9 000	7 870	n.i.
Denmark	•	•	•		•	37 000	~40 000	3 673	~14 000
Estonia	•	•	•	•	•	~755	n.i.	n.i.	n.i.
Finland	•	•	•	•	•	10396	25 000	1 200	n.i.
France	•	•	•	•	•	n.i.	700 000-800 000	896	n.i.
Germany	•	•	•		•	202 880	~240 000	n.i.	n.i.
Hungary	•	•	•	•	•	n.i.	n.i.	600	10 000
Ireland						n.i.	2 000	n.i.	n.i.
Iceland			•			n.i.	300-400	2	n.i.
Italy	•	•	•	•		8 873	n.i.	1 251	n.i.
Lithuania	•	•	•	•	•	~1 700	n.i.		n.i.
Luxembourg			•	•		616	n.i.	175	n.i.
Netherlands	•	•	•	•	•	n.i.	110 000 - 120 000	n.i.	n.i.
Norway	•	•	•	•	•	2 121	n.i.	n.i.	n.i.
Spain	•	•	•	•		4 902	n.i.	370	n.i.
Sweden	•	•	•	•	•	7 000	n.i.	12 000	22 000
Switzerland	•	•	•	•	•	35 000	50 000	~3 500	n.i.
United Kingdom						n.i.	~100 000	n.i.	~10 000

Box 3.6.4. The accident of Doñana

In April 1998, a tailing-dam dike in an open-cast pyrite mine at Aznalcóllar (Seville, Spain) breached, allowing water and solid materials from the tailings pond to be discharged into the nearby Agrio river, an affluent of Guadiamar. About 4.5 million cubic meters of slurry composed of acidic water, fine divided metals (mainly pyrite) and other materials inundated the riverbanks of the Agrio and Guadiamar rivers threatening Doñana, Europe's largest national park. A strip of ca. 300 m wide and 40 km long, at both sides of the rivers, was covered by a layer of toxic black sludge. About 4 500 ha of agricultural land became polluted.

Studies carried out immediately after the spilling showed that the sludge were composed mainly of pyrite (68-78%) in very fine particle size. Chemical analysis of the sludge showed a great content in heavy metals and other toxic elements (Cabrera *et al.*, 1998).

A year later 68% of soils are still contaminated with high and very high concentrations of heavy metals. With reference to the arable layer up to a depth of 10 cm, 68% of soils are contaminated with arsenic, 47% with zinc, 25% with lead, 15% with copper, 11% with tallium and 4% with cadmium. The most contaminated areas are located close to the mine and in the surroundings of the park.

Although remediation started soon after the accident and current measures allow the immobilization of a large part of the contaminants, the re-use of affected land is still a major problem.

Source: CSIC, 1999

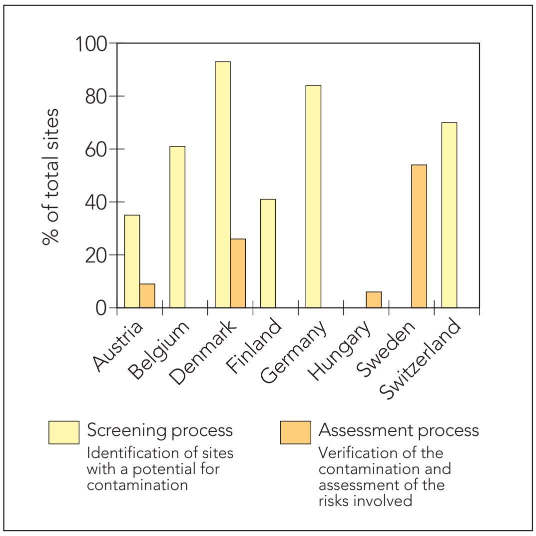
situation is not homogeneous over Europe, and some 'hot-spots' have been identified.

A survey to assess the effects of acid deposition on European forest soils began in 1989 as a joint initiative of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forest in the UNECE region (ICP Forests) and the EU Scheme on the Protection of Forests against Atmospheric Pollution. Although a common methodology for sampling and analysis was adopted in most countries, differences in national methods used exist. Moreover, information is available only for a subset of sites. Further analysis is needed to substantiate large-scale impacts of acid depositions on forest soils.

Information from 23 European countries (including the EU Member States) reported acid topsoil conditions in 42% of the 4 532 sites covered, and indicated a relationship between acid deposition and soil acidity. Extremely acid conditions (defined as a mineral surface layer pH below 3.0) were reported in 1.9% of sites, mainly located in regions receiving a very high atmospheric deposition load, and often where the soils have an extremely low buffering capacity against acidification (EC, UNECE and MFC, 1997).

Map 3.6.3 and Figure 3.6.7 show the sensitivity to acidification of the European forest soil, measured by the soil buffering capacity against added acids. The highest proportion of acid-sensitive sites are found in the Netherlands, Finland and Belgium. In Luxembourg, the Slovak Republic, Hungary, Slovenia, Portugal, Switzerland and Austria the majority of the observed forest soils are resistant to acidification.

Progress in identification of contaminated sites in selected countries as % of estimated total — Figure 3.6.6.



Source: EEA-ETC/S, 1998

Public expenditure on clean-up activities and contaminated-site management in some European countries in 1996 — Table 3.6.5.

Country	Specification	M euros/year
Austria	1996 public remediation fund + overheads	~ 25
Belgium (Flemish region)	1996 public remediation budget	~ 36
Denmark (1)	1997 public expenditure for investigations and remediations	~ 48
Finland	1996 public expenditures for investigations and remediations	~12
Hungary	1996 includes only remediation activities along with the national remediation programme	~ 6
Sweden	1996 first public budget along with a five-year action plan, the plan has already been revised and the budget been reduced	~ 23
Netherlands	1996 total public expenditure	~ 280

(1) refers to the year 1997

Source: EEA-ETC/S

Overview of clean-up funding tools — Table 3.6.6.

Country	Instruments	Specification
Austria, France	tax	Waste tax to fund remediation activities.
Belgium (Flemish region)	license system	The end of exploitation of an industrial facility requires a simple site investigation to be conducted.
Czech Republic	privatisation / property transfer	Property transfer and privatisation is only possible under the provision that the private investor conducts an environmental audit at the site and the audit is approved by the authorities.
Netherlands, Sweden, Denmark, Finland	fee on petrol price	Voluntary agreements of the petrochemical/oil industry to fund the remediation of abandoned petrol stations; financed by a fee included in the petrol price.
United Kingdom	land development	Public funds support the recycling and reuse of derelict land, including the remediation of contaminated sites.
EU	land development	The European Regional Development Fund supports regions of industrial decline in land recycling activities. These activities cover to some extent the clean-up of contaminated sites.

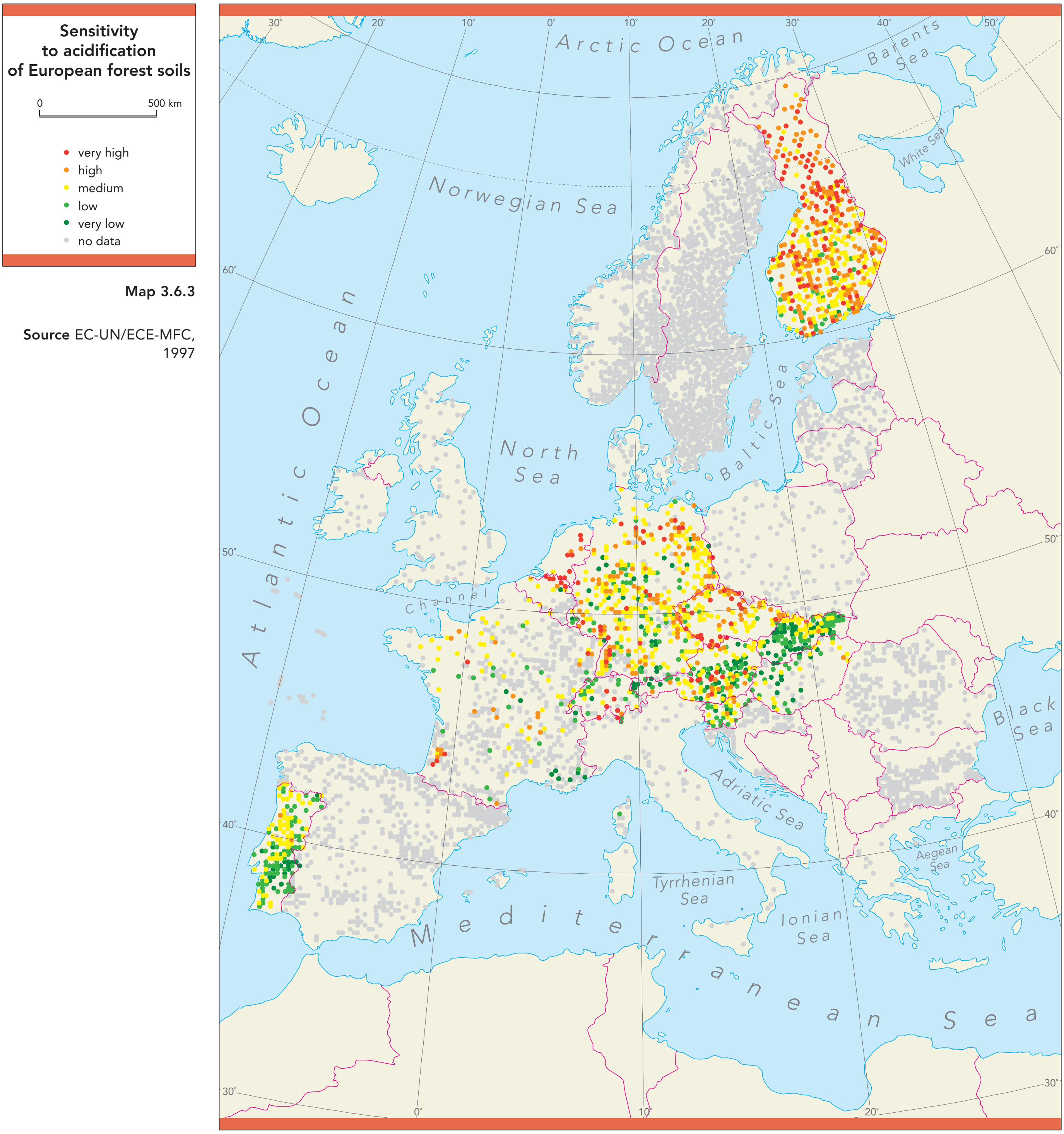
Source: EEA-ETC/S

There have already been further substantial reductions in emissions of sulphur dioxide; nitrogen oxides and VOCs emissions will be reduced by 2010 by implementation of policies in the pipeline (see Chapter 3.4). Nevertheless, there is still concern over acid deposition in 'hot-spots' and areas with sensitive ecosystems, and if acid deposition does not decrease, the area of European forest under threat may increase by 50% to 110 million ha (representing 45% of the total forest area) (EEA, 1995).

2.4.2 Heavy metals

Soils naturally contain trace elements, which function as micro-nutrients essential to plant and animal growth, while high concentrations can be a threat to the food chain. The elements of most concern are mercury (Hg), lead (Pb), cadmium (Cd) and arsenic (As), which are especially toxic to humans and animals, and copper (Cu), nickel (Ni) and cobalt (Co) which are of more concern because of phyto-toxicity. The toxicology of these contaminants depends on soil type,

Sensitivity to acidification of European forest soils



Map 3.6.3

Source EC-UN/ECE-MFC, 1997

vegetation and climate, as well as, their concentration.

Concentrations of heavy metals in soil cover a very wide range. In many cases, the higher values indicate contamination from man's activities, although large values can occur because of natural geological or soil-forming conditions.

In forest soils, results from the above-mentioned forest soil survey show that concentrations of heavy metals such as lead and zinc in humus layers and topsoils follow regional gradients, reflecting atmospheric deposition patterns. The majority of sites with high lead or zinc concentrations in the soil organic layer are found in the region with the highest deposition load. However, critical concentration of lead, zinc and cadmium are exceeded in less than 1% of sites for which values have been reported. Exceedances of critical organic layer concentration of chromium and copper have reported more frequently, in 9% and 19% of the sites respectively.

Map 3.6.4 and Figure 3.6.8 show lead availability in European forest soils. The risk of toxic amounts of plant-available lead is associated with highly industrialised areas in Germany, England and Wales. All sites classified in the highest availability class are located in the region of Europe receiving a high or moderately high deposition load (EC,UN/ECE and MFC, 1997).

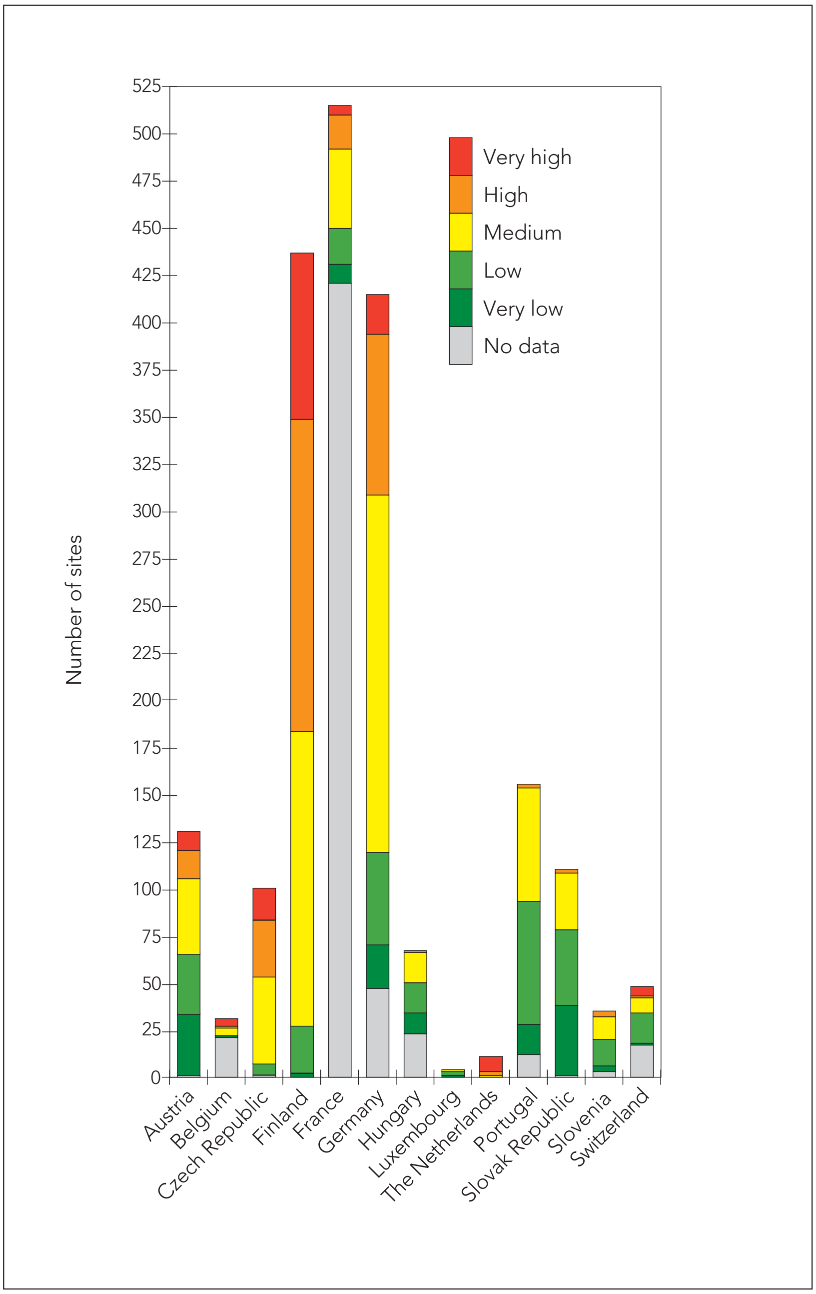
Heavy-metal exposure has been reduced throughout Europe, and a further decline is expected in the Accession Countries, although increases in cadmium and mercury in waste are projected in the EEA countries (see Chapter 3.3).

Positive effects from these reductions on European soils are expected, although methodological differences between countries preclude accurate quantitative assessment. Moreover, there are still major gaps in quantifying heavy-metal emission factors from industrial processes and in knowledge about the toxic effects of heavy metal on ecosystems or the bearing capacity of different soils.

2.4.3 Nutrient load

The over-application to soil of fertilisers with a high phosphorus and nitrogen content or livestock manure, together with acid depositions with a high content in these two elements, can have important effects on the environment. Here, capability of soil to provide nutrients to plant growth is affected, and its buffering and filtering capacity plays an important role. Both nitrogen and phosphorous are essential elements for plant growth, but can become damaging when present in quantities excessive to plant requirements. The accumulation may lead to the soil becoming saturated and the excess may be leached from the soil, eroded or simply washed off into the groundwater, waterways and coastal systems, causing eutrophication (see Chapter 3.5).

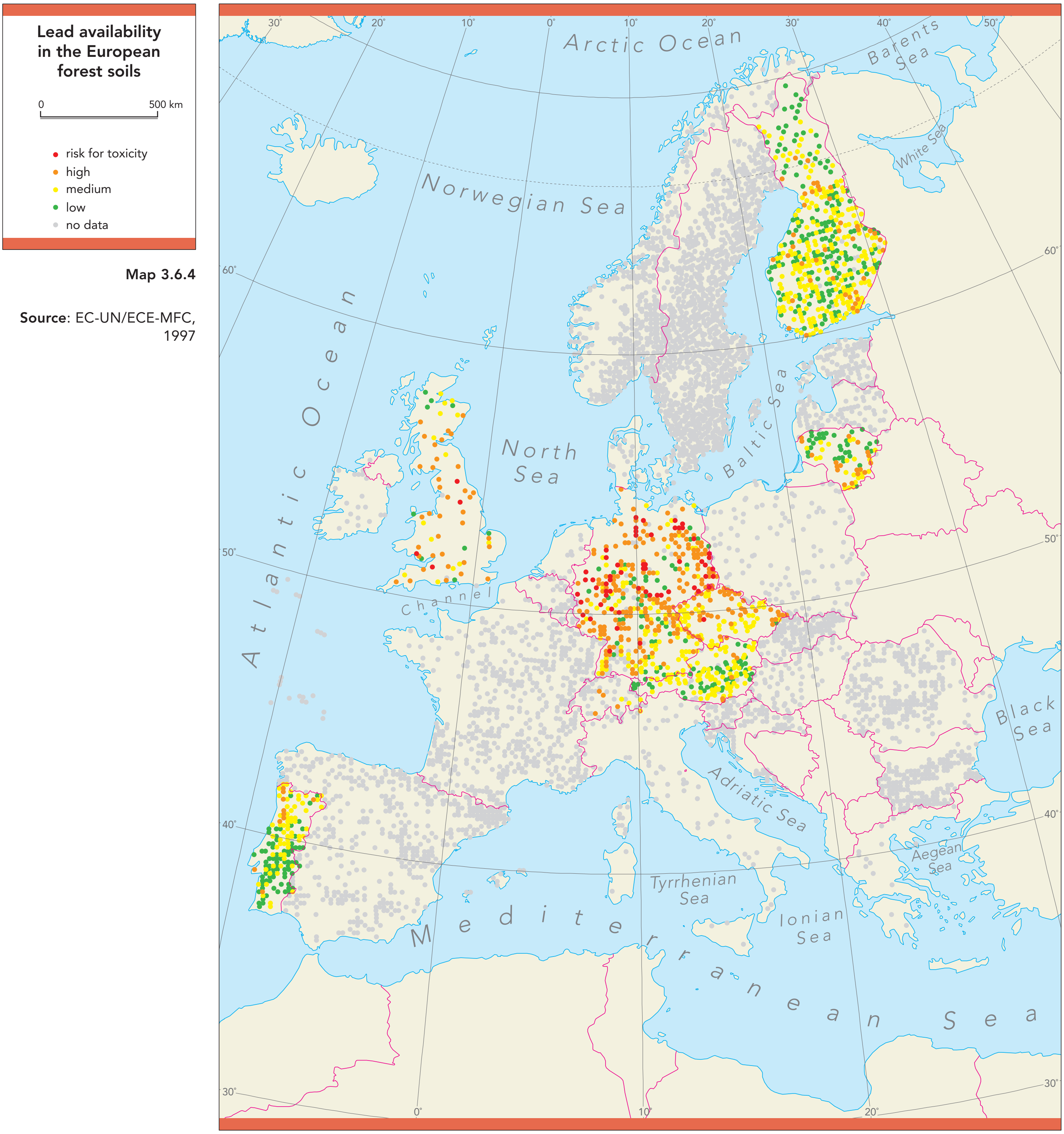
Sensitivity to acidification of forest soils in selected countries Figure 3.6.7



Source: EC-UN/ECE-MFC, 1997; EEA data elaboration, ISSS

A high nitrogen content in soil may also be an important cause for the loss of vitality of European forests. In forest soils, a higher nitrogen content in the organic layer has been observed in areas receiving a high atmospheric deposition load compared with remote areas of Europe. About 17% of the sites present high nitrogen levels in the organic layer. A low nitrogen availability has been found in Scandinavian countries and in the UK, while in the rest of Europe very low availability is expected to occur rarely. A concentration of sites with high or very high nitrogen availability has been observed in Germany, the Slovak Republic and northern Spain (EC, UN/ECE and MFC, 1997).

Although fertiliser consumption was constant or slightly decreased during the last decade, nutrient loads (nitrogen and phosphate) from diffuse agricultural sources remain high, with special reference to parts of north-western Europe where there is intensive livestock production (Map 3.6.5). However, phosphorus



Map 3.6.4

Source: EC-UN/ECE-MFC, 1997

surpluses are also relatively high in the southern Europe, due to low removal rates by harvested crops. In Accession Countries, fertiliser consumption has declined markedly, but in future agriculture production, and hence fertiliser use, may be expected to increase from its current low level (see Chapter 3.13).

3. In search of responses

3.1. What has been done to address soil degradation and local contamination

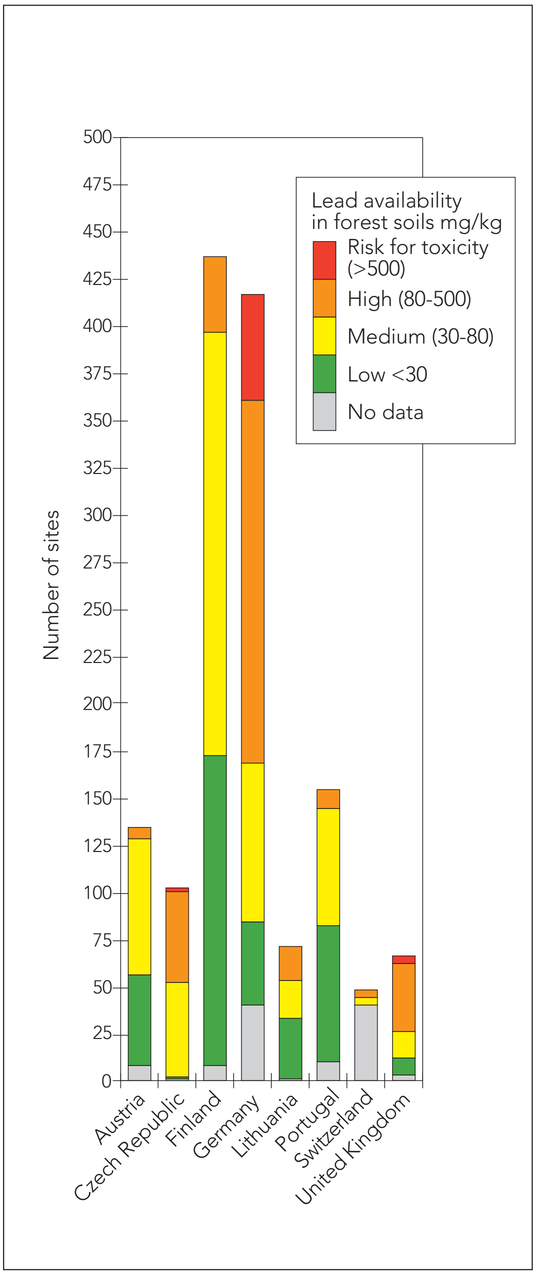
3.1.1 At the European level
Sustainable management of soil as a natural resource, together with air and water, is among the challenges and priorities mentioned in the Fifth Environmental Action Programme (5EAP). However, unlike for the two other media, soil protection is not usually the subject of specific objectives and targets; rather, it is addressed indirectly through measures directed at the protection of air and water or developed within sector policies (secondary protection). Moreover, measures developed for specific sectors without considering the possible effects on soil may lead to its further damage. The main objectives and targets with an effect on soil protection, set out in the 5EAP, are summarised in Table 3.6.7.

Below the broad framework of the 5EAP, there is also no legislation at an EU level which directly addresses soil protection (primary protection). However, there is EU legislation indirectly (but not explicitly) concerned with soil protection, including Directives on Nitrate (91/676/EEC) and Sewage Sludge (86/278/EEC and 91/271/EEC, now under revision). Table 3.6.8 lists the main policy measures which to some extent address soil protection. These measures mostly address general soil degradation and contamination due to agricultural activities and local soil contamination due to industrial activities or waste disposal.

With respect to local soil contamination due to industrial activities or waste disposal, EU policy addresses the issue of pollution prevention, of which the Environmental Programme for Europe (1995) and the EU directive on Integrated Pollution Control (1996) are the most relevant. A EU landfill directive is in preparation.

Present EU legislation has required that Member States utilise pollution-abatement

Lead availability in the forest soils of selected countries — Figure 3.6.8



Source: EC-UN/ECE-MFC, 1997; EEA data elaboration, ISSS

technologies in industry to minimise pollution and many of these technologies are installed in operating mines. However, a major cause for concern are mines that have been abandoned, often closed for many years and are still leaking pollutants to soil and water courses. In the UK, for example, abandoned coal and metal mines discharge more mining wastes to rivers than mines currently in operation.

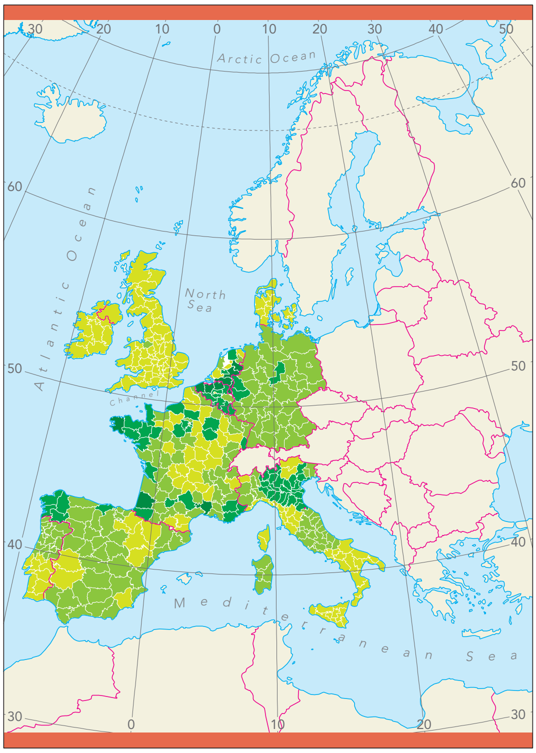
3.1.2. At the national level
Many Member States have produced legislation, policies or guidelines to improve soils or prevent them from further degradation (Table 3.6.9). However, the policy measures

Phosphorus surplus by administrative region

0 1000 km

Phosphorus balance

- < 25
- 25 - 50
- 50 -100
- >100



Map 3.6.5

Source: Eurostat

are primarily aimed at combating pollution in other compartments and affect soils indirectly.

With special regard to local soil contamination, it can be said that most EU and Accession Countries have recognised the need to set up regulatory frameworks on how to manage existing local soil contamination and how to prevent future contamination. National policies of most countries address liability questions and the prevention of new pollution. With respect to existing contamination, most western European countries and some eastern European countries also address the keeping of regional inventories, financing aspects, and site investigation procedures. A variety of countries have made an attempt to calculate total national clean-up costs. Though results of such calculations are not comparable, they are important indicators for the attention paid to this particular matter. Cost estimates deriving from Accession Countries usually address the environmental damage of former Soviet military bases. In the case of the Czech Republic and Hungary, national costs estimated go beyond this issue.

The development of a policy framework which recognises the role of soil, takes account of the problems arising from the competition among its concurrent uses (ecological and socio-economical), and aimed at the maintenance of its multiple functions, could have multiple benefits and could achieve a consistent improvement of Europe's environment as a whole. Such a policy framework is currently absent at the EU level and in most EU Member States and Accession Countries.

3.2. Monitoring and assessment frameworks for soil – what exists and what is needed

There is no European-wide monitoring network for soil, although some progress has made in some areas, such as the monitoring of forest soils within the framework of UNECE-ICP Forest and the EU Scheme for Protection of Forests already mentioned.

Statutory soil monitoring is carried out in a number of Member States, but rarely for the purposes of soil protection per se. Monitoring is more often performed in support of, for example, the provision of better plant nutrient advice for the agricultural sector. Further difficulties within the concept of soil monitoring arise from the great diversity which exists in the design of soil monitoring schemes, the frequency of sampling, the range of parameters determined, and the methods of analysis used. There are also increasing problems of data ownership and transfer (see Chapter 4.2). As a result of this diversity, there is lack of harmonisation of the data derived from soil monitoring, and there is no pan-European quality control of the existing soil-monitoring networks.

As shown by the multi-function/multi-impact approach, soil monitoring and assessment need to be addressed in an integrated way. There is a need to work towards the establishment of certain standards for all relevant types of soil degradation, based on a uniform general methodology. An appropriate degree of co-ordination at the EU level would be necessary to obtain some level of uniformity between countries in the development of criteria and methodology for the production of relevant data on soil conditions.

To this end, a complete framework for monitoring, assessment and reporting on soil issues in Europe must be developed, similar to those already in place for air and water. This must include the harmonisation/streamlining of data collection/data flow activities (setting up a European Soil Monitoring Network and related databases), the development of policy-relevant indicators, and the establishment of a coherent reporting mechanism on soil.

Policy objectives and targets related to soil in the 5th EAP — Table 3.6.7.

Target sectors	Objectives	Targets/Measures	Instruments
Industry		Integrated pollution control. Reduced waste/better waste management.	Emission and waste inventories. Civil liability.
Energy		Reduction in pollution.	Specific targets for CO_2, NO_x, SO_2.
Transport		Land-use planning. Infrastructure investments.	Environmental impact assessment. Structural funds.
Agriculture	Maintenance of the basic natural processes for a sustainable agriculture, by conservation of water, soil and genetic resources.	Maintenance/reduction of nitrate levels in groundwater. Stabilisation/increase of organic material levels in the soil.	Strict application of the nitrate directive. Setting of regional emission standards for new livestock units (NH3) and silos. Reduction for phosphate use.
	Decrease in the input of chemicals; Equilibrium between input of nutrients and the adsorption capacity of soils and plants.	Significant reduction of pesticide use per unit of land under production.	Control of sales and use of pesticides. Promotion of organic farming.
	Rural environment management permitting the maintenance of biodiversity and natural habitats and minimising natural risks (e.g. erosion, avalanches) and fires.	Management plans for all rural areas in danger.	Programmes for agriculture and environment zones.
	Optimisation of forest areas to fulfil all their functions.	Increase of forest plantation, including on agricultural land. Improved protection (health and forest fires).	New afforestation and regeneration of existing forests. Further action against forest fires.
Tourism		Better management of mass tourism. National and regional integrated management plans for coastal and mountain areas.	Improved control on land use. Strict rules for new constructions. Structural funds.
Environmental issues	Objectives	Targets	Actions/Instruments
Climate change	CO_2- CH_4-N_2O: no exceedance of natural absorbing capacity.	Stabilisation or reduction of emissions.	
Acidification	NO_x, SO_x, ammonia, general VOCs, dioxins, heavy metals: No exceedance of critical loads and levels.	Various. Emission reduction or stabilisation.	
Biodiversity	Maintenance of biodiversity through sustainable development.	Maintenance and restoration of natural habitats.	Habitats directive; CAP reform; forest protection; international conventions.
Water quality and quantity	Sustainable use of fresh water resources.	Integration of resource conservation and sustainable use criteria into other policies, including, in particular, agriculture and land use planning. Reduction of groundwater and fresh water pollution.	
	Groundwater: maintain the quality of uncontaminated water, prevent further contamination, and restore contaminated groundwater to a quality required for drinking water production.	Groundwater: prevent pollution from point sources and reduce pollution from diffuse sources.	Implementation of urban waste water and nitrate directives to reduce the input of nutrients to the soil, water and sediments. Proposals for progressive replacement of harmful pesticides and progressive use limitations.

.../...

Environmental issues	Objectives	Targets	Actions/ Instruments
Coastal zones	Sustainable development of coastal zones and their resources.	Development of better criteria for a better balance of land use and conservation and use of natural resources.	
Waste	Municipal and hazardous waste: prevention and safe disposal of any waste that cannot be recycled or reused.	Considerable reduction of dioxins emissions. Waste management plans in Member States.	Landfill directive operational. Incineration of hazardous waste operational.
Risk management	Chemicals control; risk reduction and management		

Source: European Commission; EEA

Table 3.6.8. **European policy measures addressing soil protection**

Policy document	Sector addressed	Issue addressed
Council of Europe European Soils' Charter (1972)	General	soil protection and deterioration
FAO World Charter of Soils (1981)	General	request to support sustainable farming
CAP Reform (Council Regulation, 1992)	Agriculture	lower environmental impacts within agriculture
Fifth Environmental Action Programme (5EAP, 1992)	Agriculture, Transport, Tourism, Energy	soil degradation, erosion and acidification, in relation to the contributions from various economic sectors
Environmental Programme for Europe (EPE, 1995)	Agriculture, Industry	pollution prevention; sets out long-term environmental policies
EU directive on Integrated Pollution Prevention and Control (IPPC, 1996)	Industry	pollution prevention; encouragement of cleaner production
EU Landfill Directive (draft)	Industry, Households	landfill management
Protection of Ground Water from Hazardous Substance Discharges (1980)	Agriculture, Industry	groundwater protection
Directive on Hazardous Waste (91/689/EEC)	Industry, Households	waste management
Waste Framework Directive (75/442/EEC;91/156/EEC)	Industry, Households	waste management
Directive on disposal of waste oils (75/439/EEC;87/101/EEC)	Industry	waste management
Packaging directive (94/62/ EEC)	Industry, Households	waste management
Nitrate Directive (91/676/EEC)	Agriculture	fertiliser reduction
Sewage Sludge Directive (86/ 278/EEC; 91/271/EEC)	Agriculture	limitation of heavy metal concentrations in soils and sludge
Directive on Environmental Impact Assessment (85/337/ EEC)	Transport, Industry, Land development	land consumption and contamination

Source: EEA-ETC/S

References

Blum, W.E.H. 1990. *The challenge of soil protection in Europe*. Environmental Conservation 17. In: World Resources Institute,1991. *Accounts Overdue. Natural Resource Depreciation in Costa Rica*. Oxford University Press. Oxford, New York.

Blum, W.E.H. 1998. *Soil degradation caused by industrialization and urbanization.* In: Blume H.-P., H. Eger, E. Fleischhauer, A. Hebel, C. Reij, K.G. Steiner (Eds.): *Towards Sustainable Land Use*, Vol. I, 755-766, Advances in Geoecology 31, Catena Verlag, Reiskirchen.

Cabrera, F. *et al*. 1998. *Contaminación por metales pesados de suelos caraterísticos de la cuenca del Guadiamar afectados por el vertido tóxico*. Jornadas científicas para analizar los resultados obtenidos durante el seguimiento del efecto del vertido tóxico en el entorno de Doñana. El Rocío, Almonte, Huelva, Spain.

Council of Europe, 1990. European Conservation Strategy. Recommendation for the 6th European Ministerial Conference on the Environment. Council of Europe, Strasbourg.

CSIC, Grupo de expertos del Consejo Superior de Investigaciones Científicas y organismos colaboradores sobre la emergencia ecologica del rio Guadiamar. 10º Informe, 9 March 1999. Published on the Internet at http://www.csic.es/hispano/coto/infor10/info10.htm

EEA, 1995. *Europe's Environment: The Dobris Assessment*. European Environment Agency. Office des Publications, Luxembourg, 676 pp.

EEA, 1998 . *Europe's Environment: The Second Assessment*. European Environment Agency. Elsevier, UK, 293 pp.

EEA-ETC/S 1998. *Contaminated Sites in the EU and EFTA countries*, Prokop. G., Edelgaard I., Schamann M. (forthcoming).

EPE, 1995. *Environment for Europe* - Some key documents. UNECE, Geneva

European Commission, 1992. *CORINE Soil Erosion Risk and Important Land Resources in the Southern Regions of the European Community*. EUR 13233, Commission of the European Communities, Luxembourg, 97 pp.

European Commission, United Nation/Economic Commission for Europe and the Ministry of the Flemish Community, 1997 (EC,UN/ECE and MFC, 1997). *Forest Soil condition in Europe*. Results of a Large-Scale Soil Survey.

European Commission, 1999 (forthcoming). "*Economic Assessment of Priorities for a European Environmental Policy Plan* (working title)". Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (Environrment, Nuclear Safety and Civil Protection).

Eurostat, 1995. *Europe's Environment: Statistical Compendium for the Dobris Assessment*. Office des Publications. Luxembourg, 455 pp.

Eurostat, 1998. *Towards Environmental Pressure Indices for the EU*. Draft of September, 07, 1998, 182 pp.

IPCC, 1996. *Second Assessment Climate Change 1995*, a Report of the Intergovernmental Panel on Climate Change (including summary for policy makers). WMO, UNEP, 1995.

IPCC, 1998. *The Regional Impacts of Climate Change, An Assessment of Vulnerability*, R.T. Watson, M.C. Zinyowera, R.H. Moss. Cambridge, Cambridge University Press.

German Advisory Council on Global Change. 1994. *World in Transition: The Threat to Soils*. 1994 Annual Report. Economica, Bonn.

Stalzer, W. (1995): Rahmenbedingungen für eine gewässerverträgliche Landbewirtschaftung. Schriftenreihe des Bundesamtes für Wasserwirtschaft, Bd. 1, S. 1-24.

The Tutzing Project "Time Ecology", 1998. *Preserving Soils for Life*. Ökom - Verlag

ÖSTAT & UBA, 1998: Umweltdaten 1997, p.39ff, Österreichisches Statistisches Zentralamt, Vienna.

UNCCD Interim Secretariat, 1997. *United Nation Convention to Combat Desertification in those countries experiencing serious drought and/ or desertification, particularly in Africa*. Text with Annexes. Geneva, Switzerland.

UNFCCC 1998. Kyoto protocol to the United Nations Framework Convention on Climate Change. FCCC/ CP/1997/L.7/Add.1, December 1997.

Van Lynden, G.W.J., 1994. *The European Soil Resource: Current Status of Soil Degradation causes, impacts and need for action*. Council of Europe. Strasbourg, 71 pp.

Country overview indicating the existence of policy measures for contaminated land — Table 3.6.9.

Country	Legislation		Inventory		Special CS funding	Official cost estimates
	Indirect	Direct	PCS	CS		
Austria	•	•	•	•	•	•
Belgium(1)	•	•	•	•	•	•
Denmark	•	•		•	•	•
Finland	•	•	•	•	•	•
France	•	•	•	•	•	
Germany	•	•	•	•	•	•
Greece	•					
Iceland	•					
Ireland	•					
Italy (2)	•	•	•			•
Luxembourg	•					
Netherlands	•	•	•	•	•	•
Norway	•	•	•	•	•	•
Portugal	•					
Spain	•		•	•	•	•
Sweden (3)	•	•	•	•	•	•
Switzerland	•	•	•	•	•	•
UK	•	•			•	•
Bulgaria	•					
Czech R.	•				•	•
Estonia (4)	•					•
Hungary	•	•	•	•	•	•
Latvia (5)	•		•			
Lithuania(4)	•		•			•
Poland	•					
Romania	•					
Slovenia	•					
Slovakia	•					

(CS = contaminated sites, PCS = potentially contaminated sites)

(1) Belgium: applies only to the Flemish region; (2) Italy: a preliminary survey of potentially contaminated sites and their clean-up costs had been completed for most of the Italian regions by 1997; (3) Sweden: CS policy is underway; (4) Estonia, Lithuania: cost estimates apply to the clean-up of ex-Soviet bases; (5) Latvia: a test inventory was set up in 1996.

Source: EEA-ETC/S

3.7. Waste generation and management

Main findings

- Reported total waste generation within the EU and the European Free Trade Area increased by nearly 10% between 1990 and 1995, while economic growth was about 6.5% in constant prices. Half the waste comes from the manufacturing industry and construction and demolition activities, while municipal waste, mining waste and waste from other sources each contribute about one sixth of the total. In the Accession Countries, amounts of industrial waste per capita are higher, while volumes of municipal waste are currently lower than the EU average.

- Limited current systematic and consistent data hinder the development of projections for future waste trends. Nevertheless, most waste streams will probably increase over the next decade. In 2010 the generation of paper and cardboard, glass and plastic waste will increase by around 40% to 60% compared with 1990 levels. The number of scrapped cars should increase less, by around 35% compared with 1995 levels.

- Today waste is also produced as a result of society's attempt to solve other environmental problems such as water and air pollution. Some of these increasing amounts of waste give rise to new problems, such as sewage sludge and residues from cleaning of flue gases.

- In most EU countries landfilling is still the most common treatment route for waste and a major change is needed in order to implement the EU strategy on waste. Furthermore, as illustrated by municipal waste, there has been no general improvement in this trend in the 1990s.

- Paper and glass are some of the waste fractions where Member States have followed the Community waste strategy of increasing recycling instead of energy recovery and landfilling. However, the development has been only a partial success, because the total amount of waste paper and waste glass (container glass) generation has also increased in the same period.

- Sewage sludge and end-of-life vehicles are other waste streams where substantial increases in quantities can be expected, calling for more efficient waste management practices.

- The quantities of waste are now so big that transport of waste represents a significant part of total transport: in France, for instance, waste accounts for 15% of total weight of freight. The environmental impact of this remains to be assessed.

1. The main problems related to waste generation and management

1.1. The sheer quantity of waste is a problem

Waste represents an enormous loss of resources both in the form of materials and energy. Indeed, quantities of waste can be seen as an indicator of the material efficiency of society.

Excessive quantities of waste result from:

- inefficient production processes;
- low durability of goods;
- unsustainable consumption patterns.

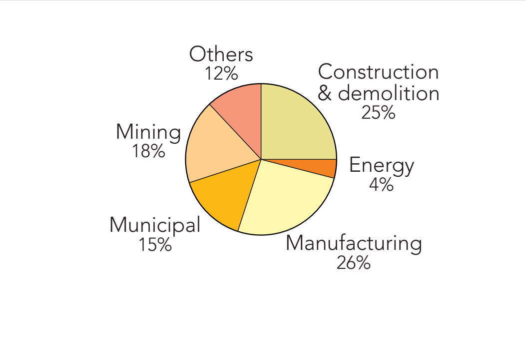
Waste generation is increasing in the EU, and amounted to about 3.5 tonnes of solid waste per person in 1995 (excluding agricultural waste), mainly from manufacturing, construction & demolition and mining (Figure 3.7.1).

Solid waste is also increasingly produced as an attempt to solve other environmental problems such as water and air pollution. Some of these wastes give rise to new problems – examples include sewage sludge and residues from cleaning of flue gases. Moreover, managing waste causes a number of pressures on the environment:

Figure 3.7.1 **Waste generation by sector**

The figure shows the distribution of total waste by sector. Since data from most countries is incomplete and lacks harmonisation, these and other data in the chapter should be regarded as best available approximations.

Sources: OECD, 1997; NRCs, 1998a



- leaching of nutrients, heavy metals and other toxic compounds from landfills;
- use of land for landfills;
- emission of greenhouse gases from landfills and treatment of organic waste;
- air pollution and toxic by-products from incinerators;
- air and water pollution and secondary waste streams from recycling plants;
- increased transport with heavy lorries.

While total waste quantities are a measure of resource loss, the environmental impact of waste can not be analysed by looking at quantity alone. Hazardous substances in waste, even in small quantities, can have a very negative impact on the environment (Figure 3.7.2). However, the following discussion is mainly based on amounts because the content of hazardous substances in waste is poorly described at EU level (see also Chapter 3.3).

An increasing part of resources contained in waste is recovered as materials or as energy in incinerator or biogas plants, but more than half is still permanently lost in landfills. Recycling of materials may reduce the environmental impact of waste but is not necessarily without environmental impact. For example, plants processing scrapped cars produce large amounts of shredder waste contaminated with oil and heavy metals and smelting of the metals give rise to emissions of heavy metals, dioxins etc. from secondary steel works and aluminium smelters.

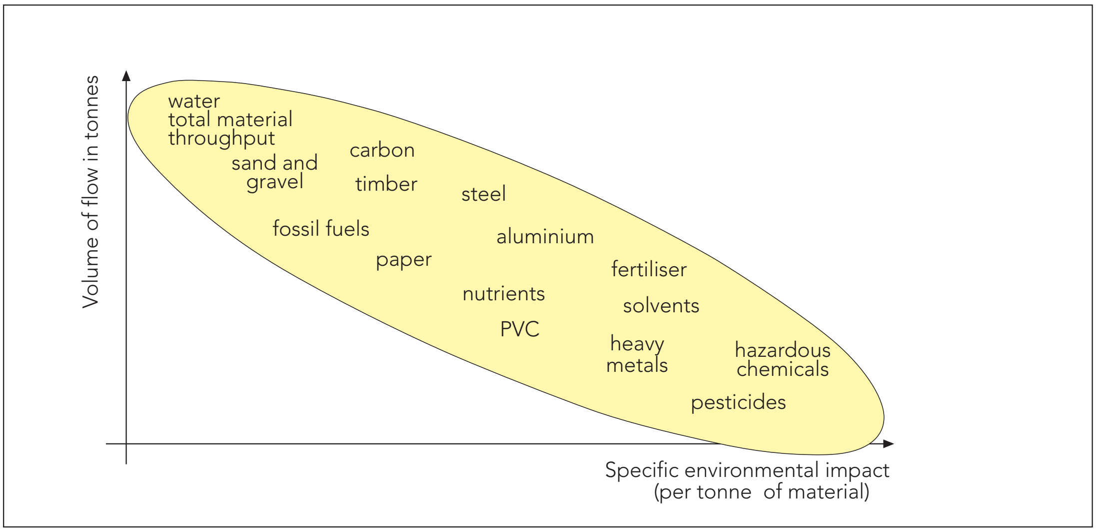
Few resources can be retrieved completely from waste. In most cases recycled material will be of a somewhat lower quality than the virgin material due to contamination or the nature of the recycling material. Even high-quality recycled materials represent a net loss of resources because the energy used for initial production is lost and some material is always lost during collection and treatment.

The quantities of waste are now so big that transport of waste is a significant part of total transport. A French study indicates that about 15% of the total weight of freight transported in France in 1993 was waste and that waste transport accounts for 5% of the total transport sector energy consumption (Ripert, 1997). Rough estimates from Denmark indicate a lower but still significant energy consumption for transport of waste. The French study also shows that transport distances are much higher for waste for recycling than for disposal. This implies that

Figure 3.7.2 **Material flow and specific environmental impact – qualitative and quantitative aspects of waste**

The relative environmental impact of waste is related to both the quantity and the degree of hazard associated with it. There are therefore two aspects to waste generation: quantitative, i.e. how much is generated, and qualitative, i.e. the degree of hazard. This is shown here for a selection of materials. Waste with a high specific environmental impact per tonne is normally found in minor volumes and is therefore more difficult to separate and collect. Until now waste management has mainly concentrated on waste streams in the middle of the area marked.

Source: Steurer, 1996



efficient planning tools are needed to control transport resulting from separation of the waste into more and more fractions for advanced treatment – although higher transport distances for recycled materials may in some cases be compensated by reduced need for long-range transport of raw materials.

1.2. Can waste generation be de-linked from economic growth?

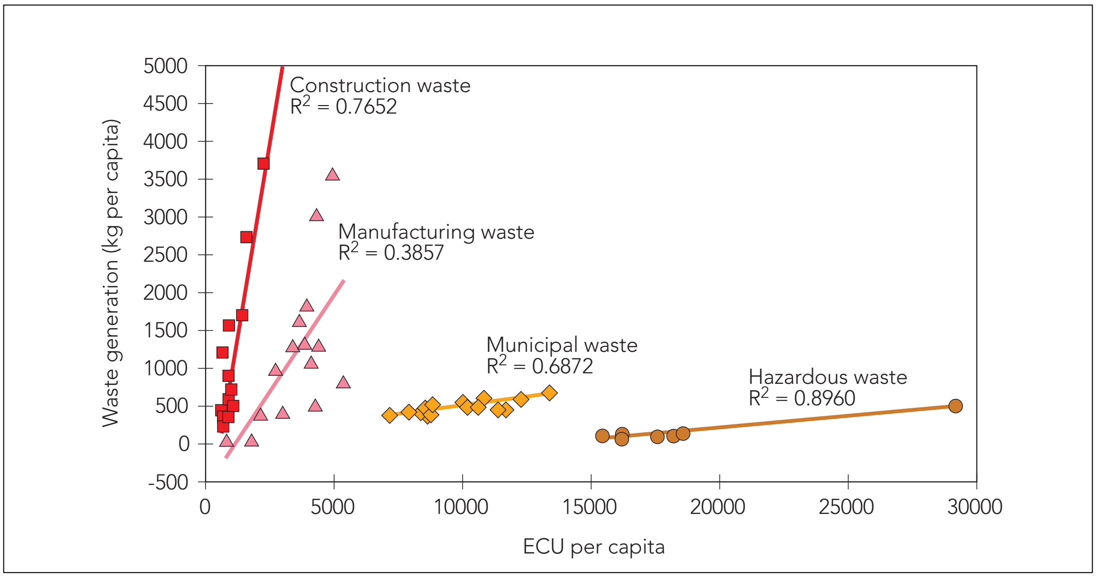
Reported total waste generation in OECD Europe increased by nearly 10% between 1990 and 1995 (EEA, 1998a) while GDP growth was about 6.5% in constant prices. This relation is also noted in the waste strategy for England and Wales which states that 'for every ton of useful products made in UK, we consume about 10 tons of other resources – raw materials and energy. ... They go to landfill, or are emitted to the atmosphere or into water. And ...a high proportion of the useful goods we produce join the waste stream quite quickly too.' (DETR, 1998).

The main challenge is to de-link waste generation from economic growth (Figure 3.7.3). A closer analysis of the relationship between economic growth and waste generation reveals several different trends. For instance, country comparisons show no general correlation between GDP and waste from energy production, which probably reflects national differences in energy supply systems. Coal-fired power plants generate large amounts of fly ash, while hardly any waste is produced from hydroelectric power stations, and nuclear power plants generate a small but extremely hazardous amount of waste.

For hazardous waste a correlation between GDP and waste quantities can be demonstrated for data from 1995, but not from 1990. In this period large changes took place in both awareness of hazardous waste and in definitions and classification procedures. Thus the apparent correlation in 1995 may be spurious.

For municipal waste and construction and demolition waste a very close link between economic activity and waste generation can be demonstrated. For manufacturing waste, however, there are significant variations between Member States; in some countries (notably Germany and Denmark) the ratio of waste generation to manufacturing GDP is much lower than in others. This may be an indicator of the use of the cleaner technology (including internal recycling) in produc-

Total waste/GDP Figure 3.7.3



For each Member State, waste quantity/capita has been plotted against economic activity related to selected waste streams. The figure shows that the generation of municipal, construction and hazardous waste seems to relate to the economic activity behind waste generation whereas such a relation does not seem to exist for manufacturing waste. A good correlation is assumed if R^2 values are above 0.7. In relation to municipal waste the economy is stated as final consumption from house-holds in Purchasing Power Standard (PPS). Hazardous waste is related to GDP stated in PPS. Construction and manufacturing waste are related to the part of the GDP originating from construction and manufacturing activties.

Source: OECD, 1997a; OECD, 1997b; NRCs, 1998a+b; Eurostat, 1999 tion, but it can also be a result of differences in industrial structure. As an example much of the heavy industry in western Europe has been closed in the last decades due to competition from Eastern Europe and Asia.

It is however significant that where the rate of waste generation from production has declined – supposedly due to better use of cleaner technology – this has not been sufficient to neutralise the increase in total waste amounts due to the growth in the quantity of goods produced and consumed.

1.3. The need for an integrated approach

The challenge of increasing waste quantities cannot be solved in a sustainable way by efficient waste management and recycling alone. There is an urgent need for integration of waste management into a strategy for sustainable development, where waste prevention, reduction of resource depletion and energy consumption and minimisation of emissions at the source is given high priority. Waste must be analysed and handled as an integrated part of total material flow through the society.

For instance, problems like heavy metals in incinerator ash and residues from flue-gas cleaning should be met with a concentrated effort to phase out the use of heavy metals wherever feasible together with separate collection and treatment of products still containing heavy metals. Further input of resources for treatment and stabilisation should be avoided. In the same way, problems such as contamination of sewage sludge should not lead to an increased use of energy in incineration plants or advanced treatment, but to a decrease in the use of chemicals and heavy metals in industry and products creating the problems. Otherwise, these substances end up in the sewer.

To stabilise or even reduce the waste amounts there is a need for many varied initiatives besides cleaner technology, such as product development based on life cycle analysis, design for disassembly, environmental management systems in manufacturing industries, re-use of products and packages, improvement of product quality with regard to for instance lifetime, better possibility for repair, increased re-use of components from discarded products and, not least, increased consumer awareness of the need for changing lifestyles.

If a product or the components of a product are re-used directly it will contribute to waste minimisation. Recycling of waste is a process which takes material from the waste stream and produces a useful material or product, but it cannot be regarded as waste minimisation as such. In fact it is already technically possible to systematically re-use components from discarded products when producing new products. For example, a photocopier can be produced with a content of re-used components valued at 10% to 50% of the total cost, with an average of 35% (Erhvervsbladet, 1997).

As stated in the book 'Beyond the Limits': 'If the average lifetime of each product floating through the human economy could be doubled, if twice as many materials could be recycled, if half as much material needed to be mobilised to make each product in the first place, that would reduce the throughput of materials by a factor eight' (Meadows *et al.,* 1991)

1.4. Main EU policies

The policies adopted at Community level are guided by the Community Waste Management Strategy which aims to establish an integrated waste management policy (see section 6). Thus, the Strategy sets up a hierarchy of principles, giving top priority to the prevention of waste generation, followed by re-use and recycling of waste materials, energy recovery, and final disposal of waste.

The legal response to the Strategy is in particular the Waste Framework Directive, the Directive on Hazardous Waste and the Regulation in the Supervision and Control of Transfrontier Waste Shipments.

2. Analysis of selected waste streams

Detailed analysis of developments in waste generation, waste management and waste minimisation is hampered by the lack of comparable definitions and statistical information across Europe. The gaps in information are analysed in Chapter 4.2.

2.1 Hazardous waste

The EEA member countries generate about 36 million tonnes of hazardous waste per year (OECD, 1997). Statistical data on hazardous waste is particularly difficult to interpret. Analysis of the data shows large changes in reported amounts over time, as illustrated in Table 3.7.1. Countries and regions with figures for both 1990 and 1995 show an apparent increase (on average 65%) in hazardous waste quantities, but this is mainly due to changed definitions and new legislation. The introduction in late 1994 of the hazardous waste list in the European Waste Catalogue is the first attempt to establish a common classification for hazardous waste in EU. In general the new list includes more waste types than previous national lists.

Germany and UK with figures for 1990 and 1993/1994 show a decline by an average of 21% before the introduction of the hazardous waste list. This decline can possibly be explained by the introduction of cleaner technology or closing of heavy industry factories/moving production outside EU for example to Asia.

2.2. Paper and cardboard

In the case of paper and cardboard (Figures 3.7.4 and 3.7.5), consumption is a reasonable proxy measure for waste generation. Consumption in the EU rose from approximately 41 million tonnes in 1983 to 64 million tonnes in 1996, an increase of 46% or 3.5% per annum (CEPI, 1997), although in the period 1992-1996 the rate of increase slowed to 1.5% per annum. There is appreciable variation between Member States: annual rates of increase between 1983 and 1996 range from 0.4% (Sweden and the Netherlands) to 11.1% (Greece).

There is a remarkably wide range in per capita consumption of paper and cardboard over the period (1982-1996) ranging from as low as 49 kg/person/year in Portugal, 1983, to as high as 260 kg/person/year in Belgium, 1996.

Growth in consumption averages 1.8%, 3.5% and 5.5% per annum for the high, medium and low range groups respectively, over a 13-year period. While this grouping system obscures differences between countries within groups, it is a useful indicator for planning at European level as countries in the lower to middle ranges might be expected to have capacity for increased consumption which has been reached in countries in the middle to higher range. On the other hand, it could also be used to set realistic targets for reducing consumption levels.

The historical trend suggests that the move towards the information age is not resulting in reduced generation of paper.

Paper waste is a high-volume waste with a middle range environmental impact (see

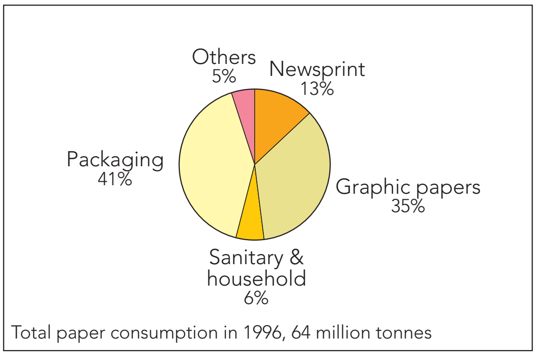
Reported quantities of hazardous waste in selected countries and regions, 1990-95 — Table 3.7.1.

Country	Year	Tonnes	Country/region	Year	Tonnes
Austria	1990	317 000	**Luxembourg**	1994	36 312
	1995	577 000		1995	180 596
Denmark	1990	116 000	**Netherlands**	1994	895 000
	1995	252 000		1995	955 000
Germany	1990	13 079 000	**UK**	1990	2 310 000
	1993	9 093 000		1994	2 080 000
Ireland	1992	143 600	**Catalonia**	1990	674 400
	1995	273 637		1995	831 439

Existing data for hazardous waste shows for many countries and regions an increase in generation of hazardous waste in the first half of the 1990s. However, the increase is primarily due to changed definitions and new EU legislation for hazardous waste.

Source: OECD, 1997a; NRCs, 1998a; Junta de Residus

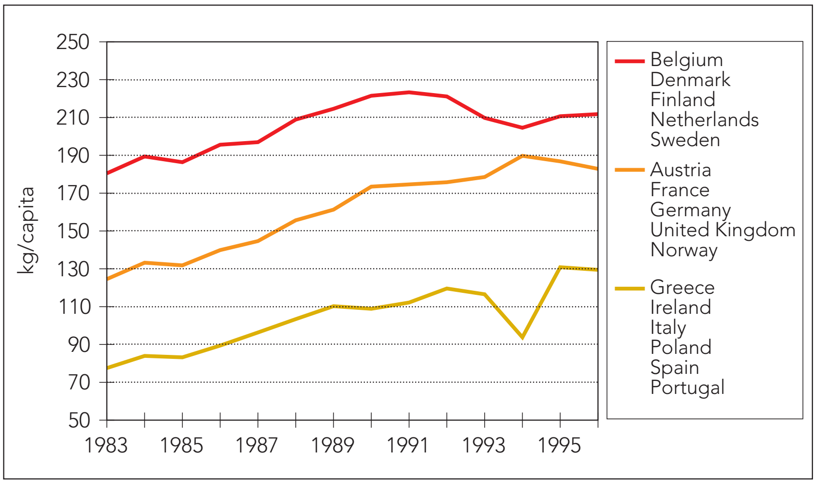
Paper composition — Figure 3.7.4



The composition of paper and cardboard consumed has changed very little during the 1990s. Packaging and graphic papers account for the major part of consumption.

Source: CEPI, 1997

Paper consumption/capita — Figure 3.7.5



Countries grouped according to general paper and cardboard consumption in the period 1983-96:
low consumption, 40-140 kg/person/year (Greece, Ireland, Italy, Portugal and Spain);
medium consumption, 110-200 kg/person/year (Austria, France, Germany, UK, Norway);
high consumption, 150-260 kg/person/year (Belgium, Denmark, Finland, Netherlands, Sweden).
All three groups show an increase per capita from 1983-96, with the highest increase among countries with low consumption.

Source: CEPI, 1997

Figure 3.7.2). Paper is one of the waste fractions where Member States have followed the Community strategy of increasing recycling instead of energy recovery and landfilling. The recycling rate has increased for EU+Norway from 36% in 1985 to 40% in 1990 and 49% in 1996. However, the total amount of waste incinerated or landfilled has increased due to the growth in consumption of paper and cardboard (Figure 3.7.6).

As shown in Table 3.7.2 energy consumption and emissions for paper production based on virgin materials and recycling paper are comparable. Although recycling of waste paper in general is more environmentally friendly than production based on virgin material, it has to be underlined that recycling also gives a pressure on the environment.

2.3. Container glass

Consumption of container glass has, like paper, augmented during the 1990s. For the EU and Norway the average increase in the consumption of glass over the period 1990 to 1996 has been 13.6% or 2% per annum. In absolute figures the increase is from 11.7 million tonnes to 13.3 million tonnes. Average glass consumption per capita differs by 400-500% from the country with the lowest consumption to the country with the highest consumption (Figure 3.7.7).

About 75% of container glass production is used for the packaging of beverages. The rest is used for food, pharmaceuticals, cosmetics and chemical products. The consumption of container glass depends on national consumption patterns and on the materials used for containers (e.g. glass, one-way systems, plastic bottles). It is reasonable to assume that the consumption of container glass gives a relatively good measure of waste production.

As with waste paper, glass is one of the waste fractions where Member States have succeeded in the Community strategy to increase recycling (Figure 3.7.8), from 43% in 1990 to 55% in 1996 for the EU+Norway. This does not include refillable bottles on deposit, which are not regarded as waste until the bottle is discarded.

2.4. The challenge of plastic waste

The EU is facing an increasing quantity of post-use plastic waste which has been increasing by about 4% per year (SOFRES, 1996) (Figure 3.7.9). In 1990, 13.6 million tonnes of post-use plastics waste was generated in

Figure 3.7.6 **Paper treatment**

Despite the success of recycling the problem remains that waste paper generation has also increased in the same period. In 1996, 32.5 millions of tonnes of waste paper and cardboard were incinerated or landfilled compared with 32.5 million in 1990 and 28.3 million tonnes in 1985.

Source: CEPI, 1997 and NRCs, 1998a

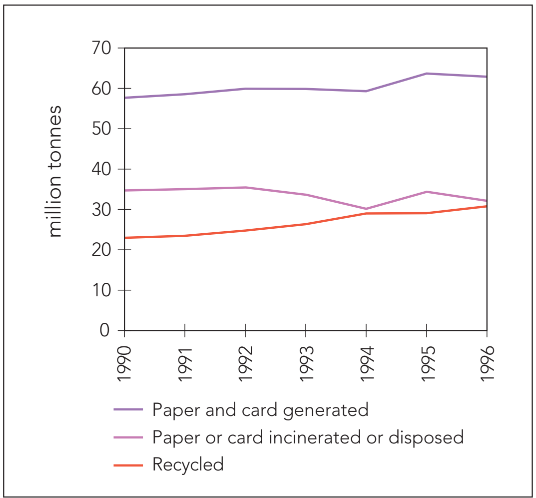


Table 3.7.2. **Energy consumption from production of newspaper and emissions from unbleached paper pulp with and without use of recycled paper for different materials in Sweden 1994-95**

The table shows that recycling of paper in general is better than using new pulp, but even recycling gives rise to considerable energy consumption and emission of phosphorous and nitrogen.

Consumption of energy				Emissions			
Raw material	Consumption of heat GJ/tonne	Consumption of electricity GJ/tonne	Total energy consumption GJ/tonne	Raw material	CO_2 kg/tonne	Phosphorus g/tonne	Nitrogen g/tonne
Newspaper with 100% recycled paper	5.7	3.2	8.9	Unbleached paper pulp with recycled paper	14-21	10-17	80-220
Newspaper without recycled paper	5.5	10.6	16.1	Unbleached paper pulp without recycled paper	12-37	18-40	230-420

Source: Naturvårdsverket, 1996

the EU, Norway and Switzerland and in 1994 the quantity peaked at 17.5 million tonnes (APME, 1995; APME, 1996).

Municipal Waste
Municipal waste is by far the largest 'source' of plastic waste with 61% of the total in 1996 (Figure 3.7.10).

Several problems are related to municipal waste, for example:

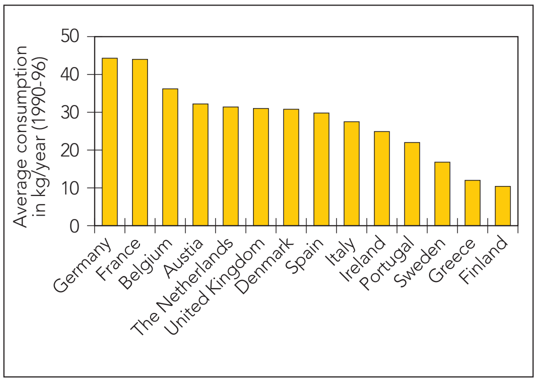
- it is difficult to handle as it consists typically of a number of fractions of waste and several plastic types; the bottleneck to more recycling is sorting the different plastics both in relation to available techniques and to health and safety problems related to sorting;
- it contains plastic types with a high degree of contamination from foodstuffs resulting in very labour- and energy-intensive recycling.

As shown in Figure 3.7.9 it is obvious that plastics waste has to be dealt with in a more innovative way in order to implement the Community Waste Management Strategy. Only 20% of plastic waste is subjected to material recovery or energy recovery while an average of 80% is disposed of. Disposal can be either incineration without energy recovery or landfilling. The figure also shows that despite increasing quantities of post-user plastic waste the fractions dealt with by material recovery and energy recovery are more or less constant at levels of about 7% and 15% respectively (APME, 1995; APME, 1996).

PVC waste
Polyvinylchloride waste (PVC waste) accounts for a total of 12% of all plastics waste in the EU, Norway and Switzerland, or 2.1 million tonnes PVC waste in 1994 (SOFRES, 1996). In comparison, PVC production in 1994 was 4.8 million tonnes (Allsopp, 1992) and is still increasing, confronting future generations with rising amounts of PVC waste. Recovery of PVC waste is lower than recovery of other kinds of plastic waste. A study in eight western European countries has shown recycling rates from 1% to 3% (DEPA, 1996). Material recovery of PVC requires sorting waste into generic materials; this is not done today.

PVC requires special attention due to its high content of dangerous substances which are used as plasticisers (phthalates), stabilisers (lead, cadmium and organotin com-

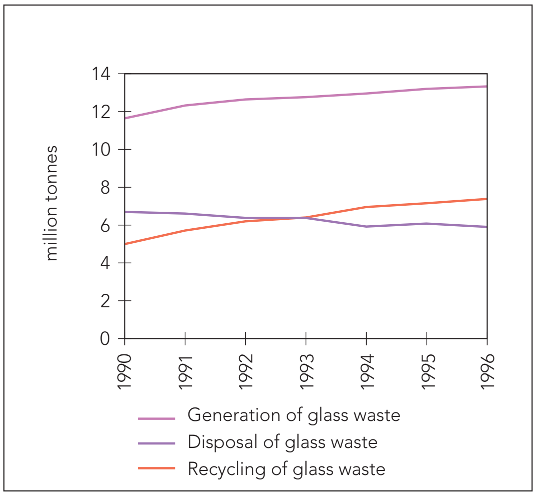
Average glass consumption in different countries, 1990-95 (in kilo per capita/year) — Figure 3.7.7



The yearly consumption of container glass per capita (and hereby the glass waste generation) is 4 times as high in countries with a high consumption compared to countries with a low consumption.

Source: FEVE, 1997 and NRCs, 1998a

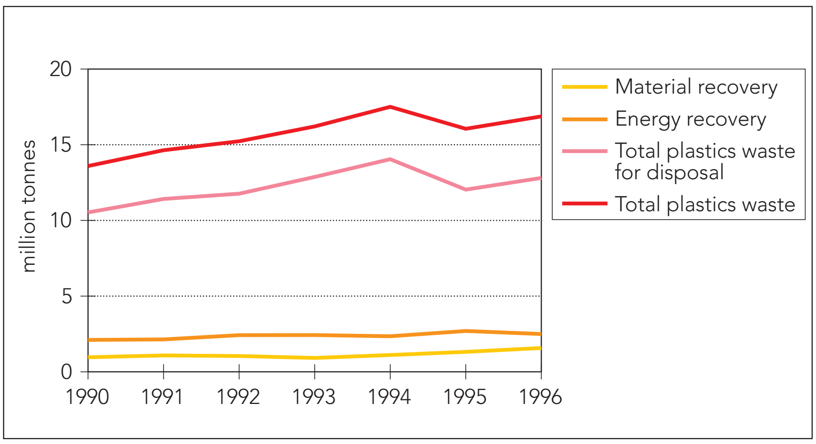
Glass generation and management — Figure 3.7.8



While recycling has increased by almost 50% from 5 million to 7.4 million tonnes per year, the amount of waste glass for disposal has decreased by only 12% (6.7 million to 5.9 million tonnes) due to the simultaneous increase in waste glass.

Source: FEVE, 1997; NRCs

Total plastic — Figure 3.7.9

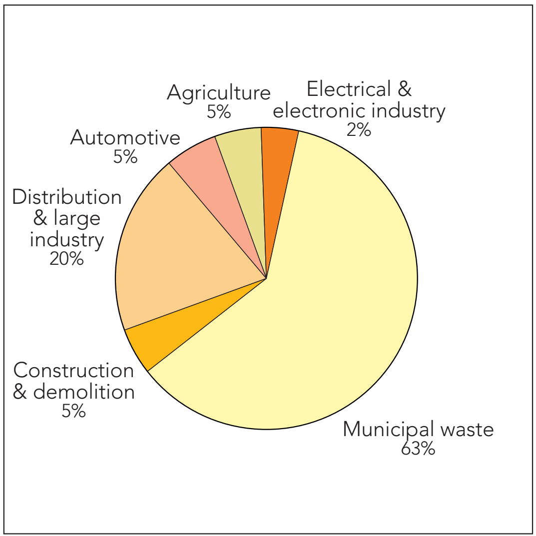


The fraction of total plastic waste dealt with by disposal is more or less constant at about 75%.

Source: APME, 1995; APME, 1996.

Figure 3.7.10 **Plastic sources**

Source: APME, 1996



pounds) and pigments (cadmium compounds). In addition, the chlorine content in PVC is very high (about 57% by weight). The dangerous substances create problems when PVC waste is landfilled, recovered or incinerated (with or without energy recovery). When PVC is landfilled, there are different problems related to the disposal of hard and soft types of PVC. In the leachate from landfill accepting soft PVC, phthalates have been identified in different concentrations. On the other hand, degradation of hard PVC in a landfill procees much slower than for other types of plastic.

With incineration of PVC large amounts of hydrochloric acid are generated making it necessary to neutralise the acidic fumes. In the dry and semi-dry gas cleaning processes 1-2 kg residues are formed per kg PVC incinerated. The high chlorine content of PVC further constitutes a risk of dioxin production during incineration. Uncontrolled burning will release dioxin and other toxic substances. A Danish study has shown that 67% of the chlorine in waste for incineration comes from PVC (DEPA, 1996). It is also worth noting that the calorific value of PVC is 22 MJ per kg – the lowest value among plastic polymers. In comparison, Low Density Polyethylene has for example a calorific value of 45 MJ per kg (SOFRES, 1996).

Under the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal, it has been discussed whether PVC should be classified as hazardous or non-hazardous waste. For the time being no common position has been reached. The normal content of lead in PVC is typically 0.6% (DEPA, 1996). Waste contaminated with lead compounds higher than 0.5% or cadmium higher than 0.1% by weight is, according to the classification rules in the hazardous waste directive (91/689/EEC), classified as hazardous. Hard PVC will normally have a cadmium level of 0.25%.

2.5. Scrapped cars

As the number of cars in EU is increasing so is the number of scrapped cars (End of Life Vehicles) that need to be treated: at present, the quantity of waste from scrapped cars in the EU is estimated at 8 to 10 million tonnes.

Scrapped cars are usually, after dismantling of directly reusable parts, shredded into small pieces and then separated into three fractions – iron and steel, other metals and non-metallics (Figure 3.7.11). The metals are to a very high degree recycled and smelted down to new raw materials. Re-smelting of metals is less energy consuming than production of metals from ore, but creates new problems of air pollution and/or hazardous dust from the cleaning of the smoke. Secondary steelworks are estimated to be responsible for 28% of the chromium, 16% of the zinc and 3% of the dioxins emitted in Europe (UNECE, 1998). Secondary steel smelting typically results in 10-15 kg dust per tonne steel recycled. In 1996 about 700 000 tonnes of dust were generated in Western Europe. The dust is polluted with heavy metals and has to be treated at special treatment plants (Hoffmann, 1997). The amount and hazardous properties of the dust reflect the quality of the scrap received. The Danish Steel Works was able to reduce the load of heavy metals in scrap by 10% from 1992 to 1995 through stricter rules for pre-treatment of the scrap. After 1995 heavy metal content has increased due to the increasing use of zinc in cars (Danish Steel Works, 1997).

In relation to waste treatment the non-metal part, shredder waste, is the most problematic. The present amount of shredder waste from cars is in the range of 2 to 2.5 million tonnes in the EU. This waste is a mixture of foam, textiles, plastic, rubber, glass, oil and hazardous waste. It is generally highly contaminated with heavy metals, oil, brake fluids etc. and at present this waste is landfilled in most Member States. It cannot be recycled and incineration is problematic due to the often high content of heavy metals and PVC. Danish studies indicate that better sorting of shredder waste can reduce the heavy-metal content considerably and make incineration with energy recovery less problematic (Miljøstyrelsen, 1997).

3. Waste amounts and treatment in the Accession Countries

The 10 central and eastern European Accession Countries applying for membership of the Union will need to harmonise legislation and practices in the area of waste management to ensure compliance with EU legislative requirements. Total reported quantities of waste reported are three times the EU average. Although there are differences of definition and data coverage, the main explanation seems to be higher reported amounts of mining waste and waste from agriculture. Where a breakdown is available by source the average figures for manufacturing waste and waste from energy are about 50% above the EU average (Figure 3.7.12 & 3.7.13).

The generation of industrial waste depends on both the type of industry and the extent to which production processes make use of cleaner technology and waste minimisation procedures.

4. Environmental impacts of landfilling and incineration of waste

4.1. Landfilling

The main environmental pressures from landfilling of waste are:

- pollution of surface water and groundwater with toxic substances and nutrients leaching from the waste;
- contribution to the greenhouse effect by emission of methane;
- land use (including loss of natural areas).

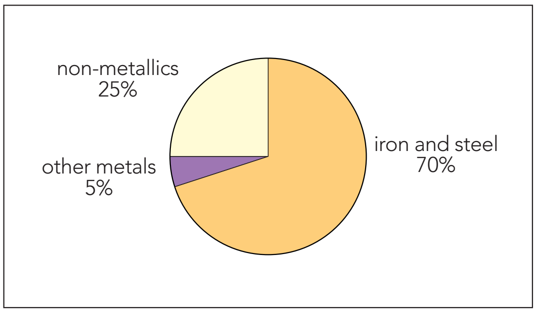
Furthermore the landfills represent a permanent loss of resources and the need for controlling the pollution leads to increasing public expenditure for monitoring and clean-up operations.

The extent of these problems varies according to the type of waste landfilled, the construction of the landfill and the hydrogeological conditions. In relation to the risk of groundwater pollution studies have shown that the leachate may be a risk even after several centuries. Pollution of

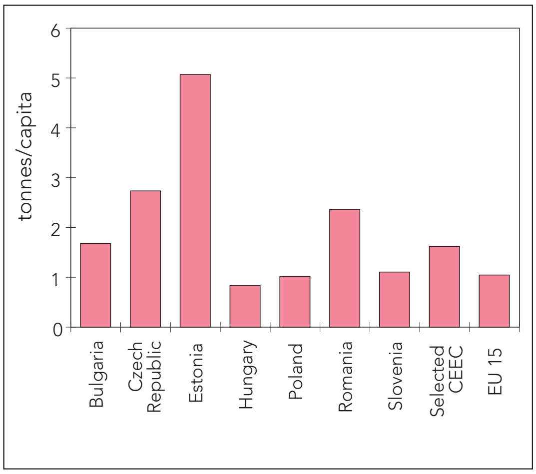
Car composition Figure 3.7.11

Major environmental problems are related to the treatment of the 25% non-metallic parts of scrapped cars.

Source: European Commission, 1997a; IPPE, 1996



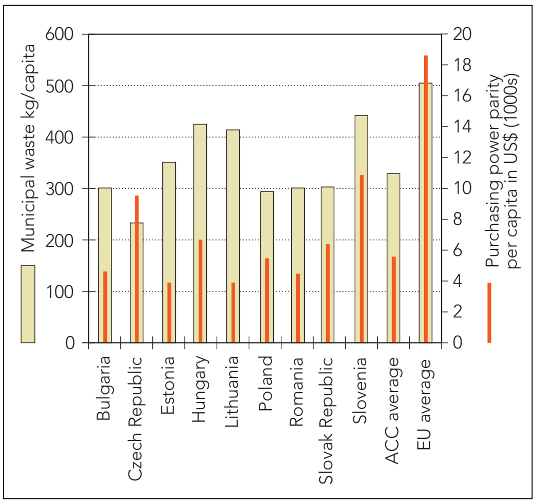
Manufacturing waste + Waste from energy/capita in selected Accession Countries Figure 3.7.12



The figure shows that the quantity of waste from manufacturing and energy production is in average about 50% higher in selected Accession Countries than in EU. The very high total for Estonia is mainly due to waste from oil-shale-based energy production.

Source: EEA, 1998b; OECD, 1997a

Manufacturing waste + Waste from energy/capita in selected Accession Countries Figure 3.7.13



The figure shows that the average generation of municipal waste is about 40% higher within EU (505 kilo/capita/year) than in the Accession Countries (AC) (311 kilo/capita/year). GDP expressed as average Purchasing Power Parity (PPP) in the AC is about 30% of the EU average. There is no trend in the connection between waste generation and PPP as there seems to be within the EU. Latvia is not included in the table because the data for Latvia is not clearly defined.

Source: EEA, 1998b; OECD, 1997a

groundwater will often give problems for decades even after the source of the pollution has been stopped because groundwater resources are generated only very slowly. Sorting and pre-treatment (e.g. incineration) of the waste can reduce the harmfulness of the leachate, but even leachate from incineration slag may exceed groundwater quality criteria for up to 100 years (Table 3.7.3).

Major gases emitted are methane and carbon dioxide from degrading organic substances in the waste. The greenhouse effect of methane is estimated to be 56 times that of carbon dioxide over a 20-year period and 21 times over a 100-year period (IPPC, 1996). Methane is estimated to be the cause of 20% of the global greenhouse effect (European Commission, 1997b) (see Chapter 3.1). From most landfills methane is released directly into the atmosphere where it contributes to the greenhouse effect. Methane from landfills was estimated to make up 28% of total methane emissions from the EU in 1995 (European Commission, 1998a). Before being released to the atmosphere methane may accumulate in buildings on or adjacent to landfills and present a very real danger of explosion.

The problems of methane emissions can be solved either by avoiding landfilling of organic matter or by collecting and utilising the gas at the landfill. A number of Member States have already issued or plan to issue general bans on landfilling of organic waste. The proposed Directive on the Landfilling of Waste (European Union, 1998) will demand gas collection from all new landfills receiving biodegradable waste and sets goals for the reduction of municipal organic waste to be landfilled. The first effects of this directive will appear seven years after implementation. Even after this date organic waste from industry and other activities can be landfilled providing gas collection systems are installed.

4.2. Incineration

The total quantity of waste incinerated in the EU is not available from official statistical sources. Data reported to the OECD indicates a total annual incineration of Municipal Solid Waste (MSW) of about 26 million tonnes (OECD, 1997a). This must be taken as the minimum quantity. In several countries reported quantities of incinerated waste are higher because other waste types are incinerated as well (industrial and commercial waste) (ISWA, 1997). Reported incineration capacities are also much higher for a number of countries (ETC/W, 1998).

It should also be noted that considerable quantities of waste are incinerated in cement kilns, steel ovens and industrial boilers. In Germany alone the following quantities of waste are incinerated in cement kilns: 170 000 - 200 000 tonnes waste oil, 60 000 tonnes hazardous waste (bleaching soil, solvents, paint sludge, contaminated wood) and 250 000 tonnes waste tyres (Johnke, 1998). To what extent these amounts are included in the OECD statistics is very unclear. The environmental impact of incineration outside incineration plants is only partially described.

Historically the primary aim of incinerating waste was to reduce the quantity of waste to be landfilled. In general incineration reduces municipal waste to about 30% of its original weight (generation of 300 kg of bottom ash per tonne of waste input). The remaining slag is much more stable than

Table 3.7.3. **Pollution from landfills can go on for centuries**

Rate of leachate production	Hazardous waste landfill	Municipal solid waste landfill	Non-hazardous low organic waste landfill	Inorganic waste
Medium: (200mm/annuum)	600 years	300 years	150 years	100 years
High: (400 mm/annuum)	300 years	150 years	75 years	50 years

Estimate of the time (in years) needed before leachate from different landfills can be released without risk to groundwater resources. The time needed to wash out the pollutants depends on the amount of rainwater washing through the waste (leachate production); two scenarios are presented. Calculations are based on a landfill with an average height of 12 m. Non-hazardous low organic waste landfills represent landfills receiving a mixture of commercial waste and non-hazardous industrial waste.

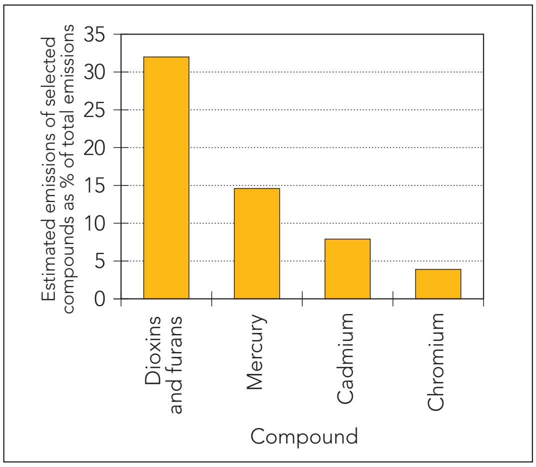
Source: Hjelmar et al., 1994

untreated waste and far easier to landfill or recycle (in road construction etc.). In many incinerator plants the energy obtained is utilised, and the focus on energy recovery has been increasing and is emphasised in the European Community Strategy on Waste.

Despite its positive aspects waste incineration also creates new problems through release of air pollutants and generation of secondary waste streams (slag and fly ash).

Air pollution
The main contaminants released in the combustion process are acid gases, polycyclic aromatic hydrocarbons (PAH), dioxins (PCDD) and furans (PCDF), dust and heavy metals.

Incinerator emissions — Figure 3.7.14



The figure shows the relative share of emissions from incineration plants compared with total European emissions including natural sources. Based on estimates for a total of 38 European countries in 1990 (latest full data available).

Source: Umweltbundesamt, 1997

For some compounds waste incineration has contributed significantly to the total pressure on the environment (Figure 3.7.14).

Emissions from incinerators have undoubtedly been reduced considerably after 1990 due to the closing of many small installations and the introduction of cleaning systems. Estimates covering the EU, Norway and Switzerland show a marked decrease in dioxin emissions from 2 000 g dioxin equivalents (I-TEQ) in 1990 (Umweltbundesamt/ TNO, 1997) to 1 341 g in 1994 (Landesumweltamt Nordrhein-Westfalen, 1997). Similar decreases must be expected for heavy metals. In 1994-95 waste incineration's share of total emissions in Germany was estimated to be 12% of dioxins, 4% of mercury and 0.3% of cadmium.

Residues from air pollution control systems
Due to both EU and national legislation most large incineration plants and all plants established after 1990 are now equipped with advanced cleaning systems. No statistical data exists on the quantity of residues from flue-gas cleaning. As the quantity of waste generated depends on the process (Table 3.7.4), the composition of the waste incinerated and the design of the treatment system, estimates will be very uncertain.

Common to all residues is that they are highly contaminated and in most cases classified as hazardous waste. Unless treated further the pollutants are also very soluble and the waste is therefore difficult to store in landfills.

The problems of incinerator slag
Based on available information the total amount of slag from incinerator plants is estimated to be between 6 and 9 million tonnes per year in EEA countries. In a number of countries the slag is recycled and used for road construction, embankments and noise barriers and for concrete production. In Denmark and the Netherlands between 85 and 90% of the slag is recycled, while only 50% is recycled in Germany and hardly any slag is recycled in Sweden (DEPA, 1998 and International Ash Working Group, 1997).

When analyzing the chemical composition of incinerator slag a major concern is the heavy-metals content which is in many cases considerably higher than the concentrations occurring naturally in soil (Table 3.7.5).

This means that in many cases the use of slag for construction purposes may in the long term lead to contamination of surrounding areas with dust containing heavy metals if the surface is not sealed. On the other hand use under asphalt or concrete will reduce this problem.

Approximate quantities of residue in kg dry matter per tonne of waste incinerated using different methods of cleaning — Table 3.7.4.

	Cleaning technology applied		
Residue Type	Dry	Semi-dry	Wet
Fly ash	(10-30)	(10-30)	10-30
Dry residue, including fly ash	20-50	15-40	
Sludge from wastewater			1-3

The table shows approximate quantities of residue per tonne waste from different flue-gas cleaning systems applied in Europe.

Source: International Ash Working Group, 1997

Table 3.7.5. **Heavy metals in slag and soils in mg/kilo**

The table compares concentrations of heavy metals and PAH in slag (mg/kilo) with natural variation in soil and Dutch target values for good soil quality. The table illustrates that for most heavy metals the content in incinerator slag may exceed even extreme natural conditions and in almost all cases exceed recommended standards.

Source: International Ash Working Group, 1997; Lamé and Leenaers,1998

	Range in slag	Range in natural soils	Dutch value for good soil quality
As	0.12 - 189	1 - 50	29
Hg	0.02 - 7.75	0.01 - 0.3	0.3
Cd	0.3 - 70.5	0.01 - 0.70	0.8
Cr	23 - 3.170	1 - 1000	100
Cu	190 - 8.240	2 - 100	36
Ni	5 - 500	7 - 4.280	35
Pb	98 - 13.700	2 - 200	85
Zn	613 - 7.770	10 - 300	140
PAH	13 - 19.000		1

In relation to contamination of water most of the heavy metals are present as very stable and insoluble chemical compounds (Table 3.7.6). Studies of leaching from slag show that the main risk of contamination of drinking water comes from lead and cadmium, but high contents of soluble chloride and sulphate also present a problem. The main risk when used for harbour construction is copper and lead. Copper is particularly toxic for marine organisms (Thygesen *et al.*, 1992).

Due to the potential for environmental pollution, recycling of slag calls for regulation and strict control of the amounts used, the conditions for use and possibly pre-treatment to reduce the amount of contaminants in the slag. The identified problems highlight the need for continuous reduction in the use of heavy metals and improved sorting of the waste before incineration.

Table 3.7.6. **Environmental risk factors from leaching from slag**

Compound	Drinking water	Sea water
Cadmium	128	13
Copper	21	1 586
Mercury	60	12
Lead	420	344
Chloride	160	0
Sulphate	126	0

The table shows how many times leachate from slag exceeds selected water-quality criteria or different compounds based on leaching tests. The quality criteria have been selected from national and EU criteria in order to represent 'worst case'. Chloride and sulphate do not present a problem in coastal areas due to the natural high concentration in sea water, while copper is particularly toxic to marine organisms but a minor problem in drinking water.
Seawater scenario is based on use of slag for harbour construction.

Source: Thygesen et al. 1992

5. Outlooks

Per-capita consumption is expected to significantly increase in the EU between 1995 and 2010. Based on assumptions that historical trends of waste generation will continue, this could more than counter gains from current policy initiatives to reduce waste generation linked to consumption, suggesting that new initiatives will be required to stem the growth in waste generation.

5.1. Outlook trends

The limited systematic and consistent data hinders the development of future waste trends. Nevertheless, if observed trends continue under the baseline scenario, most types of waste will most probably increase over the next decade. Household waste, for example, is likely to grow by around 20% to 2010 for the EU as a whole.

Projections suggest that paper and cardboard consumption in the EU could expand by 44-62% by the year 2010 (ETC/W, 1998). Thus, between 92 million and 105 million tonnes of waste paper and cardboard will probably be generated by 2010 under the projected rate of consumption.

Glass consumption could equally expand by 24-53% for the period 1995 to 2010 (ETC/W, 1998). This means that by 2010 between 16.2 million and 20 million tonnes of glass waste will probably be generated.

Within municipal waste, the amount of plastic waste is estimated to increase by 63% from 1993 to 2005 (APME, 1995; SOFRES, 1996).

Waste from scrapped vehicles could grow dramatically in the coming decades; the number of end-of-life vehicles is expected to increase by 21% between 1995 and 2010 for the EU (ETC/Waste, 1998). Another estimate suggests that the number of scrapped cars could even increase by 17% by 2000 and by almost 35% by 2010 compared with 1995 in the EU12 (Figure 3.7.15; excluding former East Germany) (Kilde and Larsen, 1998).

For total solid waste, no comprehensive projections of sectoral share are available for 2010, although currently manufacturing and construction/demolition each account for 25% of the total weight. The expected rapid expansion of the service and transportation sectors may have obvious implications for the amount of packaging and scrap vehicle waste during the outlook period.

To keep paper and cardboard waste disposal and incineration levels constant with those of 1996, about 68 millions tonnes would have to be recycled by 2010. Such a development would demand an increase in recycled amounts of more than 100% (more than 2 million tonnes per annum). Similarly, 10 to 14 million tonnes of waste glass (an increase of 35% to the 90% level) would require recycling by 2010 just to stabilize the amount of glass landfilled.

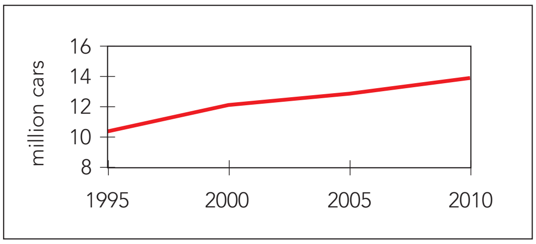
In general, landfilling is expected to decrease and recycling and incineration with energy recovery to increase during the outlook period. This will represent some progress in waste management in Europe, although hazardous waste and emissions of toxic compounds from incineration plants will continue to be produced and recycling plants will also keep generating secondary waste and emissions. Increasing efforts on waste avoidance, phasing out of toxic compounds in materials when feasible and separation at source could however mitigate these problems.

5.2 Policy implications

The expected waste trends during the outlook period suggest that existing policies, although providing some degree of success, will not be sufficient to stabilise waste arisings, meet policy objectives, or progress towards sustainability. Future product policy in EU will be of great importance for the possibilities to reduce the amounts of waste. The Commission (DG XI) has already taken the initiative to make a study in this area (Ernst &Young, 1998).

Efficient waste management and recycling must be supported by measures to reduce waste generation. This calls for consideration of the total lifecycle of products and services, emphasising preventive measures at source and re-use of products and components. Otherwise, the EU target of stabilizing municipal waste per capita by 2000, although somehow arbitrarily established by the Fifth Environmental Action Programme, is unlikely to be achieved.

Car projection Figure 3.7.15



The graph shows estimated numbers of scrapped cars in EU12 (excluding former East Germany) from 1995 to 2010. All figures are based on a model using historical data (until 1990) and projections of the car fleet combined with detailed information on age distribution of cars in the different Member States. The result should be seen as a trend more than a projection of exact numbers.

Source: Kilde & Larsen, 1998

Innovative initiatives already exist in several EU countries. Specific proposals by the European Commission include a directive on the treatment of scrapped vehicles with the aim of increasing the recycling of materials to reduce the problems associated with shredded waste. Important issues which would be addressed are the quantities of hazardous materials in cars and how to provide for more efficient disassembly and re-use/recycling of materials. Another possible initiative would be standardisation of container glass used for beverages to ensure re-use, thereby reducing the generation of glass waste.

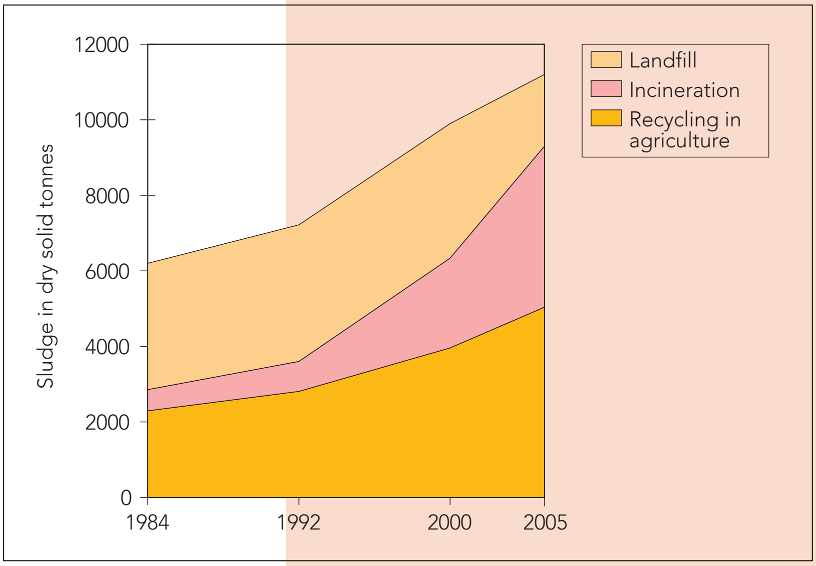
5.3. Accession countries

With strong economic growth anticipated for the outlook period in the Accession Countries, a substantial increase in the amount of municipal waste is to be expected. If quantities reach the average amount per capita for the EU, the total amount of municipal waste in the Accession Countries will increase by 50% from 34 million tonnes in 1995 to 53 million tonnes in 2010 (Figure 3.7.18). An increase of this order would cause enormous problems for waste management and demand efficient measures for collection and recycling.

Recycling plant capacity exists in eastern Europe based on the need to conserve due to the previous lack of imported products and raw materials. Previously re-use of containers and materials was an economic necessity and the governments subsidised recycling by paying small amount of money to small private companies for collecting the used material. The markets for recycling have in many cases been privatised and the subsidies removed, whereby re-use and recycling have decreased. Some of the plants, now privatized, are looking for

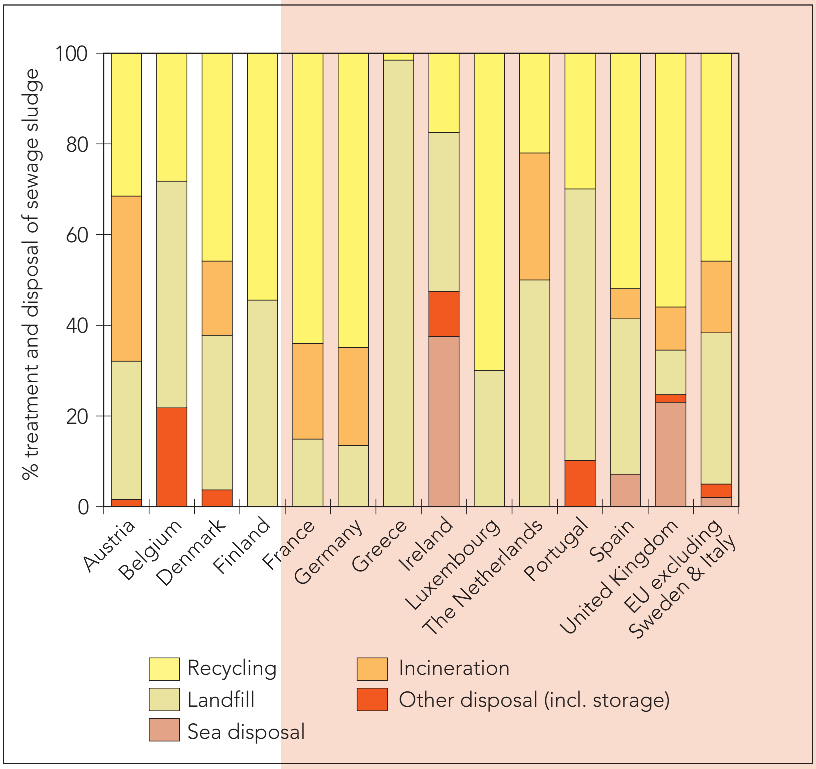
Box 3.7.1. Case study: Sewage sludge – a future waste problem?

Figure 3.7.16 **Sludge projection - EU, 1984-2005**



Source: Hall & Dalimier, 1994, *expanded to EU+3 by ETC/IW*

Figure 3.7.17 **Sludge treatment: variation in EU, 1995**



Source: European Commission, 1998c ; NRC the Netherlands (for Dutch figures), 1999

Thousands of treatment plants for urban waste water established over the last decades reduce the pollution of our lakes, rivers and coastal waters but are also the source of a rapidly growing waste problem: sewage sludge. The annual production of sewage sludge in the EU was an estimated 7.2 million tonnes dry solids in 1992. If the sludge is only mechanically dewatered the quantity of sludge to be managed is between 22 and 30 million tonnes.

Due to more stringent demands for treatment of urban waste water (Council Directive 91/271/EEC; see Chapter 3.5) many new treatment plants are due for completion by 2005. The amount of sewage sludge is thus expected to increase by 50% to at least 11.2 million tonnes dry solids by 2005 (Figure 3.7.16) (Hall & Dalimier 1994; updated to EU by ETC/IW). For some countries the quantity will increase by as much as 500%. This expected increase is in itself a challenge for waste management and the choices of treatment and disposal methods will have large economic and environmental implications.

Sludge can be a valuable fertilizer in agriculture. It is a good phosphorus source and also has a nitrogen content that can be valuable especially for crops with a long growing season (ISWA, 1998). The organic content of the sludge can help improve the soil structure and in general sludge stimulates beneficial biological activity in the soil (DEPA, 1997a). Phosphorus being a limited resource makes recycling of sludge for agricultural purposes an appealing solution for sustainable management of sludge.

However, sludge can also be contaminated with heavy metals, bacteria and viruses, and a number of organic substances, and both EU and national regulations set limits for contaminant concentrations to protect the soil and humans from pollution. Much of the sludge produced is already too contaminated and has to be incinerated or landfilled. Landfilling of sludge has hitherto been an inexpensive means of disposal, but both national restrictions and the proposed Landfill Directive will make landfilling more expensive. Several countries have introduced general restrictions on the landfilling of organic waste (Figure 3.7.17).

Incineration reduces the sludge to ash which can be landfilled. In most cases supplementary fuel is needed in order to burn the sludge and there is usually no net gain of energy (Johnke, 1998). Depending on the concentration of heavy metals and the incineration process the residual ash may be classified as hazardous waste.

The European Commission is considering tougher limit values for heavy metals and possibly limits values for some organic compounds which may further limit the potential for recycling. Several Member States have already established more stringent limit values for heavy metals and a number of Member States have also introduced limit values for a number of organic pollutants. A Danish survey indicates that up to 41% of the sludge may be in conflict with new limit values coming into force in year 2000 (Ingeniøren, 1998). In contrast availability of agricultural land in the vicinity of the waste water plant,rather than sludge quality, appears to be the primary factor determining disposal routes in the UK (Gendebien et al, 1999).

.../...

In addition, increased consumer awareness has led large supermarket chains in both France and Germany to reject products from farms using sewage sludge. Composting and other biological treatment options may to some extent solve the problem of pathogens and organic substances of concern but problems of heavy metals will still be a source of public concern.

The economic consequences of a restricted agricultural application of sewage sludge are considerable. Depending on the alternative chosen the cost may rise from EUR 75 per tonne for agricultural use to EUR 400 for incineration in some countries (ISWA, 1998). One German source even gives prices up to EUR 600 per tonne for thermal treatment (Johnke, 1998). Thus a thrust for phasing out the use of the problematic compounds may be an economically sound solution.

foreign sources of recyclable materials (Soil & Water Ltd., 1997). This course could hamper development of more efficient recycling systems for waste generated in the Accession Countries.

6. Responses – what is being done and is this sufficient to solve the problems?

6.1. Outline of community regulation and strategy

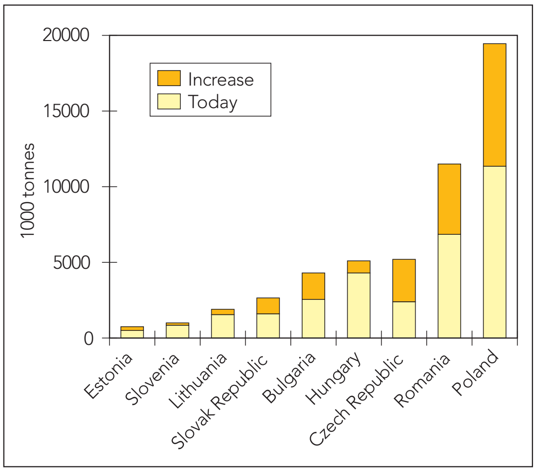
Early phases of Community waste legislation focused on clearly identified problems, including hazardous waste shipments, PCB disposal and waste from the titanium-dioxide industry. The legislation reflected the declared aim of the Treaty of approximation of national regulation directly affectingthe common market.

Later amendments of the Treaty, particularly the Single European Act (1987) and the Maastricht Treaty (1992) introduced a more general objective of protecting and improving the quality of the environment. These changes allow for a strengthening of the Community waste legislation aiming at establishing an integrated waste management policy in the Community. However this new focus may create new conflicts with the central policy of creating an internal market.

In line with the policy framework, a Community Strategy for Waste Management was initially adopted by the European Commission in 1989. The strategy sets out four strategic guidelines: Prevention, re-use and recovery, optimisation of final disposal and regulation of transport, together with a number of recommended actions.

The main strategic guidelines were maintained in the 1996 review of the Community Strategy, adding that preference should in general be given to the recovery of material over energy recovery. However, particular focus is further given to three main problem areas: i) scarcity of quantified and standardised information; ii) inadequate implementation of Community legislation at national level; and, iii) delays in adopting more sophisticated environmental measures, such as economic instruments and voluntary agreements, to encourage increased responsibility among producers and consumers.

Figure 3.7.18



The figure shows the increase in the amount of waste in the Accession Countries if economic growth leads to just the EU-average amount of municipal waste per capita. Latvia is not included in the table because data on municipal waste for Latvia is probably not comparable with that from the other countries.

Source: EEA, 1998

The following three pieces of legislation , as a response to the strategy, constitute the backbone of the Community waste management policy:

- The Waste Framework Directive which requires Member States to take all necessary steps to prevent waste generation, to encourage re-use and to ensure safe disposal. A fundamental principle of the Directive is the one on self-sufficiency and proximity requiring Member States to establish in cooperation an integrated and adequate network of disposal installations enabling the Community as a whole as well as eache Member State to become self-sufficient in waste disposal and to dispose of waste in one of the nearest appropriate installations. Member States are required to draw up waste management plans as a major tool to achieve this policy.
- The Directive on hazardous waste which sets more stringent requirements to the management of hazardous waste.

- The Regulation on the supervision and control of transfrontier waste shipments which sets out stringent requirements for the control of waste shipments, taking into account the principles of self-sufficiency and proximity of waste for disposal.

Based on the general legal framework, the Community policy on waste is supplemented by a number of more specific Directives. These may be divided into two groups:

- Directives on specific waste streams covering both measures of prevention and common rules for separate collection and treatment (in particular the Packaging Directive and the Directives on batteries and accumulators, waste oils, sewage sludge and PCBs/PCTs);
- Directives aimed at reducing the impact of treatment and disposal by setting common technical standards for operation of treatment facilities (i.e. the Directives on incineration of MSW and hazardous waste and the proposed Landfill Directive).

In Table 3.7.7 the main elements of the strategy are described and related to the present legal action in force, considered legal and political action to support the Strategy. From the table it is clear that a number of legal actions at present target the main elements of the strategy, i.e. the hierarchy of principles: prevention, material recovery, energy recovery and final disposal. However most of the legislation in force is directed towards specific problems (waste types or treatment activities), while few legal actions are directed towards the strategy in a broader sense (i.e. supporting the hierarchy of principles). In addition, these few legal actions are of a very general character, thus complicating monitoring and enforcement. This is in particular the case with the Framework Directive, which in Article 3 and 4 sets up the core elements of the Strategy, but without any concrete measures to be taken by Member States. The provisions are kept flexible due to the very different circumstances in the Member States, relying instead on waste management plans, which according to Article 7 of the Directive are to be drawn up by Member States. Except for the specific Directives, the strategy, at this stage, is therefore almost solely based on a legal framework focusing on administrative and notification procedures.

The Directive on packaging and packaging waste is the only existing directive addressing the hierarchy in more concrete terms by setting up concrete goals for recycling of material and recovery of energy.

In addition to the present legal framework, a number of new initiatives are under way, supporting the strategy in more concrete terms. This is in particular the case with the proposed Directive on the Landfilling of Waste establishing targets for the reduction of biodegradable municipal waste going to landfills. Also the current proposal for a Directive on end-of-life vehicles will provide a support to the strategy, setting up certain targets for the re-use, recycling and recovery of end-of-life vehicles. Other initiatives under way within the Commission focus on, for example, electrical and electronic waste, composting and hazardous municipal waste.

6.2. What progress has been made in implementing the EU waste strategy?

Under the EU Waste Strategy (see section 6.1 above) the general trend of increasing waste generation suggests that waste prevention initiatives have generally not been sufficient to reduce, or even to stabilise the quantity of waste.

For some countries it is possible to identify an increase in recycling and a reduction in landfilling for the period 1985-1995 (Table 3.7.8), but for many countries landfilling is still the most common treatment method (Figure 3.7.19).

For municipal waste it is possible to demonstrate trends in treatment in the EEA member countries. Even though there has been an increase in the level of recycling, landfilling remains the most common treatment and is in 1995 on the same level as in 1985-90. In the same period there has been an increase in the amount of municipal waste landfilled from 86 million tonnes to 104 million tonnes. Even if part of this increase may be due to better registration it is reasonable to conclude that in absolute figures, the EEA countries landfilled more municipal waste in 1995 than in the period 1985-90.

A breakdown of treatment routes for construction and demolition waste and manufacturing waste is provided for a number of countries. Table 3.7.9 demonstrates a shift away from landfilling towards recovery for these two selected waste streams.

However the overall conclusion regarding the treatment of waste in the EU is that landfilling is still the most common treat-

Main elements of the EU Waste Management Strategy Table 3.7.7.

Strategy	Legal action in force	Considered legal and political action
Prevent waste generation and reduce its hazardous content. Hierarchy of principles: prevention material recovery energy recovery safe disposal	Treaty, Art. 130R Member States required to: • encourage firstly, the prevention or reduction of waste, secondly the recovery of waste by means of recycling, re-use or the use of waste as a source of energy *(Framework Dir, Art. 3)*; • ensure that waste is recovered or disposed of safely, and prohibit the dumping or uncontrolled disposal of waste *(Framework Directive, Art. 4)*; • draw up waste management plans *(Framework Dir., Art. 7)*.	Possible proposals to set quantitative targets for reducing and recovering waste *(COM (96) 399)*
Prevention of waste generation	Community Regulations on eco-audit and eco-labels *(Regulation 1836/93 and 880/92)*. Member States required to take measures to prevent generation of packaging waste, limit the heavy metal content of packaging, and inform consumers *(Directive 94/62, Art. 4, 11 and 13)*.	In particular cases EU-wide rules to limit or ban the presence of heavy metals or specific substances in products to prevent hazardous waste to generate *(COM (96) 399)*. Integrate the principle of producer responsibility in all future measures on a case-by-case basis (COM (96) 399). Improve environmental dimensions of technical standards *(Council Resolution 97/C76/o1)*.
Prevention of impact on environment Prevent the negative impact on the environment	Member States required to take measures: • to reduce the heavy-metal content of batteries and accumulators, ensure separate collection, inform consumers, and prohibit marketing of certain batteries *(Directive 91/157);* • to collect and dispose of waste oils safely and prohibit any discharge of waste oils into inland surface waters, groundwaters etc. *(Directive 75/439, Art. 2 and 4);* • for the use of sewage sludge in agriculture in order to prevent harmful effects on soil, vegetation, animals and man *(Directive 86/278)*; • to implement common emission standards and operation criteria for incinerators for MSW and hazardous waste *(Directives 89/369 and 94/67)*.	Proposed specific requirements for Member States to ensure that measures aiming at reducing the negative impact on the environment from end-of-life vehicles are implemented *(COM (97) 358)*. Proposed directive on landfills setting minimum technical and administrative standards for landfills *(COM(97) 105)*.
Recovery Where generation of waste cannot be avoided, waste shall be re-used or recovered for its material or energy. Where environmentally sound, re-use shall be further encouraged in order to avoid generation. Preference to be given to recovery of materials over energy recovery operations.	Specific requirements for Member States to: • encourage re-use systems of packaging, to take the necessary measures in order to attain certain targets of recovery and recycling of packaging, and to ensure that systems are set up to provide for the return and/or collection of packaging waste *(Directive 94/62, Art. 5-7)*; • to give priority to the processing of waste oils by regeneration *(Directive 75/439, Art. 3)*;	Consider EU quality requirements to define when a given incineration operation is a recovery or a disposal operation *(COM (96) 399)*. Proposed specific targets of re-use, recycling and recovery for end-of-life vehicles, and demands for establishing systems for the collection of all ELVs. *(COM (97) 358)*. Development of a recycling industry based on modern technologies and methods and promote recyclability of materials and products *(COM(98)463)*.
Final disposal Avoidance of Iincineration without energy recovery and landfilling. Incineration with energy recovery to be promoted for all incineration installations, leaving landfilling in principle as the last solution. In the mid-term, only non-recoverable and inert waste to be accepted in landfills.	• Disposal costs must be borne by the producer of the waste (*Framework Directive, Art. 15*) • Member States required to take appropriate measures to: • establish an integrated and adequate network of disposal installations (*Framwork Dir., Art. 5*) • dispose of batteries and accumulators containing dangerous substances separately *(Directive 91/157, Art. 6).*; • ensure safe combustion of waste oils, and where neither regeneration nor combustion is feasible, to ensure safe destruction or controlled storage or tipping *(Dir. 75/439, Art. 4)*; • prohibit the uncontrolled discharge, dumping and tipping of PCBs/PCTs, making environmentally safe disposal compulsor*(Directive 96/59).*	Proposed requirement for Member States to ensure that all costs are covered by the price to be charged by the operator for the disposal of any type of waste in that site and to set up a national strategy for reduction of biodegradable waste going to landfills ensuring certain targets to be met *(COM (97) 107)*. Encourage Member States to make serious efforts to prevent and to minimise quantities of waste that go to landfills, and in the long run to ensure that the price of disposal is made more transparent *(COM(96)399)*.

.../...

Strategy	Legal action in force	Considered legal and political action
Shipment of waste: the principle of self-sufficiency aims at avoiding shipments for disposal between Member States, while shipments for recovery are mainly submitted to the principles of the internal market.	Requirements on notifications procedures *(Regulation 259/93).*	Increase approximations ofl standards in order to establish common environmental standards for recovery operations *(COM (96) 399).* Concern of large-scale movements within the Community of waste for incineration with or without energy recovery *(Council Resolution 97/C76/01).*

Table 3.7.8. **Total waste generation by disposal and treatment method in selected EU countries and regions (%)**

Country/region	Year	Land-filling	Incineration	Recycling	Other treat-ment
Denmark	1985	39	26	35	.
Denmark	1994	23	20	56	1
Denmark	1995	17	20	62	1
Denmark	1996	20	19	60	1
Germany	1990	68	3	21	8
Germany	1993	55	4	25	21
Ireland	1995	73	1	14	13
Netherlands	1985	42	7	51	.
Netherlands	1990	31	8	61	.
Netherlands	1994	21	9	70	.
Netherlands	1995	18	9	73	.
Netherlands	1996	16	11	74	.
Sweden	1990	75	13	10	.
Catalonia	1994	56	10	34	.
Catalonia	1995	56	10	34	.

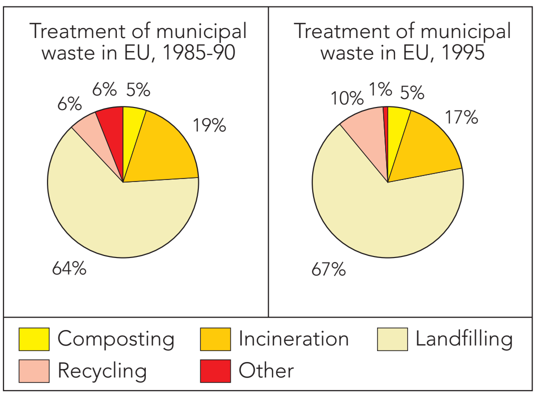
The table shows that progress has been made in some countries in increasing recycling and reducing landfilling

Source: NRCs , EEA 1998b; Junta de Residdus

Figure 3.7.19 **Development in EU from 1985-90 to 1995 in treatment of municipal waste**

The figure shows that despite increased recycling no progress has been made in reducing landfilling.

Source: EEA, 1998b; NRCs



ment route for waste and a major change is needed in order to implement the EU strategy on waste.

6.3. EU as a whole should treat its own hazardous waste

About 1.4 million of the 36 million tonnes of hazardous waste generated in EEA member countries (equivalent to 4%) is not treated in the country of origin but is exported, either to other EU countries, other OECD countries or to non-OECD countries.

According to the EU strategy, waste for disposal generated within the Community should be disposed in one of the nearest appropriate installations and should not be disposed outside the Community. For hazardous waste the EU has already banned export of all such waste for disposal to other countries except to EFTA countries. Export of hazardous waste for recovery to non-OECD countries is prohibited from 1998. This initiative follows a 1995 decision taken in the context of the Third Conference of the Parties of the Basel Convention on shipment of hazardous waste.

According to reports by the EU countries and Norway to the Basel Convention and the Commission very little hazardous waste was exported to non-OECD countries: 5802 tonnes out of a total of 1.47 million tonnes, corresponding to 0.4%, in particularly to India, New Caledonia and Kazachstan. If the figures reflect the actual situation, the export ban of hazardous waste for recovery to non-OECD countries therefore should be relatively easy for EU Member States to comply with.

EU exports to other OECD countries corresponds to 8% of the total, the destination mainly being the US, Norway and Switzerland. The remaining (91%) is exported among EU countries. The Community is thus also fulfilling the aim of treatment of hazardous waste within its borders. This conclusion does not however mean that sufficient treatment capacity for hazardous waste exists within the EU.

Table 3.7.9.

Development of disposal and treatment of waste from construction/demolition and manufacturing activities (%)

Country/ Region	Year	Construction & demolition				Manufacturing			
		Land-filling	Incine-ration	Recycling	Other	Land-filling and other disponal	Incine-ration	Recycling	Other
Denmark	1985	82	6	12	0	35	26	39	0
Denmark	1996	10	1	89	0	31	14	53	2
Germany	1990	32		10	58	38	8	49	4
Germany	1993	32		12	57	28	9	60	3
Ireland	1995	57	0	35	8	73		27	0
Luxembourg	1994	93	0	7	0				
Luxembourg	1997	93	0	7	0				
Netherlands	1985	50	1	49	0	34	2	64	0
Netherlands	1996	8	1	91	0	14	5	81	0
Sweden	1996					17	32	41	9
Catalonia	1995					37	1	52	10
Catalonia	1996					33	1	53	13

Source: NRCs; Junta de Residus

About 1 665 500 tonnes of hazardous waste was imported to EU Member States and Norway in 1995. Of this, 85% arose in other EU Member States, 8% came from other OECD countries, in particular Switzerland, US, Norway, Hungary and the Czech Republic, and 6% has unknown sources.

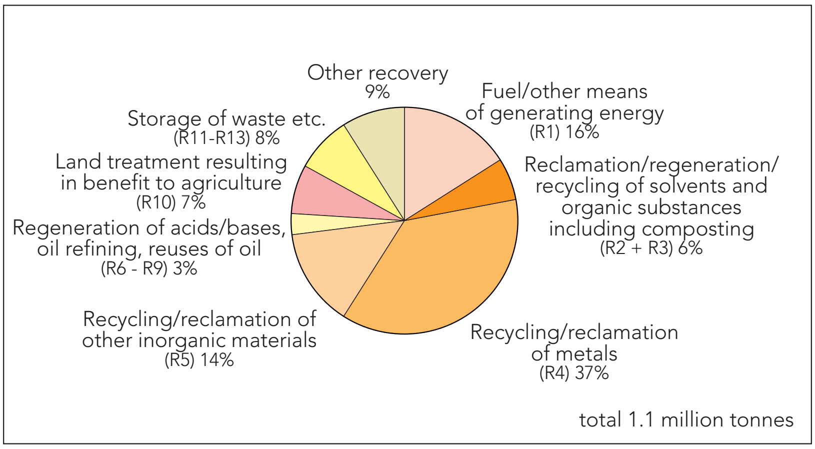
Many non-OECD countries do not have adequate facilities to treat their hazardous waste in a safe way. Until these countries are properly equipped, the EU could help by importing and treating this hazardous waste. However only 16 000 tonnes (1%) of imports to EU Member States and Norway was hazardous waste from non-OECD countries, in particular from South Africa, Brazil, Macedonia, and Slovenia.

Treatment of exported waste

About 75% of exported hazardous waste from the EU and Norway is exported for recovery and about 20% for disposal. Portugal, Spain, Luxembourg and the Netherlands export a large part for disposal. Figure 3.7.20 (according to the EU Framework Directive) shows which kind of treatment exported hazardous waste from the EU countries and Norway has received.

Figure 3.7.20

Treatment of exported hazardous waste according to the EU Framework Directive



The table does not include figures from Greece and Ireland. The figures for Sweden and France are 1994 figures.

Source: European Commission, 1998b; Norsas.

6.4. The importance of capacity, treatment prices and waste management

Waste management throughout Europe and above all the management of disposal and recovery is partly governed by the rules of market economy but is also strongly influenced by numerous EU and national regulations. Thus the success of the Community Strategy on Waste depends on a complex system governed by different national and regional regulations, the capacity of treatment facilities and the price structure between treatment forms and between nations.

Accordingly, knowledge of demand and supply of capacities for recovery, thermal treatment and landfilling and price relations is necessary to assess waste management comprehensively. Hardly any information is available on the capacity for re-use and recycling of different products and materials and an assessment is further complicated by the fact that many recyclable materials are traded on the world market. The following discussion will thus focus on capacities and prices for incineration and landfilling.

Incineration capacity in the EEA countries

Incineration plants for municipal non-hazardous waste are in operation in most EEA member countries, except Ireland, Portugal and Liechtenstein. In 14 countries a total of 533 incineration plants are reported in operation (nearly 280 of them in France). There is a very high degree of variation in the size of the plants. In addition to these, 239 incineration plants for hazardous waste are reported in operation.

By combining information on capacity where accessible with supplementary information on amounts of waste incinerated, the total incineration capacity for non-hazardous waste within the EEA is estimated to about be 33 million tonnes (NRCs, 1998b; OECD, 1997a). Incineration capacity is only available for about 17% of the total amount of municipal waste arising.

There is a very high degree of variation in available capacity for incineration (Figure 3.7.21). These differences may reflect both the level of development of waste management but also differences in strategies, climate, structure of energy supply systems and public acceptance of or opposition to incineration.

In some countries more than 90% of the capacity is reported to come from plants with energy recovery (NRCs, 1998b). While most countries have started to utilise the energy from waste there is a great deal of variation in the overall efficiency of energy utilisation (Figure 3.7.22). The variation may reflect differences in the composition of waste incinerated, but the main explanation is probably to which extent the incinerators operate only with electricity production, with heat production or a combination of the two. Optimal efficiency is obtained by combined systems where the heat is used in district heating systems.

Landfill capacities

Available data on landfill capacities is not complete and some confusion on the terminology for different types of landfills makes interpretation difficult. The following conclusions should therefore be taken only as a rough estimate.

Landfill capacity for non-hazardous waste (excluding sites used solely for inert waste) in the EU is estimated for 1996 to be about 1.2 billion tonnes in more than 8 700 licensed landfills. In addition to the licensed landfills about 3 450 unlicensed landfills have been reported from Germany, Greece, Portugal and Spain, of which 3 430 are in Greece (NRCs, 1998b; OECD, 1997b). Earlier data indicates a further 10 000 unlicensed sites in other Member States (Italy, France, Spain) (Hjelmar, 1994).

For the countries where data on both capacity and total amount landfilled in 1996 is available it is possible to calculate the remaining capacity expressed in years – i.e. how many years will it take to fill up the existing landfills at the present rate of disposal (see Figure 3.7.23).

Not all licensed landfills are equipped with the membranes and leachate collection systems needed to protect the environment properly. A survey made for the European Commission (DG XI) in 1994 and data collected by ETC/W indicates the following rates of application of liners and leachate collection systems in landfills licensed for municipal waste: Ireland <40%; United Kingdom, the Netherlands, Germany and France 40-70%, Denmark and Finland 70-90%; Austria, Belgium, Portugal and Sweden >90% (NRCs, 1998b; Hjelmar, 1994).

Considering the time needed for finding suitable locations, getting public acceptance and constructing the landfill there is therefore an urgent need for either a dramatic reduction in the amounts of waste landfilled or rapid construction of new controlled landfills or alternative treatment facilities. Furthermore, as reflected below the available capacity differs very much from one country to another.

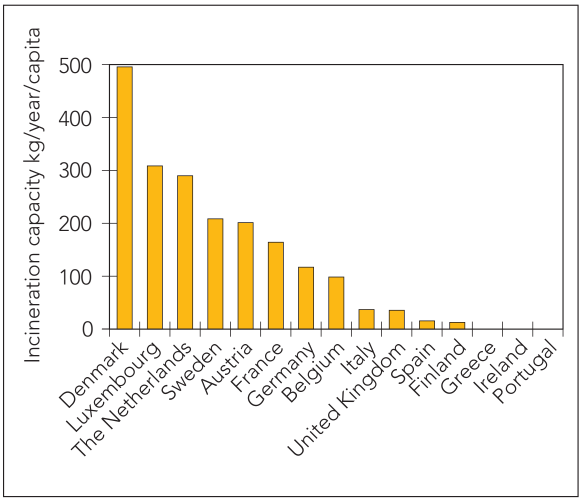
The effect of treatment prices on disposal patterns
In nearly all EEA member countries the average treatment prices for landfilling non-hazardous waste are far below those for incineration. This means that unless a new regulation is in place the market mechanism will direct waste to landfills instead of incineration with energy recovery. In other words the market mechanisms act in direct opposition to the official Community strategy. Of even greater concern is that landfills which have inadequate pollution control and make up about 67% of the landfills probably have prices below the average. Price mechanisms may thus also counteract the aim of reducing the impact of disposal (Figure 3.7.24).

The different treatment prices in EEA member countries are strongly influenced by national rules and regulations. A number of countries have issued detailed landfill regulations or guidelines which define the technical standard and the management of these waste management facilities. In particular, demands relating to the installation of liners, treatment of leachate and analysis of surrounding groundwater or surface water will increase the price of landfilling.

The difference in prices between member countries is in some cases due to very different environmental protection measures and reflects in this respect a conflict with the general community aim of environmentally safe disposal. Therefore, it is important for the Community to determine an obligatory state of the art for all kinds of waste management activities including rules for the implementation of post-treatment measures. This will lead to a gradual internalisation of external costs. This will however not change the fact that landfills are cheaper to construct and operate than incinerators.

Prices of incineration may vary according to the age of the installation, different interest rates, the income from the sale of energy or the cost of cooling towers, etc. The causes of current differences in treatment prices between incineration and landfilling have to be counteracted either by regulatory measures to harmonise environmental standards or other waste management measures supporting the general Waste Strategy or using economic instruments like waste taxes.

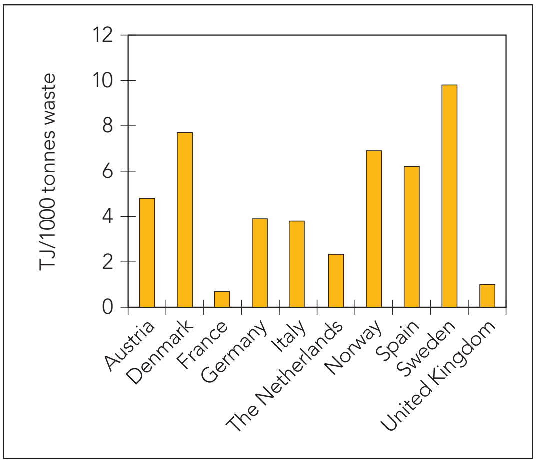
Incineration capacity in the EU Figure 3.7.21



The figure illustrates a large variation in available incineration capacity per capita within the EU. The figure covers municipal solid waste incineration plants with and without energy recovery and is based on information on capacity where available or actual incinerated quantity in 1996 or the latest reported year before.

Sources: NRCs 1998b; ISWA, 1997; OECD 1997a

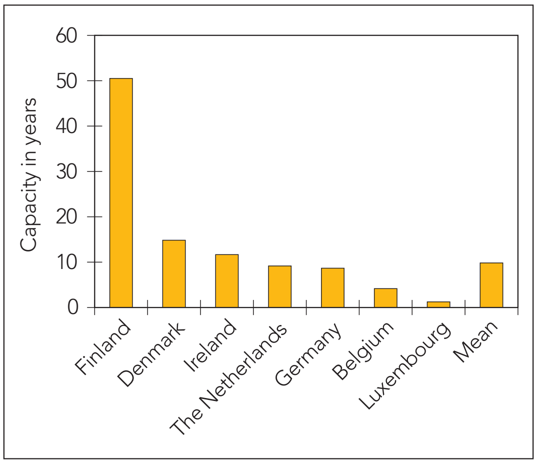
Energy recovery from incineration, selected countries Figure 3.7.22



The figure shows a large variation among the EEA countries in total energy recovery (heat+electricity)/ thousand tonne waste and is based on data obtained directly from the plants.

Source: ISWA, 1997; RIVM homepage

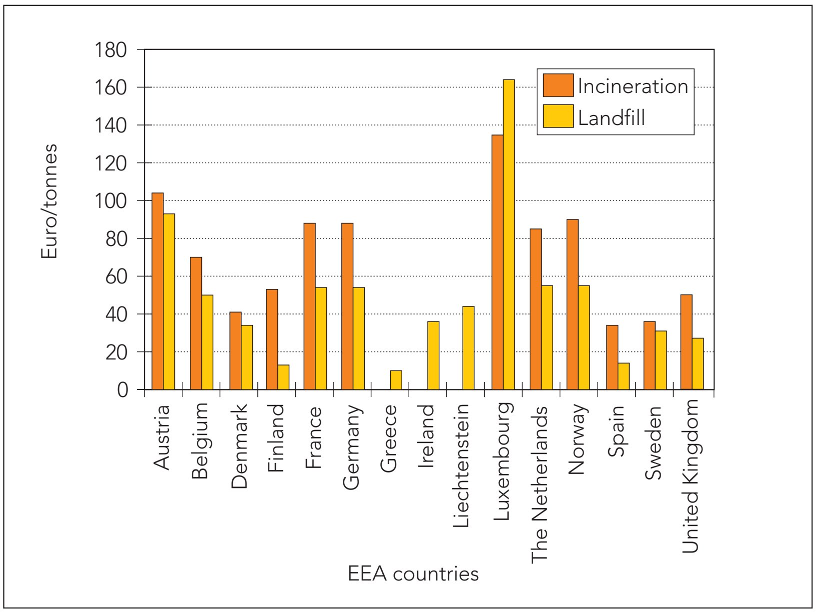
Available landfill capacity, selected countries Figure 3.7.23



The figure shows a very high degree of variation in the available landfill capacity expressed in years.
While the countries covered by the data as a total have sufficient capacity for 10 years, some only have capacity for a few years.

Source: NRCs, 1998b

Figure 3.7.24 **Avarage treatment prices for landfilling and incineration of non-hazardous waste**



Average treatment prices for landfilling and incineration of non-hazardous waste in selected EEA member countries (excl. waste tax and VAT). It should be noted that all prices are averages of observed prices and cover large variations between plants.

Source: NRCs, 1998b

Large differences in treatment prices between countries in an open market counteract the aim of treatment of the waste close to the source (the proximity principle). Large profits or savings can be obtained by finding a low-cost disposal solution. This may also directly influence the competitiveness of recycling industries where the cost of disposing of the residual waste can be considerable.

Waste taxes can be used to correct the price relation
As a consequence of the negative impact of the price relation a number of countries (Austria, Belgium, France, Denmark, the Netherlands and the UK) have introduced special landfill or general waste taxes which are levied in addition to the actual treatment price. Some German Länder also have imposed waste taxes but according to the Federal Court, they are in conflict with national legislation and have to be abolished.

Table 3.7.10. **Treatment prices in Denmark, 1997 (EUR)**

The table shows treatment prices in EUR in Denmark in 1997 with and without waste tax. The tax is acrually differentiated for incineration with only heat recovery and incineration with the more efficient combined heat/power production.

Source: DEPA, 1997b

	Landfilling	Incineration
Disposal fee before tax	20-34	14-40
Waste tax	45	28/35
Total	65-79	42-75

The rate of taxation varies among countries depending on the kind of waste (the UK, France, Austria), the kind of treatment and energy recovery (Denmark) and the technical standard of the landfill (Austria). The current rates per tonne are in Denmark between EUR 28 and 45, in AT between EUR 14 and 71 and in the UK between EUR 2.5 and 8.5. Despite differences in structure the general purpose of the taxes is to reduce landfilling and support a state-of-the-art treatment recovery and recycling of waste.

The Danish waste tax has been in operation long enough to assess the actual effect. Table 3.7.10 illustrates the effect of the waste tax on the relation between landfilling and incineration. A study of treatment patterns from 1987 to 1996 concludes that a 32% reduction of the waste landfilled or incinerated can to a large extent be explained by the effect of the waste tax. In the same period substantial increases in the recycling of building material, glass and paper have been obtained. The effect of the tax has been strongest in sectors with a high tonnage (i.e. building and construction) (Skou Andersen, 1998).

6.5. Integration into other policy areas
To support waste minimisation there is a need to integrate it into a number of related policy areas.

In relation to waste from industrial production the first steps have been taken with the Directive on Integrated Pollution Prevention and Control (IPPC) where waste is seen as an emission from production to be dealt with in the licensing process. In order to make this operational it is important to integrate the waste aspect into guidelines for best available technology.

The need for a closer focus on waste in a life-cycle perspective of products may be supported by special attention to waste generation when criteria for eco-labels are developed. Along the same line further focus on waste minimisation could be integrated in strategies for public procurement giving preference to products with minimised life-cycle generation of waste.

In some cases technical standards created by international standardisation organisations may present barriers to an increased direct re-use of components recycled material. Such barriers should only by accepted by the EU if crucial technical properties require it.

Finally it is evident that much waste generation can be seen as a product of an unfavourable relation between the prices of raw materials, production and maintenance costs (capital investment and labour) and the cost of disposal. A gradual substitution of taxes on labour with taxation on energy and raw materials is probably the most efficient way of obtaining sound resource management in a free-market economy. However this can only be done to a limited extent by individual Member States because their national industries will have higher costs than their international competitors, unless it is compensated by a reduction in labour costs.

References:

Allsopp M.W., 1992. Vianello G Poly (Vinyl Chlorid). *Ullmann's Encyclopedia of Industrial Chemistry*. Vo. A21. 1992 VCH Publishers, Inc.

APME, 1995. *Plastics recovery in perspective. Plastics consumption and recovery in Western Europe 1995.*

APME, 1996. *Plastics. A material choice for the 21st century. Plastics consumption and recovery in Western Europe 1996.*

CEPI, 1997. *Information from CEPI (Confederation of European Paper Industry) to the European Topic Centre on Waste, 1997.*

Danish Steel Works Ltd. *Green Accounts 1997,* Frederiksværk, 1998.

DEPA, 1996. Danish Environmental Protection Agency. *Environmental Aspects of PVC*. Environmental Project No. 313, 1996.

DEPA, 1997a. Danish Environmental Protection Agency. Ecotoxicological Assessment of Sewage Sludge in Agricultural Soil, *Arbejdsrapport no 69*, 1997.

DEPA, 1997b. Danish Environmental Protection Agency. *The Danish Waste Charge*. Information note from DEPA, July 1997.

DEPA, 1998. Danish Environmental Protection Agency. Waste Statistics 1996, *Environmental Review no 4*, 1998.

DETR, 1998. Department of the Environment, Transport and the Regions. *Less waste more value.* Consultation paper on the waste strategy for England and Wales, UK, 1998.

EEA, 1998a. *Europe's Environment: The Second Assessment,* European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EEA, 1998b. *Statistical compendium for the Second Assessment.* European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

Erhvervsbladet, 2 June 1997, Denmark.

Ernst & Young, 1998. 'Integrated Product Policy', A study for DGXI, 1998.

ETC/W. Data collected for the SoER98 Data Warehouse. European Topic Centre for Waste.

ETC/W, 1998. European Topic Centre on Waste. Methodology Report. *Baseline projections of selected waste streams,* June 1998.

European Commission, 1997a. 'Draft proposal for a Council Directive on end of life Vehicles', DGXI, 01.07.1997.

European Commission, 1997b. Strategy paper for reducing methane emissions, 1997.

European Commission, 1998a. 'Second communication from the European Community under the UN Framework Convention on Climate Change', DGXI Draft, May 1998.

European Commission, 1998b. Copy to the Commission, DGXI of the Member States reporting for 1995 to the Secretary of the Basle Convention.

European Commission, 1998c. Rapport de la Commission. *Mis en oeuvre de la directive 91/271/CEE du Conseil du 21 mai 1991 relative au traitement des eaux urbaines résiduaires,* modifiée par la directive 98/15/CE de la Commission du 27 février 1998.

European Union, 1998. Council of Ministers: *Proposal for a council directive on the landfilling of waste – common position*, March 1998.

Eurostat, 1999. New Cronos-database, January 1999.

FEVE, 1997. FEVE (Fédération Européene de Verre d'Emballage) *Glass Gazette*, Issue 21(1995) Issue 22 (1996) and Issue 23 (1997) and information to the European Topic Centre on Waste, 1997.

Gendebien, A., Carlton-Smith, C., Izzo, M., Hall, J.E., 1999. UK Sewage sludge survey - National presentation. Environment Agency (England and Wales), R & D Technical report P 165, pp 71.

Hall & Dalimier, 1994. Waste management – Sewage sludge, 1994, DGXI Study Contract B4-3040/014156/92.

Hjelmar, O. *et al.*, 1994. Management and composition of leachate from landfills, 1994 (DGXI contract no. B4-3040/013665/92).

Hoffmann, M., 1997. Recovery of zinc and lead from electric arc furnace steel dust, in Vol. 5 of R'97 Recovery Recycling Re-integration. Collected papers of the R'97 International Congress, Geneva, Switzerland, 4-7 February 1997.

Ingeniøren, 1998. Journal of the Danish Association of Engineers, *Ingeniøren Vol. 16*, 17 April 1998.

International Ash Working Group, 1997. *Municipal solid waste incinerator residues,* 1997.

IPPC, 1996. Climate Change 1995: 'The Science of Climate Change', Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change, 1996.

IPPE, 1996. Institut pour une Politique Européenne de l'Environment. *Final report to the European Commission on End-of-Life Vehicles*, 1996.

ISWA, 1997. *Energy from waste State-of-the-Art-Report*, 1997.

ISWA, 1998. Management approaches and experiences of sludge treatment and disposal, *EEA Environmental Issues Series no 7,* 1998.

Johnke, B., 1998. Situation and aspects of waste incineration in Germany, *UTA International,* Vol.2, 1998.

Junta de Residus (EPA-Catalonia): Information to the European Topic Centre on Waste.

Kilde and Larsen, 1998. 'Scrapping of passenger cars. Calculations based on the CASPER model.' Unpublished report for ETC/W, 1998.

Lamé, F. and Leenaers, H., 1998. Target values and background levels in the Netherlands: How to define good soil quality. In *Contaminated Soil '98*. Proceedings of the sixth FZK/TNO Conference on contaminated soil, 17-21 May 1998, Edinburgh, UK.

Landesumweltamt Nordrhein-Westfalen, 1997. *Identification of Relevant Industrial Sources of Dioxins and Furans in Europe*, Essen.

Meadows, D. *et al.*, 1991. *Beyond the limits*, Earthscan Publisher, London.

Miljøstyrelsen (Danish EPA): *Moderne, miljørigtig behandling af shredderaffald*, Arbejdsrapport nr. 90, 1997.

Naturvårdsverket, 1996. Kontorspapper – *Materialflöden i samhället,* Naturvårdsverket (EPA-Sweden) Rapport 4678, Sweden.

Norsas. Information from Norsas, Norway, to the European Topic Centre on Waste.

NRCs, 1998a. Responses from National Reference Centres to questionnaires from European Topic Centre on Waste, 1998.

NRCs, 1998b. Comments to the European Environment Agency from National Reference Centres on Waste to draft figures for the waste chapter , July-October 1998.

OECD, 1997a. *Environmental data compendium.* Paris.

OECD, 1997b. *National Accounts, Vol. II*, 1997.

Ripert, C., 1997. *La logistique et le transport des déchets ménagers, agricoles et industriels. ADEME, Agence de l'environnement et de la Maîtrise de l'Energie; Ministère de l'Equipement des Transports et du Logement.*

RIVM homepage: www.milieubalans.rivm.nl\doelgroepen\afvalverwijderingsbedrijven\energie uit afvalverbrandingsinstallat, 1999.

Skou Andersen, M., 1998. *Assessing the effectiveness of Denmark's waste tax,* Environment, Vol. 4, no 4, May 1998.

SOFRES, 1996. Counsel for the Commission DGXI: *Elements for a cost-effective plastic waste management in the European Union,* March 1996.

Soil & Water Ltd., 1997*. Impacts of implementing legislation which approximates EU environmental legislation.* Inception report for PHARE/DISAE, 1997.

Steurer, A., 1996. *Material Flow Accounting and Analysis,* Statistics Sweden, May 1996, Stockholm, Sweden.

Thygesen *et al.*, 1992. *Risikoscreening ved nyttiggørelse og deponering af slagger,* Miljøprojekt no 203, Danish EPA.

Umweltbundesamt/TNO, 1997. *The Atmospheric Emission Inventory of Heavy Metals and Persistent Organic Pollutants for 1990,* Berlin.

UNECE, 1998. 'Electric Furnace Steel Plant'. Draft chapter of Emission Inventory Guidebook, www.aeat.co.uk/netcen/airqual/TFFI/unece.html, August 1998.

3.8. Natural and technological hazards

Main findings

Since the late 1980s, natural hazards have had a bigger impact on the environment. Furthermore, between 1990 and 1996, economic losses due to floods and landslides were four times those in the whole of the preceding decade.

In spite of measures on major industrial accidents in force since 1984, the trend in accidents shows that many of the often seemingly trivial 'lessons learned' from accidents have not yet been sufficiently evaluated and/or implemented in industry's practices and standards. On the other hand, the risk of major accidents per unit of activity seems to show a slight downward trend.

In contrast to industrial accidents in fixed installations, major oil spills due to marine transport accidents as well as offshore installation accidents have shown a clear downward trend.

Lack of sufficiently detailed, comparable information on the risks posed by certain types of nuclear facilities, including the treatment of waste, means that the overall risk to the European environment from accidental releases of radionuclides, even if small, cannot be quantified. However, a gradual improvement in the overall risk of accidents is expected. A complicating factor is the increasing deterioration of the older plants in Eastern Europe.

Sound information on current natural and technological hazards is essential. Important questions include: Which hazards are connected with chronic changes to the environment, such as global warming and sea-level rise? Are human activities increasing the risk from various hazards?

1. Accidents still happen

Accidents, whether natural or technological, continue to occur throughout the EU and in the Accession Countries and lead to environmental damage and the premature deaths of people. In 1997, there were a total of 37 major industrial hazard accidents reported in the EU, the highest annual number since records began. The number of major floods in the EU also increased during the 1990s. Although major hazards are less frequent than, say, traffic accidents, they are of great concern as sources of impacts on the environment and human health. This concern arises mainly from their unpredictability in terms of where and when they will happen and the scale of the impacts.

1.1. We are all living with risk

There is no such thing as 'zero risk' to individuals, society or the environment. No matter how people occupy their time, whether at home or in a hazardous industry, they are exposed to a number of hazards and risks. In a wide variety of industries, many of which have benefited from many years of design evolution and operational experience, there remains a residual risk which must be consciously managed and controlled. Moreover, in many areas, people are living with a relatively high level of risk from natural hazards, such as earthquakes and flooding.

Clear factual information is required for the public and policy-makers to assist in recognising the problems associated with this risk and to help in the improvement of accident prevention and disaster response. This includes information about 'reasonable doubt' concerning hazards or risks, or lack of information in areas of concern. The public perception of various hazards and risks, and the influence of various pressure groups, can be a major factor, but the perceived risk is often far removed from reality. For example, the number of fatalities from natural hazards far outweighs those from major industrial hazards (95% of the total in the period 1985-96) which may be contrary to public perception.

1.2. Policies have been implemented…

The 5th Environmental Action Plan has targeted certain sectors to set out an integrated policy-cum-strategy for both environmental themes and causes of environmental degradation. These sectors include industry (petrochemicals, chemical, manufacturing, water, etc.), energy (oil and gas, nuclear, etc.), transport (dangerous goods by road, rail, ship) and military.

The most significant EU Directive to help protect people and the environment from major accident hazards is the Seveso II Directive (Box 3.8.1). This Directive applies to those industries that use significant amounts of materials that are hazardous to people and the environment. Operators must demonstrate that they have a policy for the prevention of major accidents (safety management systems), that they have assessed the risks and are managing these, and that they have adequate response plans in case of emergencies.

Previous policies and associated regulations on major hazards have focused on the acute effects, mainly on human health. However, there is a particular lack of information on the long-term effects of accidents on the environment. This is often due to the paucity of baseline information available. It is virtually impossible to assess the long-term ecological damage from a spill of toxic chemicals into a river if the original state of the ecosystem had not been previously examined. Hence the need for Directives such as the proposal to establish a framework for Community action in the field of water policy (European Community, 1997b).

Box 3.8.1 General aims of Seveso II Directive

to limit major accidents which involve hazardous substances

to limit the consequences of major accidents to humans and the environment

to ensure high levels of protection throughout the European Community in a consistent and effective manner

Source: European Community, 1997a

1.3. … but some hazard types call for special attention

1.3.1. Radiation accidents

The risk from an accidental release of radioactivity from a nuclear installation is a special type of hazard arising from technology to which much attention has been given by policy makers and the public. A large radioactive release has the potential to cause irreversible and far-reaching effects, as was seen by the accident at the Chernobyl nuclear power station in the Ukraine in 1986 which had huge health, social and environmental consequences. Accidental releases of gaseous or liquid toxic materials into the environment are not subject to direct limitation of the amounts involved and the probability of such releases in either the nuclear or non-nuclear fields. However, the competent national authorities do carry out safety analyses of nuclear installations prior to licensing and have in many cases developed national criteria for the consequences of an accident occurring as a function of the potential population exposure.

Thus, different countries have their own national approaches for acceptable levels of dose and risk. There is no unifying legislation but due to the work of ICRP, UNSCEAR and others, there is a widely accepted philosophy of radiation protection and unifying recommendations by international scientific organisations, which find their way into national legislation. There is also a move towards integrating radiation safety issues into the broader context of environmental safety. The perception of risk, however, is not uniform and different countries express their standards of safety in different ways. The European Commission has formulated Basic Safety Standards (BSS) for radiological protection, which form part of EU legislation (European Commission, 1996a). The fundamental limit on whole body exposure for members of the public in the EU BSS is 1 mSv per year. Probability criteria for risk of death from an accidental release from a nuclear installation have been set by a number of countries in Europe, at levels ranging from 10^{-5} per year (United Kingdom) to 10^{-6} per year (the Netherlands). A number of European countries have also set limits on the probability of occurrence of large releases of radionuclides.

1.3.2. Natural hazards also to be addressed

Certain environmental hazards have not been addressed by previous environmental policies. For example, the recent environmental disaster in the Guadiamar valley in Spain, where toxic mud burst from a mine reservoir and cascaded down the valley, impacting the Doñana National Park, Spain's most important nature reservoir (the Chemical Engineer, 1998), is not addressed by the Seveso II Directive, although the environmental effects were catastrophic. There is a need to identify such major hazards that are not immediately obvious to policy makers or engineers.

There is no targeted policy to reduce natural hazards, although programmes such as EPOCH (the European Programme On Climatology and natural Hazards) have specifically addressed this source of risk. The relative importance of natural hazards must be addressed to determine the significance of these in environmental concerns, particularly as such hazards have the potential to cause several hundred or even several thousand fatalities in one incident. Human impacts can to some extent be prevented by integrated land-use planning, although the spreading of settlements has seen a progression into higher risk areas, for example from flooding, where the risk appears to be increasing, possibly with the onset of climate change. Emergency response plans have been produced throughout the EU to react to various natural disasters, but these appear to be ad hoc, generally not tested, and are considered unlikely to work well in practice.

2. Are we having more major accidents?

The available evidence shows that whilst there has been a reduction in accidents in some areas, others have actually seen an increase during the past decade.

2.1. Industrial accidents

2.1.1. Trend slightly increasing

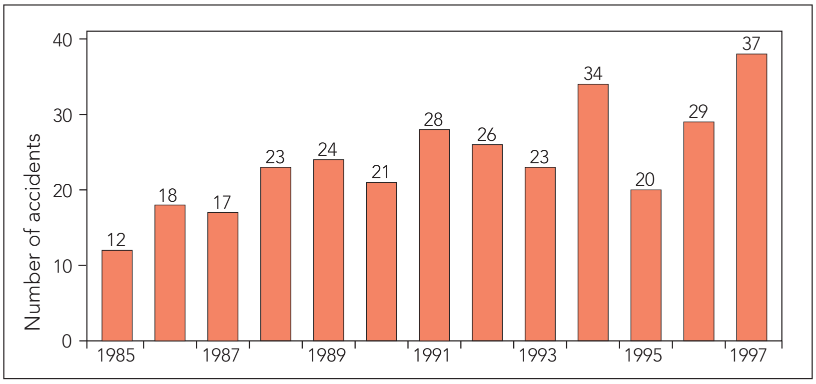
In the EU, the number of major industrial accidents reported every year has shown a slight upward trend since 1984, the year when the Seveso Directive (European Commission, 1992) was introduced (Figure 3.8.1). For the period 1984 to 1999, over 300 accidents have been reported by the EU Member States to the European Commission's Major Accident Reporting System (MARS). Since the rate of reporting major accidents to MARS is in good correspondence to the actual rate of occurrence of major accidents, this gives an indication that many of the often seemingly trivial 'lessons learned' from accidents have not yet been sufficiently evaluated and/or implemented in industry's practices and standards. Therefore, many efforts are still necessary to further reduce the risks related to major accidents from fixed industrial installations. On the other hand, since the industrial activities which give rise to most of the major accident risks are increasing in intensity in Europe, the risks of major accidents per unit of activity seem to have a slightly falling tendency.

However, lessons learnt are soon forgotten. One of the foremost authorities on safety, Trevor Kletz, writes that organisations have little memory when it comes to safety (Kletz, 1993). Industrial accidents for the most part are not new occurrences – their root causes can often be the same as previous accidents which did not involve significant damage or injury to workers or bystanders. In many cases, companies investigate only the immediate causes, such as operator error or the misuse of substances, and thus the root cause, such as inadequate engineering or management failures, remain unaddressed.

Information for industrial sites from the MARS database indicates that major accidents involving hazardous substances usually result from a number of simultaneous causes, such as operator error, component failure, and uncontrolled chemical reactions. Recent detailed analyses of major accidents (Drogaris, 1993; Rasmussen 1996) indicate that component failure and operator error were the two most common immediate causes of major accidents, but the dominant underlying causes identified (for 67% of the accidents) were due to poor safety and environmental management, resulting in a lack of control. Lack of expenditure on safety and environmental aspects is often a result of pressure from shareholders to increase profitability, although this may result in major losses in the long run.

The age of process plant is a major factor in the likelihood of accidents, as the probability

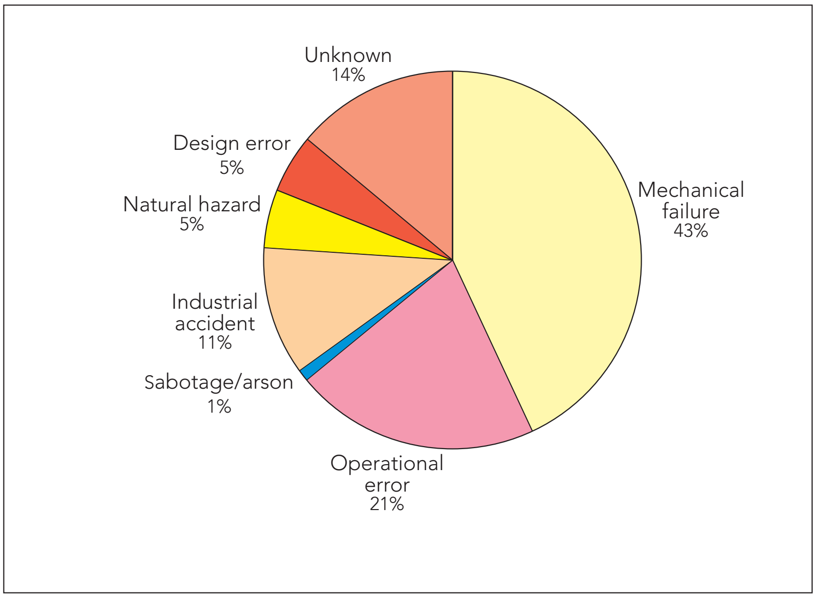
Number of major accidents in the EU reported to the MARS database, 1985-1997 — Figure 3.8.1



Source: MARS database

of 'wear-out' failures increases with age. The most frequent cause of accidental releases in the hydrocarbon-chemical industries cited by M&M Protection Consultants (1997) is 'mechanical failure', as shown in Figure 3.8.2, and a significant proportion of these are due to 'wear-out', which highlights failures in preventative maintenance programs. Many plants are operated past their design life in an attempt to gain the maximum return on investment and, as such, accidents are more likely.

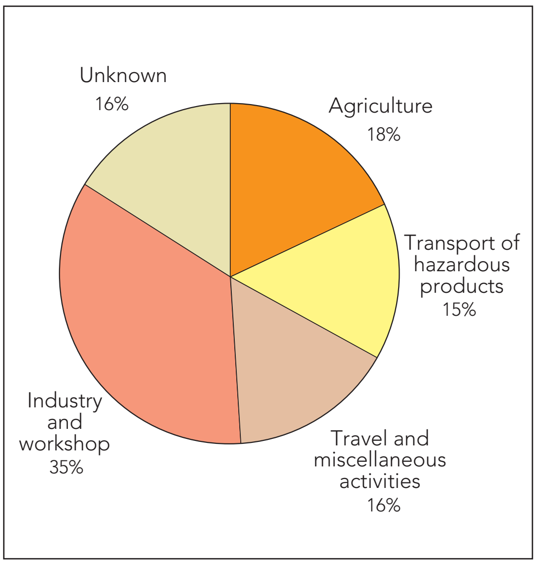
Figure 3.8.2 **Causes of accidental releases in the hydrocarbon-chemical industries**



Source: M&M Protection Consultants, 1997

Figure 3.8.3 **Number of technological accidents in France in 1997**

Source: BARPI database



2.1.2. Accidents occur in a variety of industries

Many people associate the chemicals industry with major technological hazards and indeed the majority of sites that are subject to the Seveso Directive would be described as chemicals facilities. However, there are many other sectors where serious accidents occur, resulting in fatalities and major injuries, although there may not be the same potential for off-site effects. In France in 1997, there were four sectors with a worse accident record than the chemical industry, as shown in Figure 3.8.3.

Arguably, hydrocarbon accidents and oil spills at sea gain the most media attention. The Piper Alpha explosion in the North Sea in 1988 caused 167 fatalities (Cullen, 1990). The most recent oil spill in the EU was that of the Sea Empress near Milford Haven, UK, where 72 000 tonnes of crude oil impacted 200 km of coastline (MIAB, 1997). The environmental impact of oil spills can vary considerably. This depends less on the quantity of oil spilt than the type of oil, prevailing weather conditions and whether or not the oil is spilt in coastal waters which are ecologically sensitive. Furthermore, without overlooking the unacceptable short- or medium-term impacts of oil spills, it is worth noting that in the long term devastated areas can recover. Thus for example, the impacts caused by one of the largest spills ever, from the Amoco Cadiz 300 km off the Brittany coastline in 1978, were only felt in the immediate years following (Bonnieux *et al.*, 1993) and the area is now thriving again. Currently, there is little evidence of irreversible damage to marine sources, either from major oil spills or from chronic sources of oil pollution. However, there has been little long-term monitoring of the biological effects of oil on the various forms of marine life. More extensive monitoring and research will be required before the potential chronic effects of oil spills are known (ITOPF, 1998).

2.1.3. Community life often disrupted as a consequence

The consequences of major industrial accidents in the EU are listed in Table 3.8.1. About 16% of these accidents resulted in loss of life and about one-third included fatalities in neighboring communities. About two-thirds of the accidents resulting in ecological harm involved water pollution (reservoirs, rivers) and in about half of these the pollution was caused by firewater runoff. However, it is difficult to gauge the long-term effects of such accidents and there is insufficient data.

2.2. Natural hazards are the most devastating

2.2.1. What are they?
Natural hazards, such as earthquakes and landslides, are often more devastating, in terms of loss of life and environmental damage, and also have the potential to precipitate technological hazards. As with technological accidents, the consequences depend both on the magnitude of the event and on factors such as population density, disaster-prevention measures and emergency planning.

Figure 3.8.4 illustrates, for the whole of Europe, the number of incidents associated with natural hazards and the associated number of fatalities between 1980 and 1996. Several types of natural hazard are described and it is apparent that they have the potential to cause large numbers of fatalities. The available evidence suggests that the hazards that cause the largest numbers of fatalities in one event are earthquakes (Box 3.8.2). In the 1990s there have already been 13 earthquakes world-wide where the fatalities have exceeded 1 000 people. Next to earthquakes, landslides and flooding have the potential to cause the largest numbers of fatalities in one event.

2.2.2. Human influence causes the increase
The trend for the annual number of natural-hazard accidents is more obviously upward than that for major industrial accidents. This is particularly clear for those precipitated by human activities, such as land clearing (see Chapter 2.3); other types of natural hazard, such as earthquakes and volcanoes, do not show any increasing or decreasing trends.

Consequences of industrial accidents in the UN notified to MARS since 1984 — Table 3.8.1.

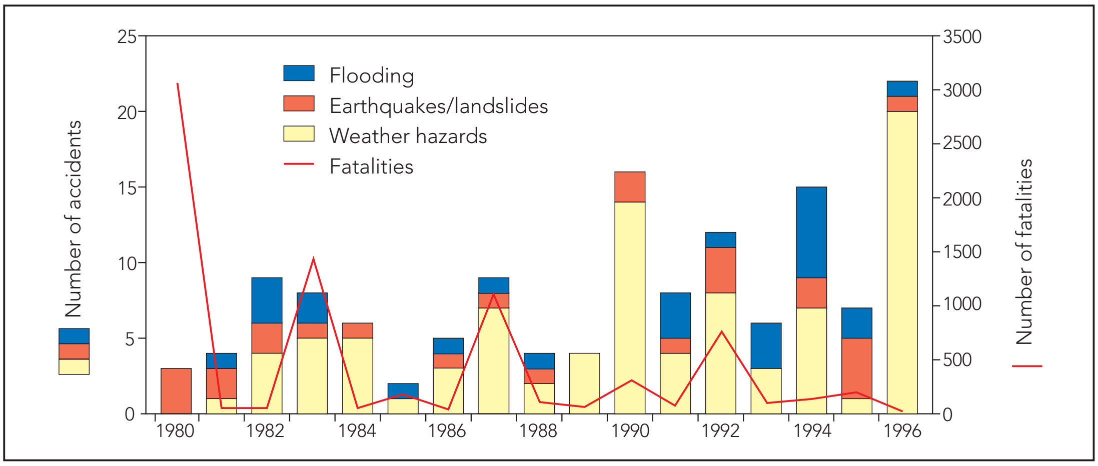
Consequences		Number of Accidents[1]
None or negligible		43
Fatalities	- on site[2]	47
	- of site	16
Injuries[3]	- on site	94
	- of site	26
Ecological harm		21
National heritage loss		0
Material loss[4]	- on site	57
	- of site	9
Disruption of comunity life		121

[1] Each accident can have multible consequences, hence the total exceeds the total number of accident reported in the period.
[2] Fatalities and injuries on-site are those to internal staff, contractors and emergency teams at or near the site of the accident.
[3] Injuries include minor injuries as well as those requiring 24 hours or more of hospitalisation.
[4] Material losses refer to cases where credible cost estimates have been given.

Source: MARS database.

Since the late 1980s, there has also been an apparent increase in the impacts of natural hazards (Swiss Re, 1993). As an example, at one city on the German-French border (Kehl), between 1900 and 1977 the Rhine's floodwaters rose over seven metres above flood level only four times, or about once every 20 years. Since 1977, that level has been reached 10 times, an average of once every other year (UWIN, 1996). This leads to a multitude of economic losses. Data from

Accidents involving natural hazards and the associated number of fatalities in Europe 1980-1996 — Figure 3.8.4



Note: exact figures for numbers of fatalities only for 1980, 1982, 1983, 1987, 1991. Where no exact number is available, a smallest estimate has been used.

Source: OECD Environmental Data, 1997

Box 3.8.2 Seismic activity in the EU

Earthquakes are widespread in the EU (Wild, 1998). The most destructive events have occurred in the Mediterranean countries, particularly Greece and Italy, which are in the collision zone between the Eurasian and African crustal plates, as shown in Figure 3.8.5. Smaller earthquakes are felt by other nations, although there is generally little damage.

The European Mediterranean Seismological Centre (EMSC) co-ordinates rapid acquisition and dissemination of information on earthquakes greater than 5.5 on the Richter scale. A major earthquake is defined as having a magnitude of 7 or greater on the Richter scale (USGS 1998a).

Examples of earthquakes in the EU in the past 25 years resulting in severe impact are as follows

1976	Greece, Thessaloniki	45 dead, 220 injured, major damage
1976	Italy, Frioul (twice)	977 dead, 2 400 injured, 189 000 homeless
1979	Italy, Umbria	5 dead, numerous injured, 2 000 homeless
1980	Italy, Campania	2 739 dead, 8 816 injured, 334 000 homeless
1980	Portugal, Azores	50 dead, 86 injured, 21 296 homeless
1981	Greece, south regions	19 dead, 500 injured, 12 220 buildings damaged/destroyed
1983	Belgium	1 dead, 26 injured
1984	Italy, central regions	7 500 homeless
1986	Greece, Kalamata	20 dead, 300 injured, 2 000 buildings damaged/destroyed
1990	Italy, SW Sicily	12 dead, 99 injured, 14 596 homeless
1992	Netherlands, Limburg	Extensive damage

Source: European Commission, 1996b

Effects on people and the environment
The list of earthquakes gives evidence of the potential catastrophic effects that an earthquake can have on society. However, the effects will continue long afterwards. There may be secondary effects such as flooding, landslides and fires, or even the precipitation of major technological disasters. Numerous people will need to be rehoused, either due to the destruction of their homes or out of fear of a recurrence, although people generally remain in the area (European Commission, 1996b). The event (and its anticipation for those in high risk areas) may cause severe trauma and this will be amplified by factors such as decomposing bodies which have not been cleared away, polluted drinking water and lack of essential supplies, particularly if the earthquake has affected transport.

Civil protection
Each EU member state has a programme for Civil Protection. In Greece, where there is a higher risk of major earthquakes, the Earthquake Planning and Protection Organisation (EPPO) is responsible for planning national policy regarding seismic prevention, education-information and protection (European Commission, 1996b. EPPO has established an emergency scientific team of various experts to advise the government body that co-ordinates action plans in case of disasters.
The EMSC has co-ordinated a two-year project to extend data communications and acquisitions to allow the rapid release of information for any earthquake of a magnitude greater than 5.0 occurring in the European-Mediterranean region (Wild, 1998). This information is issued in a two-step procedure, with the location, depth, time and magnitude of the earthquake generally available within one hour, followed later by detailed information on the earthquake's source mechanism. Such forward planning and the rapid dissemination of information will help in the protection of the public in these high risk regions, although such is the nature of earthquakes that there will always be casualties from major incidents. Unfortunately, city planning policies and building codes invariably have been insufficiently mature to ensure that structures are constructed in a manner that mitigates earthquake damage and affords civil protection (Gunn, 1998).

Munich Re (1997) reveal that in Europe in the seven-year period 1990-96, economic losses due to floods and landslides were four times the loss in the complete 1980-89 decade.

Landslides, one of the major causes of fatalities, are likely to increase unless there is adequate management of the land to reduce the likelihood of soil erosion. There is also an increased likelihood of certain natural hazards, such as flooding and droughts, due to climate change, in many temperate and humid regions (see Chapter 3.1). Furthermore, susceptibility to these hazards may be enhanced by certain land-use activities, and the lack of environmental management in land-use planning (see Box 3.8.3 and Chapters 3.12-15).

In Europe, as world-wide, storms and floods are the most common natural disaster and, in terms of economic and insured losses, the most costly. The damage caused by floods

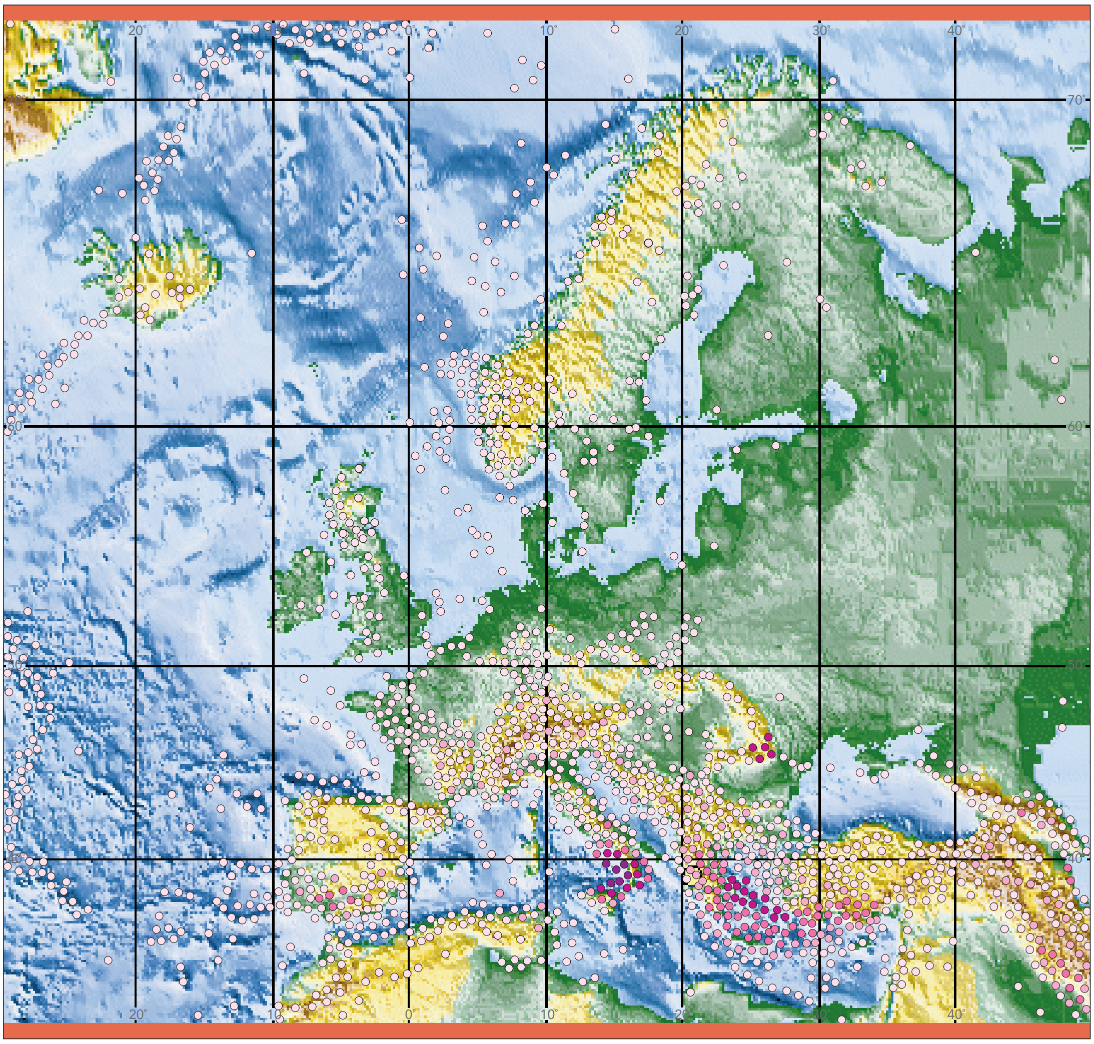
Box 3.8.3 The Campania landslide of 5 May 1998

What happened?
After two days of incessant rain, torrents of mud and water engulfed hundreds of homes in the southern Italian region of Campania, killing almost 300 people and leaving around 2 000 homeless. The area affected was a 50 km strip between the cities of Naples and Salerno. The landslide moved through the towns of Sarno and Quindici and surrounding villages, tearing apart houses and bridges, submerging cars and causing severe panic among residents, some of which sought escape on roofs. The mud then dried and solidified in intense sunshine, trapping persons caught in it. There was little preparation for the tragedy, although during the past 70 years 631 landslides have hit the region and about 3 800 people in Italy have been killed from mudslides since 1945. Subsequently, there was a lack of co-ordination between various response groups. Funds of about EUR30 million were later earmarked to aid initial relief and reconstruction.

Underlying causes
The landslide was caused by heavy rain over two days, although the 150 mm in total fell far short of any records. The consequences were intensified by human changes to the surroundings. The clearing of trees and burning scrub-land to create pastures or make room for construction led to massive erosion in the Campania region. In some areas, chestnut trees were replaced with hazelnut tress, which are much weaker and produce a smaller root system. Houses had been built without permission in areas where construction is forbidden because the land is geologically unstable. The Sarno river has diminished, the water being used by industry and the river bed had been built upon. Thus, there was no natural path for flood waters to escape.

The need for improved land management
The disaster revealed several shortcomings in land management and disaster prevention and response. For the past half-century geologists have warned against the construction of housing in the area, due to the high risk of mudslides. This risk was increased by removing vegetation from the mountains and interfering with natural water channels. Improved land management is essential to reduce the risk of further landslides. Training exercises for disaster response would facilitate improved co-ordination between the various response groups and the lessons learnt from this and other disasters need to be widely disseminated.

Sources: Hanley, 1998; CNN, 1998; Ieropoli, 1998



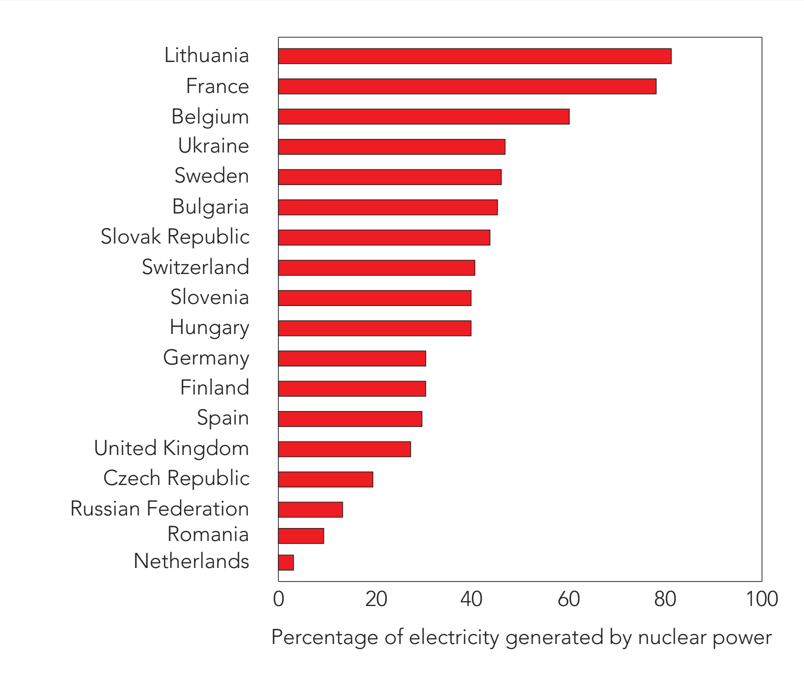
Seismicity of Europe

Depth in km
- 301 – 800
- 151 – 301
- 71 – 151
- 33 – 71
- 0 – 33

Figure 3.8.5

Source: USGS National Earthquake Information Center, 1998b

Figure 3.8.6 **The percentage of energy produced by nuclear generation in European countries that utilise nuclear power.**



Source: ??

depends on the duration and height of water levels, topography and use of the flood plain, flood defence measures, and the awareness of the population likely to be affected by flooding. However, human activities can influence both the likelihood and magnitude of the flooding, for example drainage of wetlands and straightening of rivers increase peak water flows. Also, in mountainous areas the clearing of land for agricultural purposes or developments, including those related to heavy tourism, may lead to soil erosion and landslides. Land clearing has been conducted by deliberately starting forest fires, although in many regions fires have occurred by natural processes. Forest fires, which occur every year in the EU, can not only cause fatalities, but can create vast clouds of smog over the surrounding area, as well as the environmental disaster of the loss of extensive areas of forest.

2.3. Nuclear accident risk declined lately

2.3.1. Nuclear power production facilities are the focus

Generating electricity from nuclear power is a well-established technology, with more than 30 countries world-wide operating or building plants. Nuclear generation today accounts for about 17% of the electricity produced globally and about 34% in the EU. While a number of European countries use nuclear power extensively and are likely to continue to do so (Figure 3.8.6), it is unclear to what extent nuclear power will be used to meet the projected increases in demand for electricity. The prospects for the extended use of nuclear power globally have recently been reviewed by the International Atomic Energy Agency (IAEA, 1996c).

Nuclear reactors generating electricity are not the only plants in Europe (Table 3.8.2) which have the potential to cause accidental releases of radionuclides. Other types of plant include nuclear reprocessing plants, other nuclear fuel-cycle facilities, plants producing pharmaceutical products and medical sources, and nuclear weapons development plants. Plants of all these types exist in Europe; for example the numbers of fuel-cycle facilities in Europe are shown in Table 3.8.3. In addition to accidents occurring at nuclear installations, accidental damage to radiation sources used in medical or industrial applications may also result in releases of radionuclides. There is also the potential for accidents in nuclear-powered submarines.

2.3.2. Radiation exposure risk assessment, a model to follow

Apart from the Chernobyl accident in 1986 other accidents have occurred in Europe over the past 40 years. Some of these have had environmental consequences, although these have been minor compared with the effects of Chernobyl. These other accidents include the 1957 Windscale fire in the UK and the nuclear weapons accident at Palomares in Spain in 1966. Environmental contamination from these accidents was localised, and the collective radiation doses were low. There is little or no remaining contamination in Western and Central Europe now from accidental sources other than from Chernobyl.

Atmospheric testing of nuclear weapons resulted in the largest release of radionuclides into the environment and by far the largest collective effective dose from man-made sources (Table 3.8.4). By contrast, nuclear power production, nuclear weapons fabrication and radioisotope production result in comparatively small doses to the population. Accidents may have significant local impact, but only Chernobyl gave rise to a substantial population dose.

Much information is available on the current levels of radioactivity in the environment in Europe. This is published nationally, and is also collated by the European Commission which periodically issues a compilation of levels of environmental radioactivity in the EU, on the basis of reports from Member States. The most recent of these covers the year 1993 (European Commission, 1998).

The assessment of risks from radiation exposure has led the field of environmental risk assessment for many years and has been the model followed for other sources of contamination. Therefore many aspects of the assessment from nuclear installations are significantly more developed than those in other fields. In particular, techniques for assessing the potential accidental risk posed by nuclear installations are well developed (London, 1995). However, the availability of the results of such studies varies.

Assessments of risks posed by the newer designs of nuclear power stations are comprehensive, and have in some cases been published (Kelly and Clarke, 1982). Less and in some cases no information is available for other types of plants. For example, there is no published comprehensive summary of the risk of accidents from Europe's reprocessing plants. Accident risk information for Europe's nuclear installations has not been collated internationally although much information exists at a national level. Moreover, the use of different approaches at national level (as already noted) would render any uniform collation extremely difficult to prepare. It is not known, therefore, to what extent existing national risk assessments might be judged internationally to be sufficiently comprehensive as regards the range of accidents scenarios and types of plant taken into account.

The older types of reactors found on a number of sites in Eastern Europe present a greater hazard than the more modern Western designs. This includes the RBMK reactors, found in Russia, Ukraine and Lithuania, including the Chernobyl plants, and the first generation pressurised water reactors (VVERs), located in Bulgaria and Slovakia. These are considered to have some of the most serious design deficiencies (IAEA, 1996d). It is also possible that accidents occurring at plants outside Europe could present an environmental threat to countries in Europe – Chernobyl demonstrated the great distances potentially affected – but again information on the risk posed by plants outside Europe has not been collated. The risk from potential accidents involving medical and industrial radiation sources has also not been collated.

Status of nuclear power reactors in Europe (1995) — Table 3.8.2.

Country	In operation	Under construction	Shut down	Suspended	Cancelled
EU Member States					
Austria					1
Belgium	7				
Denmark					
Finland	4				
France	56	4	10		
Germany	20		16		6
Greece					
Ireland					
Italy			4	3	
Luxembourg					
Netherlands	2				
Portugal					
Spain	9		1		4
Sweden	12		1		
United Kingdom	35		10		
EU total	**145**	**4**	**42**	**3**	**11**
Central & eastern European Accession countries					
Bulgaria	6				1
Czech Republic	4	2			2
Hungary	4				
Lithuania	2				1
Poland					2
Romania		2		3	
Slovak Republic	4	4	1		
Slovenia	1				
CEE Accession countries total	**21**	**8**	**1**	**3**	**6**
Other countries					
Switzerland	5				
Armenia	1				
Russian Federation	29	4	4	6	10
Ukraine	16	5	1		3
Total other countries	**51**	**9**	**5**	**6**	**13**
Total Europe	**217**	**21**	**48**	**12**	**30**

Source: IAEA, 1996a.

Table 3.8.3. **Number of fuel cycle facilities**

Country	Mining & ore processing	Fuel fabrication	Fuel reprocessing	Spent fuel storage	Other
Belgium		2			1
Bulgaria				1	
Czech Republic	2				
Denmark		1			
Finland				1	
France	2	4	5	2	12
Germany	1	1		4	2
Hungary	1				
Netherlands					1
Portugal	2				
Russian Federation		3		4	2
Slovak Republic				1	
Spain	1	1			
Sweden		1		1	
Ukraine	1			1	1
United Kingdom		7	4	7	6
Total	**10**	**20**	**9**	**22**	**25**

Source: IAEA, 1996b.

Table 3.8.4. **Doses from man-made sources**

Source	Collective effective dose (man Sievert)
Atmospheric nuclear testing	30 000 000
Chernobyl accident	600 000
Nuclear power production	400 000
Radioisotope production and use	80 000
Nuclear weapons fabrication	60 000
Kyshtym accident	2 500
Satellite re-entries	2 100
Windscala accident	2 000
Other accidents	300
Underground nuclear testing	200

Source: Bennett, 1995

2.3.3. How have radiation risks changed and how are they likely to change in the future?

Since 1970 the number of nuclear installations in Europe has increased and many European countries now have nuclear reactors at or towards the end of their working lives (Figure 3.8.7). It can be seen from the table that over the next 10 years there will be an increasing number of aged operating reactors in Europe. Some of the plants that will be decommissioned will be replaced with plants with better safety features.

New advanced designs incorporate improved safety concepts and features to reduce the chance of significant releases of activity to the environment. Following these developments, it is likely that the overall risk from nuclear accidents increased in the 1970s as more plants were commissioned, but has subsequently declined in the 1990s as older plants have been taken out of service and building of new plants has slowed, with increasingly safe designs being used. How this trend will continue over the next decade is, however, uncertain. A complicating factor is the increasing deterioration of the older plants in Eastern Europe.

Safety concerns focus on certain older designs of plant, in particular the RBMK reactors of which Chernobyl was an example: 15 RBMK reactors continue to function in Russia, Ukraine and Lithuania. Implementation of improved safety plans for these reactors is delayed for a number of reasons including the lack of financial resources in these countries, despite significant assistance from the European Commission, EBRD and on a bilateral basis from individual Western countries.

The major technical causes of the Chernobyl accident were the coincidence of several deficiencies in the RBMK reactor's physical design and in the design of the emergency shutdown system. These causes were compounded by violation of operating procedures made possible by the lack of an adequate 'safety culture'. Development of safety measures have been in progress at RBMK plants since 1986, but plans to upgrade the safety of all RBMK plants are behind schedule due to economic difficulties. Accelerated implementation of this is seen as a top priority for international co-operation (IAEA, 1996e).

Newer plants will incorporate improved safety features and will be less likely to suffer severe accidents, while older plants, built to standards lower than today's will gradually be decommissioned, particularly in Central and Eastern Europe. While the result of these developments will gradually improve the risk from nuclear accidents, it is not expected that there will be a marked impact on the overall risk of accidents over the next decade. The lack of sufficiently detailed, comparable information on the risks posed by certain types of nuclear facilities, which would then allow a consistent generalised analysis, means that the overall risk to the European environment from accidental releases of radionuclides, even if small, cannot be quantified. It seems likely that the greatest hazard is presented by sites where large quantities of radioactive materials are stored and used, such as nuclear power stations, reprocessing plants and military plants. Chemical plants which produce radio-pharmaceutical products and hospitals pose lesser risks.

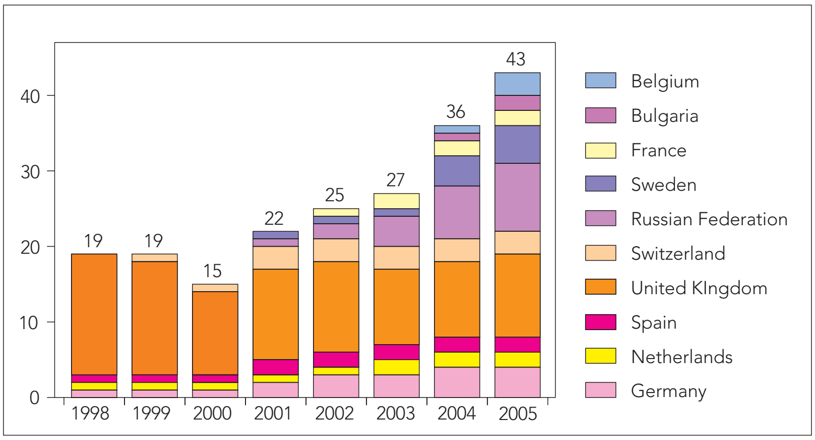
In addition to this there is the potential for accidents to occur during the disposal of radioactive sources. An increase in the numbers of accidental smeltings of industrial and medical radiation sources may occur as more sources reach the end of their useful lives. Lessons have been learnt from past accidents such as that in Goiânia, Brazil, where a caesium-137 source caused four deaths and about 20 serious exposures, and the similar incident in Estonia in 1994 when a stolen caesium-137 source irradiated 19 people. Many smelting plants that deal with scrap metal have radiation detectors to prevent this occurrence but this practice should be universal. A worldwide register of sources is being prepared by IAEA. While several incidents reported in Europe have led to radioactive contamination due to the accidental disposal of a source, they do not seem to have had significant dose implications for more than a handful of individuals.

2.4. Oil spills

World-wide, the annual number of oil spills and the total oil spilt from tankers and barges during transit and loading/discharging is showing a downward trend, as illustrated in Figure 3.8.8. The downward trend is also apparent in European waters, but is less obvious. On average, since 1970, 25% of the major spills world-wide (above 700 tonnes) have been in European waters. In the 1980s this figure was about 24%, but during the 1990s it increased to 32%.

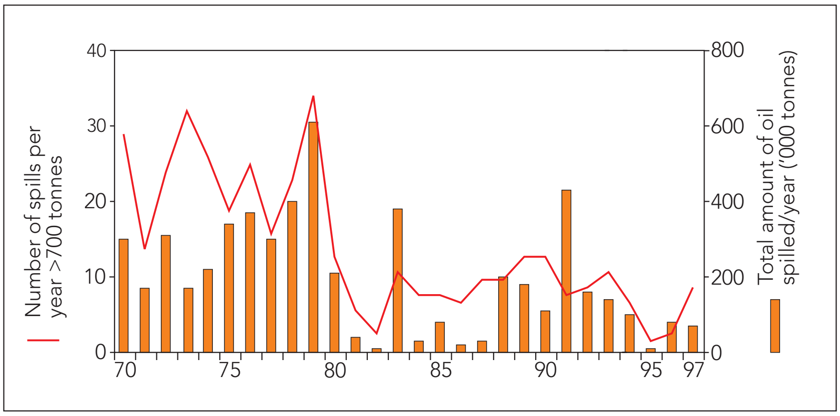
Tanker safety is a major issue on the International Maritime Organisation's marine

Operating Nuclear Power Plant Units in Europe with an Age of 30-40 Years in 1998 - 2005 — Figure 3.8.7



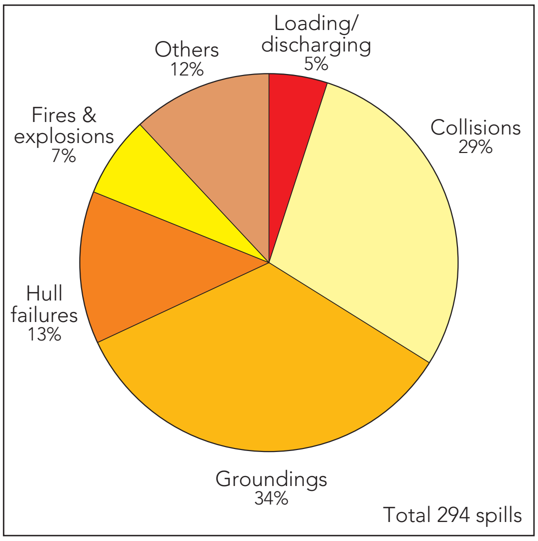
Source: IAEA Yearbook 1994 & M. Pohl, pers com

Number of oil spills world-wide and total oil spilt 1970-1997 — Figure 3.8.8



Source: ITOPF, 1998

Causes of oil spills 1970-1997 — Figure 3.8.9



Source: ITOPF, 1998

protection agenda. The bulk of the world's tankers are being fitted with double hulls or scrapped within the next few years, which is likely to reduce the likelihood of spills, although most of the world's tankers were built in the 1970s and so do not comply with many of the stricter standards introduced since. Figure 3.8.9 provides evidence of the causes of the 294 major oil spills that have occurred world-wide in 1970-1997, 76% of which were due to hull failures, collisions and groundings.

3. More management of hazards is necessary

There is no doubt that disasters will continue to occur throughout the EU. Some of these will be due to technology, some to the forces of nature, others to the combined effects of the two. Inevitably there will be loss of life and environmental damage.

However, hazards can be managed to reduce risks. Even catastrophic events can be predicted as to where they may happen, although the question of whether they will in fact happen within any given timespan (for example, the lifetime of an installation) is not predictable. Nevertheless, it is at least possible to pre-plan responses, so that loss of life and environmental impact can be minimised.

3.1. Hazard management procedures cover many industries

For many technological hazards, holistic approaches are becoming more prevalent, with increasing attention on the reduction of risk of long-term environmental impact as well as acute health and property damage from accidents. In the case of the Seveso II Directive, industrial operators must demonstrate that they have taken all the necessary measures to prevent major accidents and to limit their consequences on humans and the environment. This is likely to reduce levels of risk, especially from high-frequency, low-consequence accidents. Seveso II should also help identify the potential for low-frequency, high-consequence events, although these are by nature difficult to address.

The problem of low-frequency, high-consequence events is likely to remain a key issue in terms of risk management. However, the extent and location of the technological hazards are generally known and, as such, pre-arrangements can be made in emergency response plans. The correct response may limit the consequences of an accident by ensuring that escalation to a larger event does not occur. Lessons learnt from previous accidents should be essential research for operating companies. Testing of emergency plans at least every three years is a new requirement under the Seveso II Directive, as experience has shown that unless a plan is tested, the response during an actual accident can be inappropriate and disorganised, particularly the liaison between different groups.

There is an improved culture with regard to accident reporting and sharing the lessons learnt from accidents. Several accidents databases are already available. The improved reporting criteria (Box 3.8.4) for major accidents will result in more accidents being reported to the European Commission, and the causes, lessons learnt and preventative measures necessary to prevent a recurrence will be available to relevant bodies. This should lead to a better understanding of the issues and root causes of accidents, and, if the process is managed well, to a subsequent decrease in the number of accidents.

The European Commission's Accident database MARS is now complemented by SPIRS (Seveso Plants Information Retrieval System) (http://mahbsrv.jrc.it/spirs/Default.html). This was set up in response to Article 9 of the Seveso II Directive requiring access to information for all interested parties, including the European Commission, on the contents of the safety report for each 'Seveso Plant' in a Member State.

The main objective of SPIRS is to support the Member States in their risk management related decision-making processes by giving an insight into the geographical component

Box 3.8.4 Criteria for the notification of an accident in the Seveso II Directive

The criteria for notification of an accident relate to:

- substances involved
- injury to persons and damage to real estate
- immediate damage to the environment
- damage to property
- cross-border damage.

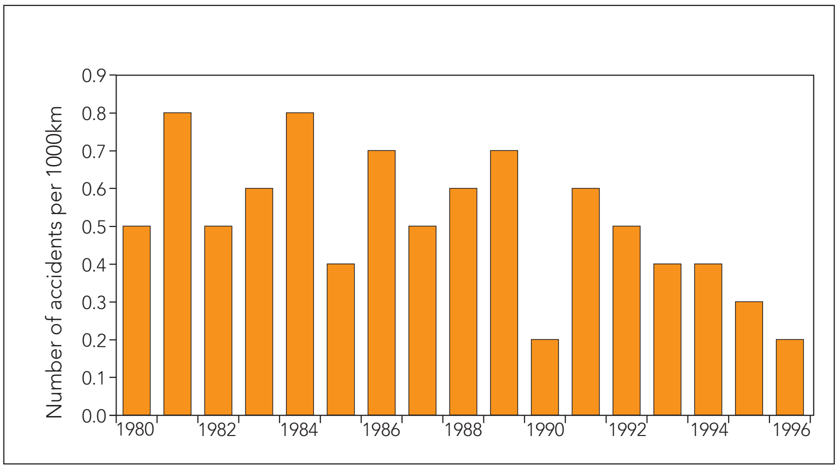
Source: European Community, 1997a

of risk from Seveso Plants. This is mainly done by providing a map of all Seveso Plants in the EU together with information on their hazard and risk potential. So far, SPIRS is still in a developing phase and four EU Member States have provided data on Seveso Plants in their countries on a voluntary basis for inclusion in the SPIRS prototype covering about 400 major hazardous chemical plants.

For the nuclear industry the International Nuclear Event Scale (INES) and the Incident Reporting System (IRS), both under the aegis of the International Atomic Energy Agency, are now used widely to collect information from around the world on unusual nuclear events in nuclear power plants that may be important for safety or accident prevention.

Research into the different approaches adopted in the EU for regulating technological hazards would be useful to determine if any patterns have developed, i.e. are there advantages in using a risk-orientated, goal-setting approach where the risk must be below 'acceptable' levels, or rather a consequence-orientated approach where prescriptive codes and standards must be met. The available data should be scrutinised in the future.

Number of cross-country pipeline accidents in Western Europe per 1000 km-yr, 1980-1996 — Figure 3.8.10



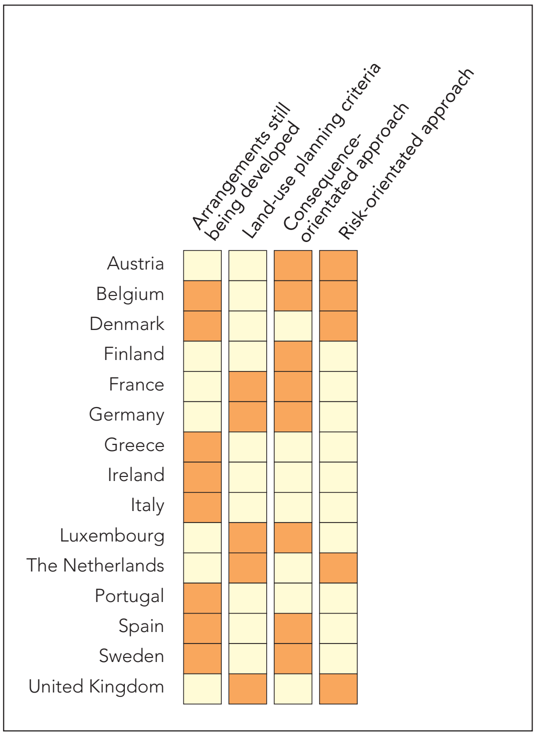
Source: CONCAWE, 1983-1997

3.2. Where hazard management procedures are still needed

One area where it is difficult to predict the location of an accident is transportation. In particular, the consequences of a pipeline rupture could be severe, as a large amount of material could be released before insulation. For example, in Russia in 1989, the rupture of a gas transmission line and subsequent ignition of the flammable cloud resulted in the deaths of over 600 people on two passenger trains (Crooks, 1992). With an ever-increasing pipeline network throughout Eastern Europe, there is an increasing likelihood of such events if the risk is not managed adequately. The scope of the Seveso II Directive does not include pipelines and, thus, pipelines need to be adequately addressed in the future for an enlarged EU, although there is a downward trend in the number of accidents in Western Europe, as illustrated in Figure 3.8.10.

For the EU Accession Countries, the use of the Seveso II Directive would be appropriate and, encouragingly, some are already using this. The comprehensive nature of the Directive in its mandatory requirements for management of safety and the environment and its power to prohibit unacceptable activities would provide an effective model before accession. There is currently no equivalent database to MARS that covers Central and Eastern Europe, but this may change as a result of the EC's co-operation projects (PHARE and TACIS) and the work of UN-ECE's regional co-ordinating centres for the prevention of industrial accidents (Budapest) and for industrial accident training and exercises (Warsaw). If a data-

Regulatory approaches in the EU — Figure 3.8.11



Source: updated from Smeder et al., (1996) base could be set up before accession, it would be extremely useful to see how the adoption of the Seveso II Directive affects the frequency of accidents in the Accession Countries, although the results could be confused by progressive improvements in reporting practices.

3.3. Management of natural hazards

For natural hazards, difficulties in forecasting and prediction, coupled with limited technical or behavioural responses, seem likely to lead to fewer improvements in both levels of exposure and associated damage from significant events.

As with technological hazards, the problem of low-frequency, high-consequence events is likely to remain a key risk-management issue. However, a major difference is that it is extremely difficult to predict where, as well as when, they will occur, although it is appreciated that some areas may be more susceptible to natural hazards than others, e.g. from earthquakes, flooding and landslides.

Adequate land management is essential and the management systems applied to technological hazards can be used as a model. Moreover, risk assessment and land-use planning can play a vital role in identifying, mitigating and avoiding such impacts. The use of societal risk limits could avoid the potential for large population growth in areas that are susceptible to natural hazards. Figure 3.8.11 shows the regulatory approaches in the EU and it can be seen that some Member States are already applying land-use planning criteria.

Land-use planning clearly has to take into account the environmental conditions of a particular area. While scrub clearing to create agricultural land may increase the likelihood of flooding, soil erosion and landslides in areas susceptible to heavy rainfall, it may be advantageous in forest areas that are susceptible to fires. One of the major underlying causes of forest fires is lack of land management resulting in the build-up of undergrowth that will easily ignite. However, clearing of such undergrowth to reduce the likelihood of fires must be balanced with good ecological management of the forests and in some areas it may be better from this point of view if forests were 'abandoned'.

The flood experience of some countries is forcing them to re-evaluate approaches to flood prevention and environmental security, but all such environmental considerations must be addressed for specific regions, not just those due to the hazard of flooding. A change of attitude is required, from regarding hazard prevention and response as essentially a technical problem to seeing it as part of a dynamic interaction between people and nature. The economic damage and massive social and environmental disruption that natural hazards can cause calls for more awareness and understanding of the interactions between human activities and natural systems throughout the EU and the Accession Countries.

The United Nations launched the International Decade for Natural Disaster Reduction (IDNDR 1990-2000) to make people more aware of actions to take to make themselves safe from natural disasters. Guideline principles have been drafted for natural-disaster prevention, preparedness and mitigation. Some EU Member States have procedures in place for taking account of the risks of flooding, avalanches, landslides and earthquakes in their planning and development processes. However, it does not appear that procedures have resulted in adequate responses to natural disasters in practice, and the impact on humans, the environment and the local economy has not been mitigated. Policy-makers need to investigate an overall approach to co-ordination of disaster management, and lessons learnt from previous incidents should be collected before they are forgotten, leaving the door open for disorganised response to be repeated. Real-time training exercises to prepare emergency teams for likely natural disasters would be beneficial.

3.4. There have been many initiatives following the Chernobyl accident

The Chernobyl accident alerted the international community to the potential for serious nuclear accidents to cause effects in both neighbouring countries and also those at considerable distances. Attention focused on the IAEA as a forum for obtaining agreements on nuclear safety, early notification and international response. As a result, three international conventions were developed under the auspices of IAEA:

- The Convention on Nuclear Safety was adopted in 1994, with the objective of committing participating states to a high level of nuclear safety by setting international benchmarks to which the states would subscribe. It is unusual in that there are no legal sanctions for breaking

its terms, but instead States are required to submit reports to regular meetings where the reports are peer reviewed.
- The Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency. This was adopted in 1986, and requires states to notify IAEA of the assistance they could provide in the event of an accident.
- The Convention on the Early Notification of a Nuclear Accident. This was adopted in 1986 and required States to report accidents at nuclear sites to potentially affected States either directly or via IAEA, and to the IAEA itself. Data essential to an assessment of the situation must also be transmitted.

Most recently, the joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was adopted on 5 September 1997. It follows similar objectives to the Convention on Nuclear Safety and has the same procedure of reporting and peer review. IAEA has also developed revised emergency response criteria and has issued guidance on the development of national plans for emergency preparedness (IAEA, 1997). IAEA also funds education, training, technical co-operation and expert missions to aid future nuclear safety.

Following Chernobyl, the European Commission also initiated and supported projects aimed at improved data management and information transfer in the event of a future accident. A comprehensive decision support system (RODOS) is being developed with support from the European Commission as part of the procedures to improve and harmonise future accident response in Europe.

Since 1986, many countries and organisations have developed sophisticated computerised systems for gathering, managing, assessing and disseminating information about a future accident. For example, a large national network of accident monitoring stations has been established in Spain (NucNet 27/95). In the UK, the automatic monitoring network RIMNET has been developed, and the Netherlands has set up its National Radiation Monitoring (NRM) network. The German IMIS system (Integrated Measuring and Information System) is however by far the largest such network of monitoring stations in the EU. The international reporting of incidents and the sharing of information has progressed, with the IAEA Convention on Early Notification, the International Nuclear Event Scale, international emergency exercises, and initiatives such as ECURIE (European Commission Urgent Radiological Information Exchange) and EURDEP (European Radioactivity Data Exchange Platform). An enormous amount of environmental data is now being collected in various systems across Europe, generating results with a daily volume of hundreds of gigabytes. The major development now required is to make these systems communicate with each other and to provide appropriate information to non-specialists.

A Centre for Information and Valorisation of European Radioactive Contaminated Territories (CIVERT) has been established at the Environment Institute of the EC's Joint Research Centre, Ispra, with the aim of providing assistance to local and national authorities in managing large contaminated areas in the event of a future accident.

Guidance on food intervention levels have been developed to ensure food safety in Europe in the event of food being contaminated after a future accident. The EU has issued regulations (European Commission – Euratom) that will apply in Europe in the event of a future accident, containing maximum permitted activity concentrations for contamination in marketed food. Further regulations deal with food imported from and exported to countries outside the EU. In addition to these, there are Codex Alimentarius Council (CAC) guideline levels developed by FAO/WHO for food moving in international trade (codex, 1989). IAEA and WHO have also issued advice on intervention levels in food. These levels issued by the EC, CAC, IAEA and WHO are not entirely consistent, and therefore despite attempts to harmonise action levels following a future accident, the potential for inconsistency remains. In the longer term after an accident, many different types of action may be taken to reduce the transfer of radionuclides to food products. Practical advice on these is at present country-specific.

EU radiation protection legislation is summarised in the Community Radiation Protection Legislation (European Commission, 1996c) and includes the legislation under the provisions of the Euratom Treaty.

References

Bennett, B. G., 1995, *Exposures from world-wide releases of radionuclides. In: Proceedings of a symposium on environmental impact of radioactive releases*, Vienna, 8-12 May 1995. IAEA-SM-339/185

Bismuth, C., Schmitz, E., Wiemann, A., 1998. *Das Oderhochwasser*. Umweltbundesamt, Germany.

Bonnieux, F., Rainelli, P., 1993. Learning from the Amoco Cadiz oil spill: damage valuation and court's ruling. In: *Industrial & Environmental Crisis Quarterly*, Vol.7, No.3, pp.169-188.

Chemical Engineer (The), 1998. News in Focus, Issue No.657, 14 May, p.4.

CNN, 1998. www-page http://www.cnn.com/WORLD/europe/9805/07/italy.mud/index.html and www-page http://www.cnn.com/world/europe/9805/11/italy.mudslides/

Codex, 1989. Codex Alimentarius Commission. Contaminants: *Guideline levels for radionuclides in food following accidental nuclear contamination for use in international trade*. Geneva, WHO, Supplement 1 to CODEX Alimentarius Volume XVII (1989).

CONCAWE, 1983-1997. Performance of Cross-country Oil Pipelines in Western Europe. Annual reports giving statistical summaries of reported spillages.

Crooks, E., 1992. A Review of Major Incidents and their Consequences. In: *IChemE Loss Prevention Bulletin*, No.115.

Cullen, The Hon. Lord, 1990. *The public enquiry into the Piper Alpha disaster.* Department of Energy, HMSO, London, UK.

Drogaris. G., 1993. Learning from Major Accidents Involving Dangerous Substances. In: *Safety Science*, No.16.

European Commission, 1996a. Council Directive 26/29/Euratom of 13 May 1996 laying down the Basic Safety Standards for the protection of the health or workers and the general public against the dangers arising from ionising radiation. *Off. J. Eur. Commum.*, L159, Vol. 39 (1996).

European Commission, 1996b. Vade-Mecum of Civil Protection in the European Union, DG XI.

European Commission, 1996c. Community Radiation Protection Legislation. Doc. XI-3539/96 – EN. European Commission (1996).

European Commission, 1982. Council Directive 82/501/EEC on the Major Accident Hazards of Certain Industrial Activities ('Seveso I'). In: *Official Journal of the European Communities*, No.L 230.

European Commission, 1997a. Council Directive 96/82/EC on the Major Accident Hazards of Certain Industrial Activities ('Seveso II'). In: *Official Journal of the European Communities*, No.L 10.

European Commission, 1997b. Proposal for a Council Directive establishing a framework for Community action in the field of water policy. COM(97)49, In: *Official Journal of the European Communities*, No.C 184.

European Commission, 1998. Environmental Radioactivity in the European Community, 1993. Joint Research Centre, European Commission. EUR 17714 EN (1998).

European Commission – Euratom, Council Regulation (Euratom) No. 3954/87 laying down the maximum permitted levels of radioactive contamination of foodstuffs and feedingstuffs following a nuclear accident or any other case of radiological emergency. *Official Journal of the Commission of the European Communties.*, L371/11 (1987), amended by Council regulation 2218/89. *Official Journal of the Commission of the European Communities*, L211/1 (1989).

Council Regulation (Euratom) No. 944/89 laying down the maximum permitted levels of radioactive contamination in minor foodstuffs following a nuclear accident or any other case of radiological emergency. *Official Journal of the Commission of the European Communities.*, L101/17 (1989).

Council Regulation (Euratom) No. 770/90 laying down the maximum permitted levels of radioactive contamination of feedingstuffs following a nuclear accident or any other case of radiological emergency. *Official Journal of the Commission of the European Communities.*, L83/78 (1990).

Gunn, D., 1998. A European Forum on Managing Major Natural Risks. In: *Earthwise*, Issue 11, February.

Hanley, A., The Independent, 7 May 1998 and 8 May 1998.

IAEA Yearbook 1994. IAEA, Vienna (1994).

IAEA, 1996a. Nuclear Power Reactors in the World, IAEA. Reference data series no. 2, April edition

IAEA, 1996b. The Nuclear Fuel Cycle Information System. A Directory of Nuclear Fuel Cycle Facilities, 1996 edition. IAEA, Vienna (1996).

IAEA, 1996c. IAEA Bulletin, 38, No.1 1996.

IAEA, 1996d. *One decade after Chernobyl: Summing up the consequences of the accident.* Proceedings of conference in Vienna, April 1996. Vienna, IAEA (1996); IAEA, Nuclear Safety Review 1993. IAEA, Vienna (1993).

IAEA, 1996e. *One decade after Chernobyl: Summing up the consequences of the accident.* Proceedings of conference in Vienna, April 1996. Vienna, IAEA (1996).

IAEA, 1997. *Method for the development of emergency response preparedness for nuclear or radiological accidents.* IAEA TECDOC 953, Vienna, IAEA (1997).

Ieropoli, R., 1998. http://www.italyflash.com/italyflash/shortt/news/archive/980520_1/html.

ITOPF, 1998. International Tanker Owners Pollution Federation, www-page http://www.itopf.com/, London, UK.

Kelly, G. N. and Clarke, R. H., *An assessment of the radiological consequences of releases from degraded core accidents for the Sizewell PWR.* NRPB-R137, Chilton, UK (1982).

Kirchsteiger, C., Gohla, H., Ostuni A., (in press) SPIRS: A Pan European GIS and Information System On Major Hazardous Chemical Process Plants. European Commission, DG JRC, Systems Modelling and Assessment Unit, Major Accident Hazards Bureau.

Kletz, T.A., 1993. Organizations have no memory when it comes to safety. In: *Hydrocarbon Processing*, Vol.72, No.6, pp.88-95, June.

London, 1995. Proceedings of international conference on probabilistic safety assessment in the nuclear industry. London, 1995.

MIAB, 1997. *Report of the Chief Inspector of Marine Accidents into the grounding and subsequent salvage of the tanker Sea Empress at Milford Haven between 15 and 21 February 1996.* Major Accident Investigation Branch, Department of Transport.

M&M Protection Consultants, 1997. *Large Property Damage Losses in the Hydrocarbon-Chemical Industries A Thirty-year Review.* 17th Edition, New York.

Munich Re Insurance Company, 1997. *Topics, Annual review of natural catastrophes 1996.*

NucNet 27/95

OECD, 1997. *OECD Environmental Data Compendium 1997*. OECD, Paris , France.

Rasmussen, K., 1996. *The Experience with the Major Accident Reporting System from 1984 to 1993.* CEC, EUR 16341 EN.

REC, 1997. *The Bulletin:* Quarterly Newsletter of the Regional Environmental Center for Central and Eastern Europe, No.2, Vol.7, Summer 1997.

Smeder, M., Christou, M., Besi, S., 1996. *Land Use Planning in the Context of Major Accident Hazards – An Analysis of Procedures and Criteria in Selected EU Member States.* EC Institute for Systems, Informatics and Safety Major Accident Hazards Bureau, Report EUR 16452 EN, Ispra, Italy.

Swiss Re Insurance Company, 1993. Natural Catastrophes and Major Losses in 1992: Insured Damage Reaches New Record Level. In: *Sigma Economic Studies*. Ed: E. Rudolph.

USGS National Earthquake Information Center, 1998a. *Glossary of Some Common Terms in Seismology*. www-page http://wwwneic.cr.usgs.gov/neis/general/handouts/glossary.html

USGS National Earthquake Information Center, 1998b. *Seismicity of Europe: 1975 - 1995.* www-page http://wwwneic.cr.usgs.gov/neis/general/seismicity/europe.html.

UWIN, 1996. ‘World-wide Paper on River and Wetland Development’. Universities Water Information Network, Southern Illinois University, Carbondale, USA.

Wild, P., 1998. Rapid Warning of European Earthquakes. In: *Earthwise*, Issue 11, February.

3.9. Genetically modified organisms

Main findings

All releases of GMOs to the environment in the EU have to be authorised under the Deliberate Release Directive, 1990, which operates through a 'step-by-step' progression and uses data from earlier experiments to inform decisions about the safety of future field trials. This procedure may not deal satisfactorily with cumulative impacts of many releases in the complex situation of the natural and agricultural environments. Risk assessments of releasing GMOs across the EU need to take account of the diversity of agricultural practice and of potential effects on biodiversity, taking into account Member States' commitments to conservation.

There are serious disagreements between Member States on the main potentially adverse effects of GMOs and there is very little public confidence in or support for the current development and regulation of GMOs. Public concern about the use of GMOs includes issues of trust, control, information (via labelling etc.) and the related benefits and justification of the effects of the technology for particular applications. Attitudes to medical applications for example are much more sympathetic than to the use of the technology in food.

Efforts are increasing to inform, involve and consult the public about GMOs, in order to reach a consensus on GMO regulation. Further research into potential environment and health impacts, and approaches to risk assessment, as well as more comprehensive monitoring are needed help fill the knowledge gaps and inform the risk evaluation system.

Achieving the right balance between risk and innovation with GMOs may help resolve generic issues surrounding new technologies, such as the management of scientific uncertainty, application of the precautionary principle, public information, monitoring, liability, informed consent to imports, and the resolution of trade and environmental/ health issues.

1. GMOs in the European Union: setting the scene

This chapter focuses on applications of genetic modifications (GM) with the greatest potential for environmental effects: in agricultural production, food processing and animal feed. It does not consider medical applications, apart from listing GM vaccines which have been approved under environmental regulations.

1.1. Experimental and commercial releases of GMOs licensed in the European Union

Deliberate experimental releases to the environment of GM crops have been conducted in Europe since 1985-86. At present there is very limited experience in the EU of cultivation of GM crops, although there have been over 1 300 experimental field trials with genetically modified organisms (GMOs), involving over 60 species of plants and microorganisms, and some 18 marketing approvals have been given for GM crops and vaccines. It is therefore not possible to evaluate the environmental effects of GMOs, such as the transfer of inserted genetic materials to related wild species. Assessment and management of risks in this area are beset by complexities and uncertainty (Royal Society, 1998), despite recent scientific advances (see the case study of GM oilseed rape in section 2 below).

Genetically modified foods are now starting to be sold commercially. In the United States almost 30 varieties of crops have been given approval for commercial planting and use. In contrast, in the EU only four commercial

Box 3.9.1. Basic definition

Genetic modification involves the transfer of genetic material between species (the use of recombinant DNA technology to transfer genes), a technology which was developed using microorganisms in the 1970s and applied to plants and animals during the middle and late 1980s.

The transferred gene(s) from the donor organism then functions in a specific way in the host organism, altering both its genetic makeup and its biological behaviour. There is usually more than one donor organism, as DNA sequences from bacteria or viruses are needed to facilitate the transfer of genetic material (as vectors), as control mechanisms (e.g. promoter genes); and as markers to demonstrate that the genetic modification has been successful (e.g. antibiotic and herbicide resistance).

food crops (oilseed rape, maize, soybean and chicory) have been approved (Table 3.9.1) and only one, Novartis's GM insect-resistant maize, has been grown commercially during 1998 in France, Spain and Germany. Some varieties of GM maize and soybean can be imported into, but not grown in, the EU. One oilseed rape variety has been given approval for importation and a GM chicory has also received approval. Zeneca's GM tomato paste has been sold in the UK since 1996 but because this is grown and processed in the US it is not considered a living GMO, and therefore not regulated under the EU's Deliberate Release Directive. Certain GM vaccines, a test kit for antibiotic residues and a GM herbicide-tolerant tobacco have also been approved for commercial use. However, Member States have not given approval to four products (two cotton, one tomato and one maize) and the European Commission will now have to decide about these.

Box 3.9.2. Disputed GMO marketing authorisations

Austria and Luxembourg banned the sale of the Novartis GM maize in 1997 because of concerns about the presence of a marker gene conferring resistance to the antibiotic ampicillin, the absence of a resistance management plan for insect resistance and concerns about herbicide resistance.

France used Article 16 in December 1998 to restrict the use of two varieties of herbicide-resistant oilseed rape made by Plant Genetics Systems and AgrEvo. France has also not signed the consent license for another Plant Genetics Systems oilseed rape which has completed the authorisation process. France is concerned about the potential for gene flow to its native flora.

Greece used Article 16 in October 1998 to ban the import of AgrEvo's herbicide-tolerant oilseed rape because of environmental and health concerns; and has recently called for a moratorium on GM crops in Europe.

The European Parliament's Environment Committee called for a moratorium on all new GM crop varieties in October 1998.

Products can take a number of years to obtain marketing consent, and as Table 3.9.1 shows, there has so far only been unanimous approval for three GM carnations. Even when given approval, Marketing consents can remain controversial. Several EU Member States have imposed restrictions on GM crops which have already been given marketing consent under Article 16 of the Deliberate Release Directive. Box 3.9.2 lists the Article 16 objections currently in place.

Table 3.9.2 gives details of the numbers of experimental trials carried out in EU countries and in other European countries for which data is available. In EU trials, herbicide tolerance and insect resistance have been the most common traits tested. Over 60 species of GM plants have been tested in Europe with four crops making up 75% of the trials: maize accounted for 28%; oilseed rape 22%; sugar beet 15% and potato 10%, reflecting the importance of these crops in European agriculture. The majority of early research focused on herbicide tolerance in crops and this is reflected in the first products coming to market. Insect resistance has also been a common subject of research and is marketed in the form of Novartis' insect-resistant maize. On the evidence of developments in the US (where more GM crops are available because the market opportunities are greater) and the experimental field trials conducted in Europe, forthcoming commercial applications are likely to include: viral disease resistance in crops such as potatoes, altered starch characteristics in potatoes to improve processing, altered oil composition in oilseed rape to reduce reliance on other sources and fruit that ripens more slowly.

1.2. Policies

The main EU legislation covering environmental safety of the release of GMOs is the 'Deliberate Release Directive' (90/220/EEC). Genetically modified microorganisms that are released accidentally or incidentally from research and production facilities are regulated under the Contained Use Directive (90/219/EEC), with a view to protecting health and the environment. Food safety aspects are covered by the Novel Foods Regulation (258/97). This chapter concentrates on the Deliberate Release Directive as it most directly affects environmental safety; its approach is summarised in Box 3.9.3. The decision-making tree is shown in Box 3.9.4. Crucially the approach is intended to be precautionary – the possibility of serious, irreversible harm is acknowledged, justifying preventative action without scientific proof of harm.

Products approved under the Deliberate Release Directive 90/220/EEC to 31 December 1998 Table 3.9.1.

Product	Use	Notifier	Conditions	Date of Commission Decision*/ Member State Consent**
1. Vaccine against Aujeszky's disease	Pigs	Vemie Veterinär Chemie GmbH	According to veterinary product licenses	18.12.92
2. Vaccine against rabies	Foxes	Rhône-Mêrieux	Hand or aerial dropping twice annually	19.10.93
3. Tobacco tolerant to bromoxynil.	Herbicide tolerance	SEITA	Growing and use by tobacco industry	08.06.94
4. Vaccine against Aujeszky's disease (further uses)	Pigs	Vemie Veterinär Chemie GmbH	According to veterinary product licenses	18.07.94
5. Oilseed rape resistant to glufosinate ammonium	Herbicide tolerance and hybrid production	Plant Genetic Systems	Seed production only	06.02.96
6. Soybeans tolerant to glyphosate	Herbicide tolerance	Monsanto	Importation for food and feed	03.04.96
7. Male sterile chicory tolerant to glufosinate ammonium	Herbicide tolerance	Bejo-Zaden BV	Growing	20.05.96
8. Bt-maize tolerant to glufosinate ammonium	Herbicide tolerance	Ciba Geigy	Growing, animal feed and food use	23.01.97
9. Oilseed rape tolerant to glufosinate ammonium	Herbicide tolerance and hybrid production	Plant Genetic Systems	Growing	06.06.97
10. Test kit to detect antibiotic residues in milk	Agriculture	Valio Oy	Use in test kit only	14.07.97
11. Carnation lines with modified flower colour	Horticulture	Florigene	Cut flowers and plants	01.12.97 (MS consent)
12. Swede rape tolerant to glufosinate ammonium	Herbicide resistance	AgrEvo	Growing	22.04.98
13. Maize tolerant to glufosinate ammonium (T25)	Herbicide resistance	AgrEvo	Growing	22.04.98
14. Maize expressing the Bt cryIA(b) gene (MON 810)	Insect resistance	Monsanto	Importation for animal feed and human food uses	22.04.98
15. Maize tolerant to glufosinate ammonium and expressing the Bt cryIA(b) gene	Herbicide and insect resistance	Novartis (formerly Northrup King)	Importation for animal feed and human food uses	22.04.98
16. Carnation lines with improved vase life	Horticulture	Florigene	Cut flowers and plants	20.10.98 (MS consent)
17. Carnation lines with modified flower colour	Horticulture	Florigene	Cut flowers and plants	20.10.98 (MS consent)

* where objections were raised by Member State authorities

** in the absence of objections by Member State authorities

Bt = *Bacillus thuringienis*

Table 3.9.2. Numbers of experimental-release notifications of GMOs to the EC (from 1 January 1992 to 1 September 1998)

Country	Plant	Micro-organisms	Vaccines	Total
Austria	3			3
Belgium	91		1	92
Bulgaria	3			3
Denmark	32			32
Finland	16	1		17
France	385	5	4	391
Germany	92	2		94
Greece	12			12
Ireland	4			4
Italy	201	12		214
Netherlands	100	2	1	103
Portugal	11			11
Russian Federation	4			4
Spain	115	8		123
Sweden	36			36
Switzerland	2			2
United Kingdom	165	7		172
Total	1269	37	6	1312

A notification may relate to several different species at several sites. Therefore this data only gives a guide to the relative numbers of experiments in different countries.

Source: European Commission's Joint Research Centre 'Biotechnology and Environment' database: http:/biotech.jrc.it) and those in other European countries where available (from OECD Biotrack Online database: http:/www.oecd.org).

There is also provision for GM products to be assessed under product regulations alone as long as these include a risk evaluation which is equivalent to that required under the Deliberate Release Directive. For example, in December 1998, the Council adopted amendments to the Directives relating to the marketing of seeds (66/400/EEC, 66/401/EEC, 66/402/EEC, 66/403/EEC, 69/208/EEC, 70/457/EEC, 70/458/EEC) aiming among other objectives, at integrating the process of environmental risk assessment with the procedure of variety acceptance.

The EU now faces a challenge, with the revision of the Deliberate Release Directive, to reconcile these commitments with the need for rigorous assessment of the environmental risks of GMOs, taking account of commitments to environmental protection under legislation such as the EU's Habitats Directive and the Biodiversity Conventions (see section 3 below).

1.3. Applications of genetically modified organisms

Conventional crop breeding has produced large agricultural and other benefits, some of which have been monetised. For example, the crossing of a perennial Mexican corn able to grow in marginal soils at high altitudes, and which is resistant to seven major corn diseases, with modern corn varieties,

Box 3.9.3. Regulating the releases of GMOs in the European Union

- ALL environmental releases of GMOs must be licensed under the Deliberate Release Directive (90/220).
- The approach is intended to be precautionary.

Experimental releases are covered by Part B of the Directive (following the general provisions of Part A):

- Safety is assessed by a 'step-by-step', progression using data from earlier experiments to inform decision about safety of future field trials.
- At each stage it is assumed the presence or absence of effects will be identified thus allowing for a decision to be made on whether a lower containment level can be allowed.
- Simplified procedures can be introduced for some crop species where the characteristics of both the inserted gene and the host organism are well known.
- Approvals can be given either for a single release or for a programme of releases taking place over several years and at several sites.
- The risk assessment includes the conditions of release and the receiving environment, and interactions between the GMOs and the environment such as characteristics affecting survival, multiplication and dissemination, and interactions with the environment.

Marketing authorisations are covered by Part C of the Directive and Europe-wide approval for marketing may be given following a risk assessment which considers:

- Information about the GMO – the recipient and donor organism, the vector and the GMO.
- Conditions of release and the receiving environment.
- Assessment of potential health effects.
- Interactions between the GMOs and the environment – characteristics affecting survival, multiplication and dissemination, interactions with the environment and potential environmental impact.
- Information provided derives from earlier field trials either in Europe or elsewhere.

If new information becomes available that a product may be a risk to human health or the environment, a Member State may temporarily restrict its use or sale, pending a decision at EU level.

Box 3.9.4. Current practice in the decision-making process for marketing authorisations of GMOs

1. Application to Member State (MS).
2. Opinion given to the European Commission.
3. Other MSs comment and consent granted if no disagreement between MSs.
4. Commission may consult expert EC scientific advisory committees.
5. Decision based on a qualified majority voting procedure if disputes between MSs.
6. If no qualified majority possible, then the Council is asked to decide.
7. If failure to agree, the Commission makes a final decision.
8. MS where initial application made issues consent for placing on the market.

had generated some $4 400 million a year in potential benefits by 1990 (UNEP, 1990). It is the ability to alter crops in more clear-cut and particular ways, together with a much greater scope for alteration without the long time-scales involved in conventional breeding, that has attracted industry to GM technology.

The main applications of GMOs are shown in Box 3.9.5.

Future applications include cold tolerance (in plants and animals, especially fish); specialised products such as new fibres and oils; 'functional foods' and 'nutraceuticals' which claim health advantages such as lowered cholesterol or raised vitamin levels; and the production of vaccines and other pharmaceuticals in plants. Designing GM products to meet the needs of certain markets, such as farming or food processing, may provide significant business and employment opportunities. However, there may also be costs (Box 3.9.6). Although traditional crop breeding also has costs, they are better known, slower to arrive, and generally are easier to manage than some of the potential costs of GM technology.

In addition to the jobs and profits potential, there are other socio-economic implications, such as the information rights of consumers, and the property rights of GM producers and farmers.

1.4. Key issues associated with the release of genetically modified organisms

The direct environmental risks from GMOs have been examined by a number of expert groups (including the UK's Royal Commission on Environmental Pollution (1989) and the US's Ecological Society in the same year (Tiede *et al.*, 1989)), as have the perceived risks to human health from eating GM foods (see for example Clydesdale, 1996; Advisory

Box 3.9.5. GMOs: main applications

Food crops

- Herbicide tolerance – allows crops to resist non-selective weedkillers.
- Insect resistance – allows crops to resist insect attack by producing an insecticidal toxin.
- Male sterility systems – for production of hybrid crop giving enhanced yield
- Disease resistance – prevents crops developing viral and fungal diseases.
- Delayed softening in fruits – prolonging storage life.
- Altered oil characteristics – to fit processing needs.
- Nitrogen fixation – to transfer this ability to non-nitrogen fixing crops.

Non-food crops

- Flowers with modified colour and extended vase life.
- Trees with altered characteristics to make paper production easier.
- Plants to produce plastics and pharmaceuticals.
- Plants to assist in bioremediation of polluted sites.

Animals

- Increased growth rates – to reduce time to reach mature weight.
- Therapeutic substances in milk – to provide sources of medicines which are difficult to produce by other means.

Microorganisms

- Production of enzymes or drugs – for use in food processing or as medicines.
- Degradation of pollutants – to clean up contaminated sites.

Box 3.9.6. The main potential benefits and costs attributed to GMOs

Potential benefits:

- promoting efficiency in farming – for example by reducing labour costs of herbicide or insecticide spraying and less tillage;
- increased yields – by reducing losses from pests and disease, hence reduced pressure for more farmland;
- providing altered product characteristics to aid in food processing – such as tomatoes which soften more slowly and therefore have lower water content facilitating processing into paste;
- controlling fertility – to improve the purity of hybrid seed, hence higher yields;
- reducing fertiliser inputs through nitrogen fixation;
- reduced pesticide use.

Potential costs

- **Direct environmental effects**:

- if there is gene transfer from the GMO to native flora or fauna – leading to new pests as a result of hybridisation;
- unexpected behaviour of the GMO in the environment if it escapes its intended use and becomes a pest;
- disruption of natural communities – through competition or interference;
- food web effects through harm to non-target species – for example, if the host range of a virus was increased it may affect beneficial as well as the targeted species or there may be secondary effects of the insect toxin contained in a crop on the food web;
- harmful effects on ecosystem processes – if products of GMOs interfere with natural biochemical cycles;
- squandering natural biological resources if, for example, the use of a genetic modification to bring pest resistance in many difference species induces the emergence of resistance and loss of efficacy.

- **Indirect environmental effects**:

- continuation of intensive agricultural systems – as a result of the requirement for high levels of external inputs;
- impacts on biodiversity as a consequence of changes in agricultural practice – for example by altering patterns of herbicide use, effects on flora may be seen;
- cumulative environmental impacts from multiple releases and interactions;
- alterations in agricultural practices, for example, to manage any direct environment impacts such the evolution of insect, herbicide or disease resistance in weeds.

- **Health:**

- new allergens being formed through the inclusion of novel proteins which trigger allergic reactions at some stage;
- antibiotic resistance genes used as 'markers' in the GM food being transferred to gut microorganisms and intensifying problems with antibiotic-resistant pathogens;
- the creation of new toxins through unexpected interactions between the product of the GM and other constituents for example.

Committee on Novel Foods and Processes, 1994; Royal Society, 1998).

Official regulatory processes (see section 4 below) are based on a risk assessment of the potential for direct environmental effects of GMOs. These assessments have been criticised for failing to take proper account of indirect effects: an early example of this critique was of GM herbicide-tolerant crops, *Biotechnology's Bitter Harvest* published in 1990 (Biotechnology Working Group, 1990) and there have since been similar criticisms from various non-governmental organisations (NGOs) and scientific advisory bodies (Box 3.9.7). US growers have recently proposed to limit the cultivation of Bt insect-resistant crops such as cotton and maize on GM crop lands to 80% of the area in order to prevent the build up of insect resistance (FOE, 1999).

Ethical issues concerning GMOs (see Grove-White *et al.*, 1997) have been more clearly articulated in relation to patenting (Box 3.9.8) and animal welfare (see O'Brien, 1995) than to environmental implications. There has also been considerable debate on implications for developing country agriculture – whether the technology will assist food security or increase poverty and hunger (see for example the differing views of Monsanto, 1998; Action Aid, 1998; Shiva, 1999). Concern has recently arisen over the so-called 'Terminator Technology' which prevents use of seeds from a previous crop, and which in the event of cross pollination might lead to the formation of non-viable seeds in neighbouring non-GMO crops. The 4th Conference of the Parties to the Convention on Biological Diversity has requested its Subsidiary Body on Scientific, Technical and Technological Advice to consider and assess any consequences for the conservation and sustainable use of biological diversity from the use of this new technology.

1.5. Industrial and public opinion about GMOs

1.5.1. Industrial opinion

There is no single industrial position on GMOs and their use. While developers of GMOs see them as a huge market opportunity, food producers, although interested in new technological developments, are under pressure from consumers who wish to avoid GMOs. According to their impressions of public opinion some companies have had different positions in different parts of the EU. For example, a major food company in Germany avoids the use of GM ingredients in all its products but in the UK and the Netherlands the company uses GM ingredients in some products, with labelling.

Food retailers have come under pressure to label and segregate GM products containing GMOs. Some supermarket chains in various European countries have taken the step of ensuring only GM-free sources are used in their own brand products.

Box 3.9.7. Some indirect effects of GM products on wildlife

> 'There are concerns that the current regulatory regime may fail to identify long-term indirect effects on biodiversity resulting from commercial use of GM crops in agriculture, if production management methods, such as herbicide use for weed control, are encouraged … Whether or not the crop itself was considered to pose a low risk to human health and the environment, widespread commercial uptake by farmers could result in declines in certain wildlife species.' (ACRE, 1997)
>
> 'The specific issue that faces ACRE is that, while the decision to grant licenses to introduce genetically modified seeds for one crop may have a very small impact on insect populations and so on bird populations, as licenses are granted to introduce genetically modified varieties of more and more crops then the impact on insect and bird populations becomes more severe. The only policy instrument that is required is a subsidy to the growing of non-modified crops. We determine both the optimal number of technologies to introduce, and the optimal usage of each technology. These decisions in turn determine the amount of food available for insects to feed on and hence the number of species of insects and birds that survive. This subsidy should be introduced even before the new technology becomes available, and then should be raised over time so as to choke off the demand for further crop modification' (Sianese and Ulph, 1998).

The attitude of the conventional farming industry is not yet clear. Because GM crops and food are not allowed under organic standards, the attitude of organic farmers across Europe is firmly opposed. They are worried that if cross-pollination occurs between GM and organic crops that they will lose their organic status.

Box 3.9.8. Patenting

Patenting is one form of intellectual property protection (others include copyright, plant breeders' rights, trademarks, etc). In exchange for disclosure of the invention, the inventor is given a right to exclude others to commercially exploit the invention for a period of time, usually 20 years from the filing date. The intention of patent protection is to encourage further innovation by making information available whilst allowing for the costs of research and development to be recouped by allowing only the innovator to market the product of their investment in R&D.

There are three requirements for an invention to be patentable in Europe:

- novelty (not known before);
- inventiveness (not obvious to one skilled in the art; more discoveries are not patentable);
- capable of industrial application.

Businesses have applied for patent protection on the genetic material, useful micro-organisms, cells, plants and seeds they have produced using molecular techniques. The objections include that:

- patent protection should not be extended to living material;
- genes, cells, plants and seed are the products of natural process and therefore cannot be claimed to be inventions;
- it is unethical to allow monopoly control over such materials: 'life is not patentable';
- farmers will have to pay royalties to companies if they keep seed from their own crop to resow in subsequent seasons.

The EU has tried to resolve these conflicting positions through the introduction of a Directive on the Patenting of Biotechnological Inventions. Directive 98/44/EEC was introduced by the Commission in 1996 and was agreed in 1998. Some safeguards such as the clarification of inventions which would be considered contrary to public order and morality, and the inclusion of a 'farmers' privilege' (to allow seed to be kept for future years) helped secure the agreement of the European Parliament, which was also concerned about possible delays in medical applications.

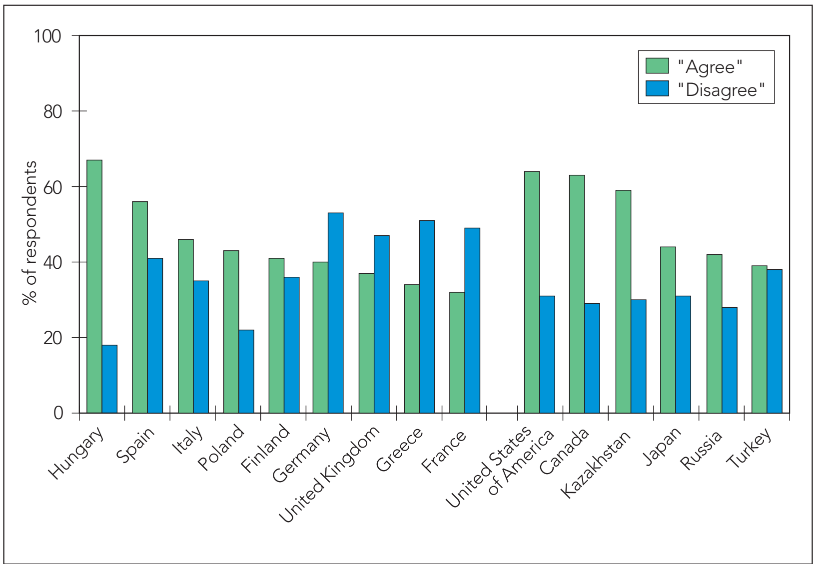
However, the European Patent Convention (EPC) excludes patenting on plant varieties and case law to date at the European Patent Office (EPO) has led to patents being refused for GM plants, a situation which conflicts with the patenting Directive. The Enlarged Board of Appeals at the EPO is reconsidering the exclusion of plant varieties.

Internationally, the European approach to patenting biotechnological inventions also has to be consistent with the TRIPS agreement (Trade Related Aspects of Intellectual Property Right) which was negotiated as part of the Uruguay Round of the GATT. The TRIPS agreement met opposition of 45 indigenous, peasant and non-governmental organisations from 19 countries who agreed on the so called Thammasat Resolution (December 1997). It is their conviction that the TRIPS agreement will 'result in new and further monopoly rights over plant varieties'. The TRIPS article is to be reviewed in 1999.

1.5.2. Public opinion

Public opinion across Europe has tended to be sceptical about GM foods, a development which has proved contentious (Figure 3.9.1).

Figure 3.9.1 **Public opinion on GMOs**



The population of respondents who agree/disagree with the statement that the benefits of using this technology to create GM foodcrops that do not require pesticides and herbicides are greater than the risks.

Source: International Environmental monitor 1998

The GM soybean imported from the US since 1996, amongst growing controversy, is now found in a large range of processed foods in the EU. However, neither citizen nor consumer acceptance are at all certain. There has been opposition from a broad range of environmental and consumer organisations, and GM crops have suffered direct-action destruction in several EU Member States including the UK, Germany, the Netherlands and France.

Public opposition to GM foods has been seen by some as reflecting a lack of knowledge about the technology, but comparing the results of Eurobarometer surveys in 1991, 1993 and 1996 shows that whilst basic knowledge about the technology has increased, optimism about its ability to improve the quality of life has decreased (Biotechnology and the European Public Concerted Action Group, 1997). The 1996 Eurobarometer results confirmed other research showing that on GM foods, environmental and consumer groups were much more trusted sources of information than public bodies or companies. Eurobarometer also demonstrated that 74% of the European public supported the labelling of GM foods; 60% believed there should be public consultation about new developments; and just over half, 53%, felt current regulations are insufficient to protect people from the risks of the technology.

Relying on opinion poll information alone does not provide a good basis for measuring public attitudes as it reveals little about underlying concerns and can be heavily biased by the way in which a question is asked. Qualitative research has shown that, for example, the British public have considerable mixed feelings about GM foods and the adequacy of present systems of regulations and of official 'scientific' assurances of safety, especially given the knowledge gained during the BSE crisis (Grove-White *et al.,* 1997). The same study also claimed that *consumer* acceptance in terms of purchasing a product such as tomato paste made from GM tomatoes which soften more slowly, should not be equated with *citizen* acceptance as there is often an underlying lack of support for such interventions even from people who behave pragmatically in the marketplace.

This and similar research from the Netherlands (e.g. Hamstra, 1995) also showed that the public are discriminating in how they judge GM technologies, looking more favourably on applications, especially in the medical domain, where a clear social benefit is seen. Applications which give benefits to, say, food processors are viewed less favourably since benefits appear restricted to certain financial interests. The public also displays awareness – and negative evaluation – of the interests driving GM innovations which are slanted to the affluent markets of the developed world rather than the needs of poor countries. The ultimate trajectory of the technology also plays in the public mind, with the concern that apparently innocuous uses may lead to misapplication in the future which they may be unable to control.

Thus the public appears to bring together issues of trust, control, the controlling purposes and the particular costs and benefits of the application when evaluating the effects of GM technology. Public expressions of concern also show ethical judgements to be part of risk judgements. The public are therefore making rather complex and sophisticated judgements in forming their attitudes towards GMOs. Some local authorities reflect the publics concerns; for example, in Germany and the UK they have recommended GM-free foods in schools and other institutions, and the city of Munich has recommended GM-free crops on its leased allotments (FOE, 1999).

2. Investigating the risks of gene flow: a case study of gene transfer from oilseed rape to related wild plants

Research programmes developed over the past 10 years have allowed identification of the crops where gene flow to weedy relatives can occur. One environmental concern associated with the release of GM crops is the risk of dispersal of the transgene within cultivated and wild populations. Such genetic transfers may have already occurred from traditionally bred plants, so the risk here relates to the nature of the transgene rather than the transfer as such. Such transfer could enhance the invasiveness of the wild populations and modify the pressures on agriculture as well as agricultural practices, with consequential environmental impacts of their own, depending on the transgene concerned.

With crops such as sugar beet, radish and alfalfa, gene flow will undoubtedly occur because weeds belonging to the same species as the crop are present in the cultivated areas. There are also crops, such as maize in Europe, for which gene flow is impossible because of the absence of wild weeds which are related to the cultivated plant; however, even in such cases it remains essential to assess pollen dispersal because cutivated crops can cross-pollinate, affecting the ability to produce non-GM crops. Other crops, such as oilseed rape, are in an intermediate situation. Many different, related weeds are present in or close to the crop fields but they have different abilities to cross-pollinate. Research programmes have still to be developed to provide information on the genetic mechanisms of recombination according to the location of the transgene or on the occurrence of new weeds.

Oilseed rape (*Brassica napus*) is therefore particularly suitable for a case-study of gene transfer to illustrate the complex problems of environmental assessment. Gene dispersal can take place via pollen and seeds and there are numerous weedy species more or less related to oilseed rape with an overlapping flowering period within the cultivated area. Furthermore, commercial GM varieties of oilseed rape are already available. However, this case study is not intended to define the range of possible effects of GMOs but to illustrate the issues surrounding the investigation of direct effects. Gene transfer may be more or less important than some other possible impacts such as altered patterns of herbicide use or insect resistance if a crop was modified in this way. However, the complexity that is revealed in the relatively straightforward question about gene flow demonstrates how difficult unravelling secondary effects may be.

So far research programmes have focused mainly on the frequency of gene transfer rather than the impact. Gene dispersal within the same species always causes problems in conventionally bred crops as it can interfere with the purity of hybrid seeds if cross pollination by other crops or wild species occurs. However, there is little data available about gene flow from crops to related species. To be successful, gene transfer from one species to another involves the following steps: (1) production of viable hybrids from crosses between the two species, (2) occurrence of fertile plants in the successive generations, (3) gene transmission through the different generations, (4) effective gene establishment within the natural populations and maintenance of the new trait.

2.1. Development of research over the past 10 years

Research programmes have focused on the crop's ability to disseminate genes spatially and temporally and on the risk of gene introduction into the weedy relatives.

2.1.1. Gene dispersal from the crop

Oilseed rape is partially self-fertilising with, on average, a third of its pollen contributing to out-crossing. Pollen, carried by wind and insects, is the main route of spatial dispersal. Experiments to determine over what distance pollen can move have given different results depending on the assumptions and methodologies used (Box 3.9.9). So the isolation distance which would totally prevent pollen dispersal remains highly speculative.

Seeds contribute to temporal dispersal. One to 10% of the seeds are lost at harvest and result in volunteers (where seed from one crop survives and grows in different crops in following seasons) which may emerge in following years (Price *et al.*, 1996). The ability of such seeds to survive under natural conditions and to contribute to feral populations seems to be low (Crawley and Brown, 1995) but little experimental data is available.

2.1.2. Gene flow to weeds

The occurrence and frequency of gene flow from crops to weeds can be studied by two methods: either by researching genes specific to the crop within the weedy

Box 3.9.9. Whither pollen?

- How far pollen can travel is important for assessing the risks of genetic pollution by GM crops of non-GM crops, such as organic produce, with attendant safety and economic implications. An opinion from the UK government's Advisory Committee on Releases into the Environment (ACRE) stated that 'at a standard separation distance of 200 metres between the organic sweetcorn and the GM maize, the likely cross-pollination frequently would result in no greater than 1 sweetcorn kernel in every 40 000 being a GM hybrid.' However, a recent report by the UK Nature Pollen Research Unit (NPRU) concluded that 'in conditions of moderate wind speeds, the rates of cross-pollination at 200 meters would be in the order of 1 kernel in 93.' The NPRU report observed that the ACRE report failed to 'even consider cross-pollination of the organic sweetcorn by bees' despite the presence of several beehives adjacent to the disputed experimental site, and that its dismissal of long-range transport was noncompatible with the 'substantial evidence' on the 'long-range transport of considerable numbers of pollen grains… . Maize pollen remains viable under normal conditions for approx. 24 hours giving potential for pollination by grains that had travelled many hundreds of kilometres on the air flow.' (Emberlin, 1999).
- Cross-pollination can result in the crops in neighbouring, non GM farms producing GM seed. As the GM company forbids seed saving from year to year or exchange between farmers, enforcement of such agreements will be difficult if there is accidental genetic pollution by GM crops on non-GM farms, which is already happening in the US (FOE, 1999).
- Timmons et al. (1995) studying pollen movement between different fields showed that pollen can be dispersed over 1 km. In contrast experiments looking at pollen movement from a small plot within a field indicated that the majority of the pollen fell within the first meters around the plants (Scheffler et al., 1993). Comparison with global pollen dispersal suggests that measurements for individual plant pollen understate the area covered by medium- and long-distance dispersal (Lavigne et al., 1998).

populations or by producing hybrids between the GM crops and wild species (interspecific hybrids).

The first method is difficult because the weed species belong to the same botanical tribe as oilseed rape and have a common ancestor; consequently, there are no agreed specific marker genes to use in the study of gene transfer. Following the second approach, data for laboratory-developed interspecific hybrids (Scheffler and Dale, 1994), and the relative importance of the different species as weeds within the cultivated areas, has been used to target studies of gene flow from oilseed rape to related weeds under natural conditions (see Jorgensen and Andersen, 1994; Bing *et al.,* 1996; Eber *et al.,* 1994; Chèvre *et al.,* 1996; Lefol *et al.,* 1996a, b; Darmency *et al.,* 1995).

Although studies show that hybrids can be formed between oilseed rape and some related species under field conditions, there are many other factors which will influence how likely it is that gene transfer will occur and the new gene(s) become established in the weed population. The outcome is affected by:

- use of oilseed rape as female, which generally produces more seeds (Kerlan *et al.*, 1992; Jorgensen and Andersen, 1994; Jorgensen *et al.*, 1998);
- the genotype of both parent plants (Jorgensen and Andersen, 1994; Baranger *et al.*, 1995);
- variability in the weeds (Lefol *et al.*, 1996a ; Darmency *et al.*, 1998);
- the spatial relationship between the crop and the weed species (Jorgensen *et al.*, 1998; Lefol *et al.*, 1996a ; Darmency *et al.*, 1998).

Studies using herbicide-tolerant oilseed rape varieties have shown that, if genes are carried on a genome common to the weed and crop, their transfer to the weed is relatively easy. Mikkelsen *et al.* (1996b) showed that only two backcrosses to the wild species were needed for gene introgression from oilseed rape to field mustard. However, although these studies indicate that gene flow to closely related species can be rapid, studies with a less-related species, the wild radish, indicated that, at the third backcross generation, none of the herbicide-tolerant plants had the same chromosome number as the weed. So, the transgene was not established in the genome of the weed (Chèvre *et al.*, 1997; 1998). However, hybrid plants with both sets of parental genes have been detected at the first generation stage and are under further study.

The results of all these studies show that gene transfer from GM oilseed rape to related plants is possible under field conditions and that its frequency is dependent on many factors including the biology of the weeds. As research has progressed over the past decade, it now seems that this is more likely for some species than was at one time believed. However, the many interrelated factors affecting gene flow, ranging from variations in the genetic composition of weeds to spatial relationships between plants and agricultural practices mean that prediction with any certainty how, when, where and with what outcome remains extremely difficult.

The case study raises several critical methodological issues (Box 3.9.10).

3. Evolving regulations on the release of genetically modified organisms

3.1. Revision of the Deliberate Release Directive in the EU

One of the primary intentions of the Directive's revision (European Commission, 1998), driven by single market trade imperatives, is to harmonise risk assessments across the EU and to facilitate agreement on marketing authorisations in particular. Other aims are to improve transparency and introduce a monitoring mechanism to detect any effects on the environment or human health arising from the release of GMOs.

The main elements of the Commissions' original proposal are shown in Box 3.9.11. One area involves the implementation of a risk assessment which explicitly includes direct and indirect, as well as immediate and delayed effects. It also recognises how important disagreements about the scope and nature of unacceptable effects have been in the past. Such disagreements amongst Member States can result in them using Article 16 of the Directive which allows countries to ban the use of a GMO, if new evidence emerges which indicates that harm may have been underestimated.

Box 3.9.10. Critical methodological issues in gene transfer research

Some of the shortcomings of present knowledge on gene transfer for risk assessments are outlined below.

– Experiments are on a small scale providing limited evidence on:

- the effect of the parental genotypes – a large diversity exists amongst oilseed rape varieties cultivated over Europe and gene flow will vary according to genotype;
- the effect of the relative positions and density of the parental species – close to large oilseed rape fields, weedy plants can be present as isolated plants or as clusters within the field, in the border of the field or in fallow ground and this will influence how likely it is that cross-pollination can occur and at what frequency;
- the effect of time and repeated oilseed rape pollen flow from fields or volunteers which also influences the likelihood of gene flow as it affects contact time and opportunity for cross pollination;
- the fitness of the plants, according to their genomic structure along the different generations, which may increase or decrease over time and in varying environmental conditions affecting the long-term likelihood of successful gene flow;
- the impact of different agronomic practices such as the use of herbicides to control volunteers.

– Few predictive models and insufficient data for validation

– Few transgenes analysed

Most of the research programmes have been performed with herbicide-tolerant GM crops because herbicide tolerance was the first trait of agronomic interest widely used and because this trait is easy to screen on large populations. However, the results may not be directly relevant to other GM crops and thus other studies will be needed. For example, other GM traits such as pest- or fungi- or stress-resistance, and modification of oil quality, may affect the fitness of the hybrid plants differently than herbicide tolerance, and little data is available.

Other risks

Because oilseed rape is pollinated by insects, whether there are any effects on beneficial insects such as honeybees has to be assessed under product authorisation regulations. Effects of gene products at both individual and colony levels under confined conditions were analysed from different transgenic oilseed rape lines expressing pest and fungi resistance. The three proteins tested were shown to be non-toxic at the doses tested (Picard-Nizou et al., 1997). The bioassays developed will be useful in testing new transgenic lines. Potential opportunities for reducing the risks of gene flow include:

- identification of a 'safe insertion site' for the transferred gene because it has been shown that gene flow is dependent on the location of the genes in the donor species (Lukaszewski, 1995);
- modifications which reduce the dispersal of pollen (e.g. self-fertilising varieties) and seeds (e.g. reducing seed loss at harvesting and dormancy);
- adaptation of agronomic practices (e.g. management strategies for herbicide-tolerant volunteers); a multi-year monitoring study is already in progress with different GM crops (corn, sugar beet and rapeseed) tolerant to glufosinate, glyphosate or bromoxynil (Messean, 1997).

Box 3.9.11. Revision of the Deliberate Release Directive – main features of the Commission's proposals

- Maintain precautionary approach.
- Aims to promote consistency in risk assessment across the EU.
- Direct and indirect, immediate and delayed environmental impacts to be explicitly included in risk assessment.
- Monitoring plans to be included.
- Renewal of consent to market required after 7 year period.
- Product based consents continue to be allowed – e.g. GMO pesticide could be evaluated under pesticides regulations.
- Streamlining authorisation procedures to reduce evaluation times.
- Reinforcement of EC Scientific Committees advisory role on applications.

The Commission proposal has no provision for a socio-economic 'risk' assessment, or references to sustainable development which environmental and consumer organisations, and some Member States, would like to see included in the revision. Austria, in its implementing legislation of the Deliberate Release Directive, does require GMO releases to comply with principles of sustainability. However, Austria does not appear to have tested applications under this part of the regulations yet. The Finnish Gene Technology Act also calls for the '…development of gene technology in a way that is ethically acceptable'.

In February 1999 the EU Parliament, while acknowledging there could be potential benefits of GMOs, agreed over 100 amendments to the Commission proposal covering issues such as:

- a ban on releasing GMOs containing genes that are resistant to antibiotics in use for medical or veterinary treatment;
- measures to prevent gene transfer;
- unauthorised releases;
- mandatory monitoring of all releases;
- clear labelling and identification;
- compulsory liability insurance by those releasing the GMO;
- use of the precautionary principle;
- prior informed consent for exports to non EU countries;
- time periods for market approval.

How, what and when to monitor GMOs will be crucial issues and there will need to be some definition of how monitoring should be approached in the final Directive. Box 3.9.12 identifies some of the key ingredients of monitoring plans.

The disputes between Member States have concerned the scope of the Directive, what constitutes an adverse effect and (although the Deliberate Release Directive *in theory* only concerns itself with safety) the socio-economic factors some countries bring to bear implicitly or explicitly in their judgements (Levidow *et al.*, 1996). For example, under Austrian law, products should be assessed for 'social unsustainability' and some regulators have acknowledged to researchers that they do consider the presumed benefits. These issues are summarised in section 4 below.

3.2. Regulatory developments in non-EU countries

Other European countries have either followed the approach of the EU and brought in special regulations for GMOs or adapted existing laws, although not all countries have regulations in place, especially in central and eastern Europe. Where there are regulations, many of these, such as in Poland, the Czech Republic and Hungary have been specifically designed to conform to the relevant EU Directives. However, although Poland has framework GMO laws there are no implementing regulations.

Other countries such as Switzerland have adapted existing regulations to conform to EU Directives, underlining the importance of the approach taken by the EU in shaping the risk-assessment process across Europe.

Those European countries without any clearly defined GMO regulations (although most are in stages of development) are: Georgia; Russian Federation; Latvia; Moldavia; Romania; Slovenia; Ukraine; Croatia; Albania; Estonia.

The country with the most different approach in principle is Norway. The Norwegian 1993 Gene Technology Act at Section 1 'Purpose of the Act' demands that '... the production and use of genetically modified organisms takes place in an ethically and socially justifiable way, in accordance with the principle of sustainable development and without detrimental effects on health and the environment'.

The inclusion of an explicit reference to ethics, social justification and sustainable development allows a different framework of risk evaluation to take place than that which is possible under the EU approach. In requiring these issues to be addressed in public, the Norwegian legislation recognises the inability of scientific risk-assessment knowledge to provide the sole means of 'closure' in such decisions. 'Justification' or social need is difficult to determine, but there may be lessons from the field of radiation, where justification has long been a part of international and national regulations.

3.3. International dimensions of GMO releases and regulations

There are also international dimensions to the regulation and use of GMOs. The most important include the World Trade Organisation's risk-assessment rules and the Biosafety Protocol as part of the international Convention on Biological Diversity.

3.3.1. World trade rules

There is tension between the demands for environmental protection and free trade. The US advocates the primacy of free trade, whereas the European Union considers that appeals under multilateral environmental agreements should have the same status as appeals to World Trade Organisation (WTO) rules on unjustified barriers to trade. Biotechnology and biodiversity policies are framed by the *Agreement on the Application of Sanitary and Phytosanitary measures* under WTO ruling and the negotiations on a *Biosafety Protocol* under the Convention on Biological Diversity (CBD). The trade versus environment issue is reflected in the disputes on the development of both regulatory frameworks.

Most of the WTO trade negotiations are aimed at not making a distinction between so called *non-product-related process and production methods* (PPMs). The current EU Deliberate Release Directive, however, is a process-based regulation and could therefore be challenged regarding some aspects under WTO ruling. The trade-environment dilemma is also present in the basic agreement on Agenda 21 at the UNCED conference in 1992. The precautionary principle was accepted at that conference as a basic principle for environmental policy but it is was also accepted that there should be 'no unfair or unjustified barriers for trade' imposed by national governments. Since the implementation of the precautionary principle leaves open a grey area of how trade barriers could be justified by scientific risk assessments alone, trade versus environment will remain a source of dispute between trade partners.

Box 3.9.12. Some key requirements of monitoring GMOs following market authorisations

Several levels of monitoring interconnecting with other nature conservation monitoring plans:

- baseline studies of areas without GMOs for comparison;
- following changes in agricultural practices and their impacts;
- specific studies related to GMO itself e.g. manipulated gene flow.

Minimum standards with room for additions:

- specified studies of transgene flow and relevant ecological parameters such as insect abundance and diversity for insect-resistant crops;
- specified basic information on agricultural practices the GMO is used in;
- flexibility to allow for additional monitoring should new knowledge require it, or for reduced monitoring if not needed.

Intelligence gathering:

- collection of data on how and where the GMO is being used and its end fate;
- tracking public attitudes to GMOs;
- political and regulatory developments;
- transgene and resistance;
- monitoring compliance with license conditions (e.g. crop isolation measures);
- systems that maximize the chances of discovering 'surprises'.

Labelling of GM products has formed one of the first areas of disagreement between trading partners in the biotechnology domain. Mandatory labelling schemes, such as the recent European Council Regulation 1139/98 concerning the compulsory labelling of products based on genetically modified soya or maize, would fall under the WTO Technical Barriers to Trade (TBT) Code, since it is a practice which forces producers to create separate production arrangements for the markets which require labelling. However, this mandatory labelling practice imposes the same requirements upon foreign and Community producers, which is the most basic requirement of WTO obligations.

Other countries such as Japan are preparing similar regulations as the EU. Labelling requirements may be justified under Article 2.2 of the WTO's Technical Barriers to Trade agreement which mentions a non-limited list of possible legitimate objectives for technical barriers to trade: 'inter alia national security requirements; the prevention of deceptive practices; protection of human health or safety, animal or plant life or health, or the environment'.

'Consumer concerns', or 'a right of free consumer choice', or basic ethical values may be added to this list. The justification for labelling in the Europe with respect to GMOs is also related to the issue of safety and precautionary measures. Labelling facilitates tracing products in the production chain. The revision of Directive 90/220 (see section 3.1 above) foresees post-marketing monitoring of products which would be difficult to implement without labelled products. In addition, the Biosafety Protocol (see section 3.3.2 below) is likely to include requirements with respect to the labelling of, or the documentation to accompany, GMOs.

Countries which want to institute measures which restrict trade can justify these under the WTO when they are, among other things, necessary to protect human, animal or plant life or health, or relate to the natural conservation of exhaustible natural resources. These measures must not constitute 'a means of arbitrary or unjustifiable discrimination among countries where the same conditions apply, or as a disguised restriction on international trade'. The Environment field (including biodiversity) could, therefore, be a major exception to normal rules of free international trade. Parties can base their environmental case on either Multilateral Environmental Agreements or on real efforts to negotiate such agreements with parties before implementing environmental protection measures. They must also provide scientific evidence on the potentially adverse effects, including justification of any use of the precautionary principle. Disputes among WTO Members can be resolved by Article 5.7 of the Sanitary and Phytosanitary (SPS) Measures.

3.3.2. The Biosafety Protocol

Under the Convention on Biological Diversity, a Biosafety Protocol is being negotiated. The Protocol should provide a minimal legal framework for transboundary movements of living modified organisms (LMOs) for which there are currently no international rules.

The EU position has emphasised informed consent on the part of importers, to be facilitated by an Advance Informed Agreement Procedure for the transboundary movement of LMOs.

The US has called for a 'superiority clause' to be part of the Protocol which would make the biosafety protocol subordinate to the rules of WTO, in the event that the Protocol give rise to trade conflicts. The EU opposes this and wants to see Multilateral Environmental Agreements as complementary to the rulings of the WTO and to make them mutually supportive. Disputes over this, the scope of the protocol, the precautionary principle, and socio-economic impacts prevented an agreement at the Cartegna meeting in February 1999.

There are also International Technical Guidelines from the United National Environment Programme (UNEP) for Biosafety; they cover the assessment of the risks of GMOs for use by countries either in developing regims or when developing regulations. These were developed in advance of the Biosafety Protocol being negotiated and have helped restrict the scope of the Protocol which many nations had originally expected to include all uses, not only transboundary movement.

4. Defining risk assessments for GMOs

4.1. The Deliberate Release Directive in the European Union

The EU Deliberate Release Directive has been criticised because of its limited scope, excluding, for example, issues of agricultural practice and interactions, and also because assessments of GMOs allegedly give insufficient weight to their benefits.

4.1.1. The scope of the Directive

Differences over the scope of the Directive have been the most evident problem. These centre on whether the assessment should include secondary effects, not directly attributable to the GMO but related to the system of use. Some countries including Austria and Denmark have wanted to include the impacts on agriculture in their assessment of environmental harm. In the case of herbicide-tolerant crops, for example, this entails extending the assessment to include the impact of the herbicide and its changing use as a result of the introduction of the GMO.

Austrian research has questioned whether it is the deliberately engineered trait of a GM crop which has the greatest influence on its final environmental effect (Torgersen, 1996). Their research suggests that agricultural or horticultural practices have a greater influence on the environmental effects of the crop than do organism-specific parameters such as 'invasiveness' and 'gene transfer' which are more commonly associated with safety and which form the questions included in the risk assessment under the Deliberate Release Directive. The implications are that environmental effects of the GMOs may be more contingent upon the local environmental and agricultural conditions than was previously thought – hence less deterministically predictable and likely to vary across the EU.

As well as differences in ecosystems and in agricultural systems there are also cultural and social differences between Member States in their approaches to food production and environmental protection. There may also be commitments to environmental protection made under other legislation, such as the Habitats Directive and the Biodiversity Convention, which are relevant to judgements about the acceptability of certain impacts but these wider consequences tend to be hidden in the specific discussions over one single GMO marketing authorisation as framed by the current regulatory system.

Other countries, such as the UK and the Netherlands, have adhered to a restricted scope for the risk assessment by considering only the direct effects associated with the GMO, leaving issues of pesticide use and agricultural practice to be addressed under pesticides regulations (see for example Advisory Committee on Releases to the Environment, 1997). Table 3.9.3 outlines the differences between countries in how they view the scope of the risk assessment under the Deliberate Release Directive and Box 3.9.13 shows that different interpretations of the scope can affect how a risk assessment is undertaken.

4.1.2. Defining an 'adverse' effect

Directive 90/220 leaves open what precisely can be considered as an 'adverse effect on human health and the environment' and what could be 'a sufficient demonstration of safety'. The combination of a case-by-case evaluation and the absence of fixed standards for evaluating these cases provide the background for ongoing deliberations at national level and in scientific advisory committees. And because knowledge is evolving, standards could be relaxed or strengthened over time depending on the accumulation of scientific evidence. For instance, the transgene transfer from GMOs to wild relatives may either be perceived as 'genetic pollution' or as a natural (and therefore acceptable) process depending on our knowledge of whether such a gene transfer poses a threat.

Member States also have differences in their 'yardsticks' against which they measure the direct environmental effects which can be attributed to the GMO itself. For example, comparisons may be made with reference to the effect on conventional agriculture (UK), safeguarding environmental, nature and health interests (Denmark/Sweden) or reduction of biodiversity (Denmark, Sweden, Italy, Austria) (Table 3.9.3). However, even if the same comparison was made to, say, conventional agriculture in all Member States the outcomes would still be different. 'Conventional' agriculture (meaning agriculture as it is currently practised) is very different in, say, Austria, Spain and the UK.

In addition a number of Biogeographic Zones have been defined in Europe and are the basis for the selection of Special Areas of Protection under the Habitats Directive. They contain significantly different ecosystems and species assemblages. The possible effects of GMOs on such ecosystems requires local consideration and knowledge. It cannot be performed meaningfully and with scientific validity on an EU-wide basis.

So instead of fixed and uniform standards, individual Member States use flexible standards to define the acceptability of releases such as 'Reduction of biodiversity' or 'comparison with the risks of conventional agricultural practices'.

Box 3.9.13. Assessing the effects of herbicide-tolerant crops – how the scope of the assessment may influence the outcome

Examples of effects considered under an assessment approach with restricted scope:

- Gene flow to wild species;
- Potential for becoming a persistent weed;
- Potential to invade and disrupt ecosystems;
- Toxicity;
- Individual crops.

Examples of effects considered under an assessment approach with a broad scope:

- Assessment of total benefits, costs and uncertainties in weed control systems.
- Altered pattern of herbicide use and effects on biodiversity.
- Cumulative impacts on gene flow, invasiveness etc of multiple releases.
- Practical implications of the emergence of herbicide tolerance in weeds.
- Cumulative impacts from use on large, adjoining areas from multiple releases.

One of the most contentious areas has been the use of antibiotic-resistance marker genes. This has been seen in the Novartis insect and herbicide-resistant maize which carries a gene coding for resistance to the clinically important antibiotic ampicillin. Austria and Luxembourg have introduced bans on its use under Article 16 of the Deliberate Release Directive because of the presence of this gene and other concerns (see Box 3.9.2). Other Member States have also had concerns about the ampicillin resistance gene, including the UK whose scientific advisory committee advised against allowing the marketing of the maize on these grounds. However, the two EU Scientific Committees which evaluated this point concluded that the ampicillin antibiotic gene does not raise a safety issue.

4.2. Knowledge limitations, uncertainties … and their resolution?

Although it is a part of any precautionary approach, the 'step-by-step, case-by-case' approach to safety has limitations. Cumulative impacts are neglected and small-scale trials may be an inadequate predictor of performance in the wider environment (GeneWatch, 1998). In addition, since the majority of field trials also consider agronomic traits such as yield it has been argued that they produce little relevant data for environmental risk assessment (Rissler & Mellon, 1993). Thus, remaining uncertainty is a pervasive problem, leaving explicit or implicit value judgements to be made. Even with commercially authorised GM crops, as a large-scale experiment is being conducted on the environment it would seem sensible, at the very least, to monitor the effects.

Despite all the controversies, no political actor, organisation or Member State has questioned the necessity of a precautionary approach (Von Schomberg, 1998). Although the lack of standards has caused disputes between Member States, perhaps this reflection and deliberation should be seen in a positive context as an inevitable part of balancing risk and innovation. GMO regulation is controversial but it can help facilitate the resolution of generic issues that surround the development of new technologies (Box 3.9.14).

Table 3.9.3. **Differences in interpretation of the Deliberate Release Directive***

	Germany	United Kingdom	The Netherlands	Denmark/ Sweden	Belgium	Italy	Austria	France
Scope	Safety	Safety	Safety/ biodiversity	Safety/ biodiversity/ agronomic effects	Safety/ biodiversity	Safety/ biodiversity/ agronomic effects	Safety/ biodiversity/ agronomic effects	Safety
Evaluation of Adverse Effects	Safety concerns in relation to the purpose of the release	No additional risk in comparison to conventional agricultural practice	Persistant effects on the composition of natural vegetation	Safeguarding environmental, nature and health interests Sustainable development	No aggravation of existing environmental problems through releases	May change on a case-by-case basis	Compliance with social institutions and conventions	Knowledge of the genetic construct of the organism

* Since this comparison was made some Member States have begun to expand the scope of their environmental assessment to include secondary effects on biodiversity and agricultural practice.

Source: Von Schomberg, 1998

Box 3.9.14. GMO regulation can facilitate:

1. An ongoing scientific and policy deliberation on managing uncertainties in a public policy context. This includes taking decisions not only on available data but also on plausible notions of what could be the case.

2. An ongoing public policy and scientific discussion on transformable/flexible standards within the regulatory framework but also in the societal context of this regulatory framework.

3. The awareness of the need for monitoring and continuous interest in the experience with releases and market products.

4. The awareness of the need for a long-term and holistic perspective, which is implemented by a precautionary and flexible practice.

5. EU-wide comparative discussion of different Member States' resolutions of trade-offs between scientific uncertainties and public values.

6. Debate about the trade-offs between single-market uniformity of risk assessment commit-ments and Member State variations in interpretation.

7. Resolution of the ' free trade' and environment/ health conflicts.

8. The development of acceptable approaches to the generic safety, health and environment issues that surround the development of new technologies, such as:

- justification , or 'need',
- risks to safety, health and environment,
- managing uncertainty and applying the precautionary principle,
- implementation and enforcement of measures,
- monitoring of impacts,
- information to the public via labels and emissions/release inventories,
- liability,
- informed consent for export/imports, and
- trade and risk trade- offs.

References

ACRE, 1998. UK Advisory Committee on Release to the Environment. *Genetically modified crops: wider issues - Biodiversity in the agricultural environment*. http://www.environment.detr.gov.uk/acre/index.htm.

Action Aid, 1998. Letter in *The Observer*, 9th August 1998.

Advisory Committee on Novel Foods and Processes, 1994. 'Report on the use of antibiotic resistance markers in genetically modified food organisms.' July 1994. MAFF, London.

Advisory Committee on Releases to the Environment, 1997, *Annual Report* No 4: 1996/97. DETR, London.

Baranger, A., Chevre, A.M., Eber, F., Renard, M., 1995. Effect of oilseed rape genotype on the spontaneous hybridization rate with a weedy species: an assessment of transgene dispersal. *Theor. Appl. Genet.* 91: 956-963.

Bing, D.J., Downey, R.K., Rakow, G.F.W., 1996. 'Hybridizations among *Brassica napus*, *B. rapa* and *B. juncea* and their two weedy relatives *B. nigra* and *Sinapis arvensis* under open pollination conditions in the field.' *Plant Breeding* 115: 470-473.

Biotechnology and the European Public Concerted Action Group, 1997. 'Europe ambivalent on biotechnology.' *Nature* 387: 845-847.

Biotechnology Working Group, 1990. *Biotechnology's Bitter Harvest*. Biotechnology Working Group: Washington DC.

Chevre, A.M., Eber, F., Baranger, A., Kerlan, M.C., Barret, P., Vallee, P., Renard, M., 1996. 'Interspecific gene flow as a component of risk assessment for transgenic Brassicas.' Ninth Crucifer genetic workshop. ISHS. Ed. J.S. Dias, I. Crute, A.A. Monteiro, *Acta Horticulturae* 407: 169-179.

Chevre, A.M., Eber, F., Baranger, A., Renard ,M., 1997. 'Gene flow from transgenic crops.' *Nature* 389: 924.

Chevre, A.M., Eber, F., Baranger, A., Hureau, G., Barret, P., Picault, H., Renard, M., 1998. Characteri-zation of backcross generations obtained under field conditions from oilseed rape-wild radish F1 interspecific hybrids : an assessment of transgene dispersal. *Theor. Appl. Genet.* 97: 90-98.

Clydesdale, F.M. (ed) (1996) 'Allergenicity of foods produced by genetic modification.' *Food Science and Nutrition* Vol 36 Special Supplement.

Crawley M.J., Brown S.L., 1995. 'Seed limitation and the dynamics of feral oilseed rape on M25 motorway.' *Proc. of the Royal Society* 259 :49-54.

Darmency, H., Fleury, A., Lefol, E., 1995. 'Effect of transgenic release on weed biodiversity: oilseed rape and wild radish. 'Brighton Crop Protection Conference – *Weeds:* 433-438

Darmency H., Lefol E., Fleury A., 1998. 'Spontaneous hybridizations between oilseed rape and wild radish.' *Molecular Ecology* (in press).

Eber, F., Chevre, A.M., Baranger, A., Vallee, P., Tanguy, X., Renard, M., 1994. 'Spontaneous hybridization between a male sterile oilseed rape and two weeds.' *Theor. Appl. Genet.* 88 : 362-368.

Emberlin, J., 1999. *The Dispersal of Maize Pollen,* Natural Pollen Research Unit, UK.

ENDS, 1998. 'Dimming outlook for GM crops as Mem- ber States go it alone.' *ENDS Report* 285, p 46-47.

European Commission, 1998. *Proposal for a Directive of the European Parliament and of the Council amending Council Directive 90/220 on the deliberate release into the environment of genetically modified organisms.*

FOE, 1999. 'Monsanto sues N. American Farmers', Friends of the Earth, *Biotech Mailout* Vol. 5, Issue 2, Brussels.

GeneWatch, 1998. *Genetically engineerered oilseed rape: agricultural saviour or new form of pollution?* GeneWatch, Tideswell, UK

Grove-White, R., Macnaghton, P., Mayer, S. & Wynne, B., 1997. 'Uncertain World. Genetically modified organisms: food and public attitudes in Britain.' Centre for the Study of Environmental Change, Lancaster.

Hamstra, A.M., 1995. *Consumer acceptance model for food biotechnology.* Final Report. SWOKA, Institute for Consumer Research, The Netherlands.

Hilbeck, A., Baumgartner, M., Fried, P.M. & Bigler, F., 1998. 'Effects of transgenic *Bacillus thuringensis* corn-fed prey on mortality and development of immature *Chrysoperla carnea* (Neuraptera: Chrysopidae).' *Environmental Entomology* 27: 480-487.

Jorgensen R.B. and Andersen B., 1994. 'Spontaneous hybridization between oilseed rape (*Brassica napus*) and a weedy *B. campestris* (Brassicaceae) : a risk of growing genetically modified oilseed rape.' *American Journal of Botany* 81 (12): 1620-1626.

Jorgensen R.B., *et al.*, 1998. 'Introgression of crop genes from oilseed rape (*Brassica napus*) to related wild species- an avenue for the escape of engineered genes.' Brassica 97. International symposium on Brassicas. ISHS. Ed. G. Thomas, A. Monteiro, *Acta Horticulturae* 459 : 211-217.

Kerlan M.C. *et al.*, 1992. 'Risk assesssment of outcrossing of transgenic rapeseed to related species: I. Interspecific hybrid production under optimal conditions with emphasis on pollination and fertilization.' *Euphytica* 62: 145-153.

Lavigne C. *et al.*, 1998. 'A pollen-dispersal experiment with transgenic oilseed rape. Estimation of the average pollen dispersal of an individual plant within a field.' *Theor. Appl. Genet.* 96 : 886-896.

Lefol, E., Fleury, A. and Darmency, H., 1996a. 'Gene dispersal from transgenic crops II. Hybridization between oilseed rape and the wild hoary mustard.' *Sex. Plant. Reprod.* 9 :189-196.

Lefol E., Danielou, V., Darmency, H., 1996b. 'Predicting hybridization between transgenic oilseed rape and wild mustard.' *Field Crops Research* 45:153-161.

Levidow *et al.*, 1996. 'Regulating agriculture biotechnology in Europe: harmonisation difficulties, opportunities, dilemmas'. *Science and Public Policy*, Vol. 23-3, P133-200, June 1996.

Lex, M., 1995. 'Promoting the competitiveness of biotechnology in Europe.' *TIBTECH* 13: 39-41.

Lukaszewski A.J., 1995. 'Physical distribution of translocations breakpoints in homoeologous recombinants induced by the absence of Ph1 gene in wheat and triticale.' *Theor. Appl. Genet.* 90 : 714-719.

Mayer, S., Hill, J., Grove-White, R. & Wynne, B., 1996. 'Uncertainty, precaution and decision making: the release of genetically modified organisms into the environment.' Global Environmental Change Programme Briefing, University of Sussex.

Messean A., 1997. 'Management of herbicide-tolerant crops in Europe.' The 1997 Brighton Crop Conference – *Weeds:* 947-954.

Mikkelsen T.R., Jensen J., Jorgensen R.B., 1996a. 'Inheritence of oilseed rape (*Brassica napus*) RAPD markers in a backcross progeny with *Brassica campestris*.' *Theor. Appl. Genet.* 92 :492-497.

Mikkelsen T.R., Andersen B., Bagger Jorgensen R., 1996b. 'The risk of crop transgene spread.' *Nature* 380: 31.

Miller, H.I. & Gunary, D., 1993. 'Serious flaws in the horizontal approach to biotechnology risk.' *Science* 262: 1500-1501

Miller, H.I., 1994. 'A need to reinvent biotechnology regulation at the EPA.' *Science* 266: 1815-1818.

Monsanto, 1998. 'Worrying about starving future generations won't feed them. Food biotechnology will.' Advertisement in *The Observer*, 2 August 1998.

O'Brien, T., 1995. *Gene transfer and the welfare of farm animals.* Compassion in World Farming Trust, Petersfield, Hants.

Picard-Nizou A.L., Grison R., Olsen L., Pioche C., Arnold G., Pham-Delegue M.H., 1997. 'Impacts of proteins used in plant genetic engineering : toxicity and behavioral study in the honeybee.' *J. Econ. Entomol.* 90 : 1710-1716.

Price J.S., Hobson R.N., Neale M.A., Bruce D.M., 1996. 'Seed losses in commercial harvesting of oilseed rape.' *J. Agric. Engng Res.* 65 :183-191.

Rissler and Mellon, 1993. 'Perils amidst the promise ecological risks of transgenic crops in a global market', Union of Concerned Scientists, Cambridge.

Royal Commission for Environmental Pollution, 1989. *The Release of Genetically Engineered Organisms into the Environment.* HMSO: London.

Royal Society, 1998. *Genetically modified plants for food use*, London.

Scheffler J.A., Dale P.J., 1994. 'Opportunities for gene transfer from transgenic oilseed rape (*Brassica napus*) to related species.' *Transgenic Res.* 2 : 356-364.

Scheffler J.A., Parkinson R., Dale P.J., 1993. 'Frequency and distance of pollen dispersal from transgenic oil-seed rape (*Brassica napus*).' *Transgenic Res.* 2 :356-364.

Schiva, V., 1999. *Biopiracy: The Plunder of Nature and Knowledge*, Green Books, UK.

Sianese, B. and Ulph, D., 1998. *Species Loss through the Genetic Modification of Crops: a Policy Framework.* CSERGE Working Paper GEC 98-25, Centre for Social and Economic Research on the Global Environment, University of East Anglia, Norwich.

Tiede, J.M., Colwell, R.K., Grossman, Y.L., Hodson, R.E., Kenski, R.E., Mack, R.N. & Regal, P.J., 1989. 'The planned introduction of genetically engineered organisms: ecological considerations and recommendations. '*Ecology* 70: 298-315.

Timmons A.M., O'Brien E.T., Charters Y.M., Dubbels S.J., Wilkinson M.J., 1995. 'Assessing the risks of wind pollination from fields of genetically modified *Brassica napus* ssp. Oleifera.' *Euphytica* 85 : 417-423.

Torgersen, H., 1996. *Ecological impacts of traditional crop plants – a basis for the assessment of transgenic plants?* Federal Environment Agency: Vienna.

UNEP (United Nations Environment Programme), 1990. Note to UNEP on basic issues with respect to biotechnolgy and conservation of biological diversity. Ad hoc working group of experts on biological diversity, subworking group on biotechnology. Nairobi, UNEP, 14-16 Nov. 1999. (UNEP/Bio.Div/SWGB.1/2, 15 Oct. 1990, Annex 2.)

Von Schomberg, R., 1998. *An appraisal of the working in practice of directive 90/220/EEC on the deliberate release of Genetically Modified Organisms*, STOA, European Parliament, Luxembourg, January 1998.

3.10. Human health issues

Main findings

The environment in which people live, work and play is an important determinant of health and well-being, but the extent of its importance in developed economies is difficult to quantify.

The most common diseases in the EU – heart and circulatory diseases, cancer, respiratory diseases, stress and related symptoms – have many causes which are often interconnected; including genetics, the condition people are in (via diet, exercise etc.), and the environmental circumstances to which they are exposed.

Identifying cause-and-effect relationships is therefore very difficult, especially if the impact of the environment on health is delayed, or is the product of many, perhaps small, environmental factors acting together.

There is a serious lack of data and information on exposures, effects and biological models that connect them. Therefore considerable uncertainty surrounds many issues of concern, such as air pollution, noise, water contamination, waste, climate change, chemicals (including endocrine disruptors and antibiotics) and non-ionising radiation.

In many cases, however there is sufficient evidence to take preventive action, particularly where the impacts may be serious, large-scale and irreversible – circumstances which merit the use of the precautionary principle. Preventive action on many of the environmental hazards covered in this chapter is being taken, but more integrated and effective action is being proposed to reduce threats to health and well-being.

1. Introduction

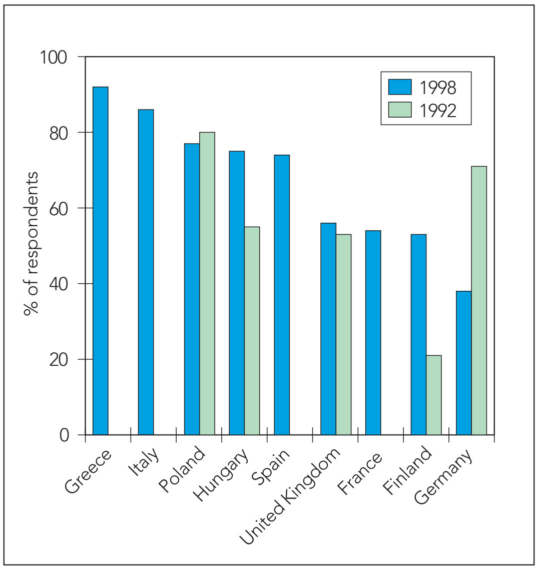
'The environment is everything which isn't me.'
— Albert Einstein

People are at the centre of 'their' world, as Einstein observed, but they are also part of the environment, and play a significant role in shaping it, as Chapter 2.1. and other chapters have shown. But the relationship is not just unidirectional: the environment 'shapes' people by the impact it has on their health.

This is not just in the obvious ways of sustaining life, through the provision of food, water and shelter, but also through the less visible impact it has on genes, cells, organs and biological systems which together can cause disease. In the more developed economies – such as the EU – where basic supplies of clean water and sewage facilities are generally available, environmental impacts on health are often less obvious – and more insidious – than in developing countries. However, people feel very concerned about the links between their environment and their health, and more so now than in the early 1990s when environmental issues were much higher on their and the media's agenda (Figure 3.10.1). Politicians have reflected this concern and declared that human health is a key objective of environ-

Opinions: Proportion of respondents who believe environmental problems affect their health a great deal/fair amount in 1992 and 1998

Figure 3.10.1



Source: Environics International, 1998 mental policies (Box 3.10.1). However, unravelling the less obvious connections between the environment and health in developed economies is not easy.

Damage to health is the result of many factors acting in various combinations, over different time periods, to a diverse range of people, of varying sensitivities, and at different stages of their lives (Figure 3.10.2). Understanding the complexities of what causes ill health is clearly going to be difficult – and, very often the more we know, the more we realise what we don't know. It is not surprising, therefore, that scientific and public controversies over environment and health have been or are currently common within scientific and public circles (e.g. leaded petrol and brain damage in children, or antibiotic growth promoters in animal feed and increased human resistance to antibiotics). Public policy decisions on environmental *hazards* (potential damage) and *risks* (probable damage) are difficult to make and evaluate. However, understanding the types of information needed for environmental health decision-making (as well as its use and limitations) will contribute to a wider appreciation of the reasons for public concerns, differences in expert opinions and the action (or inaction), of governments.

Environmental stresses for which there are reasonably good exposure and effect data are estimated to be a major factor in an estimated 5% of disease, according to preliminary report prepared for the WHO on the basis of Dutch data (WHO, 1999a; De Hollander *et al.*, in press). The main components of this environmental fraction are: external air pollution, which accounts for most of the total environment related health loss in the Netherlands (in terms of reduced life expectancy, the quality of life and number of people affected); environmental noise and indoor air pollution, including radon, damp and environmental tobacco smoke. Lead in drinking water is also significant. Traffic and domestic accidents, which together would bring the total environmental fraction of disease causation from 5% to 12% are very important public health hazards, but are not normally considered as environmental health issues.

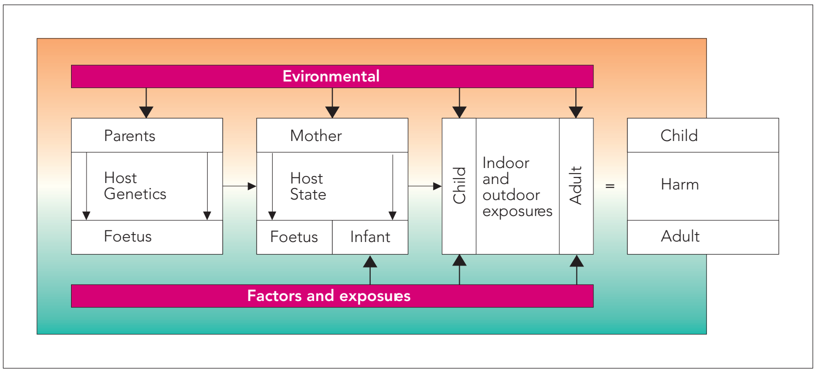
Box 3.10.1. Health and the environment: key declarations

The environment should be regarded as a resource for improving living conditions and increasing well-being (Frankfurt Conference, WHO 1989).

Human beings are at the centre of concern for sustainable development. They are entitled to a healthy and productive life in harmony with nature (Earth Summit, Rio de Janeiro, UNCED 1993).

We have a shared goal before us: to improve the living and health conditions of the present generation, to ensure that the carrying capacity of nature is not exceeded and that the right of the future generations to a satisfying and productive life is safeguarded (Helsinki Conference, WHO 1994).

Figure 3.10.2 **Environment, people and health: some key relationships**



Environmental factors (e.g. overcrowding, diet, climate, stress) and exposures (e.g. from air, food, drink, surfaces) play a part in causing and/or aggravating disease and ill health, both directly and via parents.

Source: EEA

2. Some dominant environmental health issues in Europe

2.1. Air pollution

Atmospheric pollution is a major cause of exposure to substances which are hazardous to health: the causes and effects of air pollution are discussed in chapters 3.3 and 3.4.

2.1.1 Exposure of European population to ambient air pollutants

Exposure data on suspended particulate matter is poor and is still measured by different methods throughout Europe, and the measurements of size-fractionated particulate matter of health relevance (PM10 or PM2.5, i.e. particles up to 10 and 2.5 microns in size respectively) has been introduced in only a few countries. This scarce data has to be extrapolated which increases the uncertainty of the analysis. Therefore the estimates presented below provide just an indication of the possible magnitude of the effects (Figure 3.10.3).

Box 3.10.2. Scope of the chapter

The scope of this chapter, which summarises some key environmental health impacts, is limited to a selection of those environmental stresses to which people may be exposed at home or out of doors, and which illustrates a range of health impacts and knowledge about their links to the environment. The selected information presented is designed to illustrate some general points about the links between environment and health, rather than being a comprehensive review of the literature, which is beyond the scope of this chapter. Where the issue is very well covered in other publications, such as climate change (WHO, 1999b), relatively little space is devoted to it.

The chapters on waste, hazardous substances, transboundary air pollution, climate change, stratospheric ozone, urban areas and water stress provide background information on the driving forces, pressures and associated exposures that are linked to health problems.

This chapter does not cover occupational impacts on health in much detail, despite its significant influence on public health. Fully integrated approaches to health need to include potential stresses from all parts of the environment. This is not only because human lungs and livers do not discriminate between pollutants that come from the factory or the street. but also because the sum of the exposure to stresses from all sources may be either additive, synergistic (more than the sum of the parts) or antagonistic (less than the sum of the parts), and therefore need to be included in any integrated assessment of environmental health risks (La Dou, 1998).

Knowledge of the distribution of environmental health impacts between e.g. social groups, geographical areas and generations is critical for undertaking fully integrated assessments, but apart from a few references to geography, age, class and future generations, these equity issues are beyond the scope of this chapter (Luhmann *et al.*, 1998).

A more comprehensive view of this field is available from the report 'Overview of Environment and Health in Europe in the 1990s' prepared by WHO for the 3rd European Conference on Environment and Health held in London in June 1999 (WHO, 1999a).

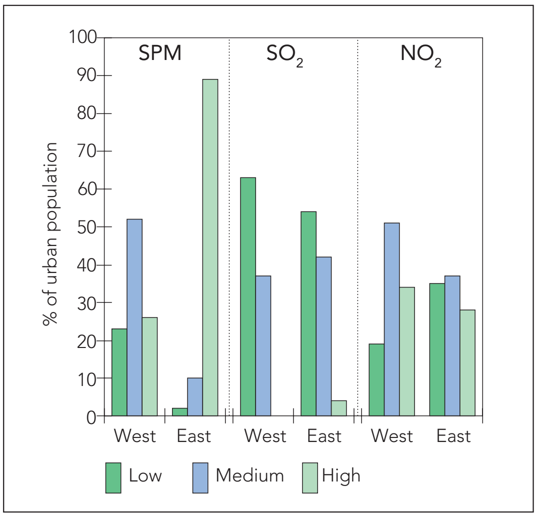
Over 24% of EU urban residents live in cities where the annual mean concentration of particulate matter (SPM) exceeds 30 µg/m^3. In the eastern part of Europe for which the data was available, close to 90% of the population live in cities with such relatively high concentration of particles. Trends in SPM were better in EU countries than in the rest of Europe, with 35% of people in EU experiencing more than a 5% per year reduction in SPM levels (21% in central Europe) and only 12% experiencing a more than 5% per year increase in SPM concentration (27% for central Europe) (for further information on urban air pollution, see Chapter 3.12).

Most of the population of Europe now lives in cities with low or medium concentrations of SO_2. In EU, 97% of urban residents have enjoyed reductions in SO_2 concentrations, whereas in the central part of Europe, almost of 20% of urban residents experienced increasing concentrations of SO_2.

More people in the western cities were exposed to medium and high levels of NO_2 than in central Europe. However, the trends were mostly stable (for 60% of urban residents) or decreasing (15%) in the EU countries, while NO_2 concentration increased for 43% residents of cities in central Europe.

Concentration of lead in ambient air has been decreasing over the recent decade, mainly due to the phasing out of lead from petrol. Several 'hot spots' were still observed in eastern Europe at the end of 1980s, mainly due to the poorly controlled emissions from industrial point sources. Monitoring data indicates that relatively high lead concentrations were also measured in the proximity of busy roads in several large cities in western Europe (Zaragosa, Toulouse, Lyon) in the early 1990s. More recent data indicates that concentration of lead in ambient air was decreasing even in those highly-polluted locations in the 1990s.

Exposure to common air pollutants — Figure 3.10.3



Data on concentration of the most commonly-monitored air pollutants (suspended particulate matter, SO_2 and NO_2) is shown for 1995 or later.

In total, information on one or more pollutants is available from 110 cities in 24 countries, including 64 cities in 13 EU countries with close to 58 million residents.

Source: EEA-ETC AQ and WHO/ECEH

2.1.2. Estimates of health impacts of some ambient air pollution in the EU

The most common of the well-known air pollutants (suspended particulate matter and ozone) are associated with ill health even at relatively low concentrations of the pollutants frequently experienced by people in Europe. This observation comes from a number of studies on the effects of daily changes in pollution levels conducted in many parts of the world, including Europe, as well as from a few studies on the health effects of longer term exposures, most of which have been conducted in the United States. The results of these new studies have been used in the revision and update of the WHO Air Quality Guidelines, which, in turn, provide a basis for the work on the new so-called 'Daughter' Directives to the EU Air Quality Framework Directive (96/62/EC), which will set revised limit values for the main air pollutants.

The most important message from these studies is the health significance of particulate matter at low levels. The effects include short-term impacts on pulmonary function, increased incidence of respiratory symptoms, and increased mortality implying considerable reductions in life expectancy. However, there is still discussion on the applicability of the results from long-term studies conducted in the United States to European conditions. One of the reasons for doubts are the possible differences in the composition of the pollution mix in the European and American cities.

In combining the information from epidemiological studies with the data on ambient concentration of main air pollutants, it is possible to calculate a proportion of health problems which can be associated with the exposure (Krzyzanowski, 1997).

The effects of *long-term* exposure to suspended particulate matter are the most important health effect of ambient air pollution in Europe, and are involved in perhaps 41 000 to 152 000 extra deaths of respiratory diseases per year in the EU cities. These effects occur at various concentration levels, including concentrations considered as 'low' and reduce life expectancy in middle age people (Brunekreef, 1997). The precise magnitude of the effects of long-term exposure is uncertain, within a wide range of estimates which reflects the weakness of the scientific evidence available.

Short-term variation of population health associated with the daily changes in air pollution levels is better documented. Air pollution with particulate matter is associated with more deaths (22 000 to 47 000 a year) or hospitalisation (4 000 to 8 000 admissions) than exposures to SO_2 and ozone which together are responsible for 3 000 to 6 000 deaths and 400 to 1 600 hospital admissions a year in the EU. It can be assumed that the health problems attributed to the pollution and registered through hospital admissions could have been avoided in the absence of the pollution. However, this interpretation is not valid for mortality (McMichael *et al.,* 1998). While there is an association between the daily number of deaths and air pollution level, it is not certain to what extent the life of the affected individuals is shortened by the exposure.

In summary, the available data from the 1990s indicates that a significant reduction in population exposure to sulphur dioxide has occurred in the last decade, and that this air pollutant remains a problem only in a limited number of cities in central Europe. However, the levels and trends of pollution with particulate matter are still of concern, and there is little improvement with respect to ambient levels of NO_2 or ozone. These components contribute to significant adverse impacts on public health, including increased mortality and reductions in life expectancy. The economic costs of these air pollution health impacts are considerable (WHO /EEA, 1997; Maddison, 1998).

2.1.3. Respiratory allergies and asthma

Outdoor air pollution also plays a role in the aggravation, and possibly the causation of asthma and other allergic responses, which are increasingly prevalent diseases, especially in children. Approximately 70% of outdoor air pollution penetrates indoors (WHO, 1999a) so that an integrated approach to both outdoor and indoor air pollution is needed. Other key components of indoor pollution which have been associated with respiratory and allergic responses are dust mites, spores from pets, damp, environmental tobacco smoke and NO_x from gas ovens.

The prevalence of asthma in children of school age varies from 4% to 27% in different parts of Europe. Wide geographical variation in asthma prevalence is also noted in adults. There is an indication that the prevalence rates have increased over the last decade. The frequency of asthma attacks, sometimes requiring medical assistance or hospitalisation, has been shown to be associ-

Box 3.10.3. Environment and immunity

There is increasing evidence that the fine ambient air particles involved in respiratory and cardio-vascular diseases impact on health via the immune system. Other examples of environmental stresses that have a negative impact on the immune system are:

- ultraviolet radiation, which is known to have effects on the immune system at doses that are currently encountered outdoors;
- natural and manmade chemicals, for which a large data base on laboratory animals shows effects on the immune system, suggesting that chronic exposures to even low concentrations may potentially have an impact on humans; and
- combinations of immunotoxic agents, such as in food, e.g. natural toxins, heavy metals etc.

However, except for allergies resulting from sensitisation by pollutants directly, there is little information or understanding about the link between negative effects on the immune system and adverse health effects in the individual. There are apparently large 'reserve capacities' in the immune system that can absorb negative effects without adverse effects on health. However, for individuals whose immune response system is already adversely affected by others stresses (e.g. infections), and for populations that contain susceptible people (e.g. the sick and the elderly), the reserve capacity may not be sufficient to prevent adverse health effects, such as allergies (skin and respiratory), or cancers. Therefore 'any deviation from the normal situation is considered undesirable: this 'precautionary principle' point of view is aimed at the prevention of adverse effects in the population' (European Commission, 1996). Small increases in the incidence and duration of frequently occurring diseases may have large social and economic impacts.

Further research is needed into identifying bio-markers that are relevant to adverse health effects, especially in sensitive groups such as children, pregnant women, the elderly and people with genetic pre-dispositions to immune system impacts.

Source: EEA, based on European Commission, 1996

ated with air pollution levels. However, it is not clear if environmental conditions can cause the onset of the disease or only make the symptoms worse. Moreover, it is not known to what extent the geographical variation in asthma levels and trends is related to environmental factors. Diet (e.g. less omega-3 fatty acids and antioxidants) or compromised immune systems (Box 3.10.3) are also implicated in the development of asthma. However, current data prompts more questions than answers (Strachan, 1995; UCB, 1997). Figure 3.10.10 in section 4 below illustrates the multi-causal chain of factors implicated in childhood asthma.

Radon is another indoor air pollutant that is responsible for several thousand lung cancer deaths a year in the EU, confined to particular localities where geological formations give off the radioactive gas into confined spaces of houses (WHO, 1999a).

2.2. Water

Water quality is a significant factor in exposure to health risks. In general, water pollution has declined in the EU, although concerns remain over localised quality problems, and particularly nitrate contamination of groundwater resources (see Chapter 3.5).

2.2.1. Quality of water

A Europe-wide assessment of drinking water quality and estimation of related health risks faces serious difficulties due to scarcity and comparability of appropriate data (Box 3.10.4). These problems are common to both EU and Accession Countries.

2.2.2 Drinking water contamination and some health effects

The detection systems across the EU for water-borne disease are generally poor and only the larger outbreaks are detected in practice. Outbreaks affecting less than 10-20% of the supplied population are rarely detected. Individual cases of gastrointestinal disease, even if registered by medical care systems, are impossible to link directly to water quality.

Inadequate microbiological water quality and occasional outbreaks of water-borne diseases are reported across the EU, even

Box 3.10.4. Problems with data for European assessment of health risks related to water quality

- Often limited to information on the coverage by services.
- Focused on operational control by water supply agencies and for compliance assessment by regulatory agencies.
- Limited availability if collected by suppliers from private sector.
- Not suitable for statistical analysis and international comparisons.
- Different drinking water quality standards resulting in non-comparability of percentage compliance data.
- Different approaches to laboratory analysis and poor inter-laboratory comparability.

from countries with high standards of supply (and notwithstanding the often limited sensitivity of surveillance systems). For example, 3 to 6 outbreaks of waterborne gastro-enteritis have been reported by Sweden each year in the 1990s (WHO/EEA, 1998). Contamination of drinking water by faecal coliforms is detected in 1-4% of samples analysed in many European countries. Microbiological pollution is especially prevalent in small supply systems, and in some countries private supplies are not subject to such stringent standards as public supplies. In up to 33% of water samples taken from small private water supply systems in Ireland, faecal coliforms were present in amounts exceeding the standard level in 1995.

Increasing chemical water pollution from agriculture is a significant problem in Europe. Nitrate concentrations in groundwater are generally low in northern Europe, but high in several western and eastern countries.

Increased contents of nitrate pose a risk of methaemoglobinaemia to infants, a potentially serious, life-threatening disease. However, the total number of cases of methaemoglobinaemia reported are low and from only a few countries, mainly in eastern Europe.

Old water distribution systems, using leaded pipes, may be a significant source of population exposure to lead, which, in turn, may affect neurobehavioural development of children (see Section 3.6. below). This exposure can be markedly reduced by adequate treatment of water before its distribution, to reduce the solvency and bioavailability of lead. In Glasgow for example, effects of exposure-reduction measures have been shown (Moore *et al.,* 1998). Increasing water alkalinity and adding organophosphate to the water supply reduced the concentration of lead (Pb) in drinking water, which in turn lead to parallel decreases in maternal-blood lead. Part of the observed reduction of lead blood levels is attributed to a decrease of lead exposure from non-water sources, such as lead in petrol, food cans etc.

Pesticides and their degradation products are, in some areas, found in drinking water

Box 3.10.5. Pharmaceutical substances in water, sewage etc.

Pharmaceutical substances, like pesticides, are designed to have a biological effect. As they are widely used as medicines, (up to a tonne/day in some countries) and as growth promoters and veterinary medicines in animals, their presence in the environment may be significant, following human and animal excretion and other routes of exposure. They have not received much attention, partly because exposure levels were thought to be too low to be of concern. However, as the effects of endocrine-disrupting substances can be observed at very low levels, similar levels of exposure to pharmaceuticals in the environment may be significant for human and ecological health.

About 70% of antibiotics used in fish farming are released into the environment (Schneider, 1994). Several studies have identified antibiotics in sediment cores beneath fish farms (Samuelson, 1992a; 1992b), in groundwater (Eckel et al., 1993; Hohm et al., 1995; Stan et al., 1994; Feuerpfeil et al., 1999), and in manure (Macri et al., 1998).

Modelling of exposure pathways and potential doses has indicated possible worst-case scenarios of 30 μg/kg for olaquindox and 70 μg/kg for tylosine, two pig-growth promoters (Jorgensen et al., 1998). Information about possible eco-toxic effects is rare, though some rather potent effects have been demonstrated for metronidazole and other antibiotics on green algae (Lanzky and Halling-Sørensen, 1997; Holten-Lutzhoft et al., 1999). There are few, if any, studies on possible impacts on endocrine or hormonal functions in either humans or wildlife (Halling-Sørensen et al., 1997; Andersen et al., in press). However, there is increasing evidence that the use of antibiotics as growth promoters in cattle, pigs and poultry can lead to increasing antibiotic resistance in both animals and humans via the food chain (Swedish Ministry of Agriculture, 1997). For example, Denmark has a higher frequency of resistance to enterococci in pigs (55-84%) than does Sweden (14-15%) which banned antibiotics as growth promoters in 1986. The transfer of antibiotic resistance from animals to humans is possible but there is as yet little or no data on the extent of the problem in humans caused by antibiotics from growth promoters in the food chain (Edqvist, 1997). However, vancomycin-resistant enterococci (VRE), which are associated with the use of avoparcin for growth promotion, have been identified in non-hospitalised humans who eat meat, but not in vegetarians). There is also a risk of the development of cross resistance involving several strains of bacteria. For example, Feuerpfeil found cross resistance in 8 types of microbes. The WHO recommends the reduction in the use of antibiotics as growth promoters and the EU has recently (Dec. 1998) banned four antibiotics (virgianmycin, spiranycin, tysolin phosphate and bacitracin zinc) and is investigating four others. However, the evidence on animal growth promoters is not clear: the European Federation of Feed Additives Manufacturers thinks there is insufficient scientific evidence for an EU ban (Swedish Ministry of Agriculture, 1997).

No new chemical class of antibiotics has been developed in the past 20 years, despite extensive research. This provides opportunities for increased resistance. It takes at least 10-20 years to find and clinically test new antibiotics, a time lag within which antibiotic resistance could increase without opposition from new drugs.

or in groundwater (see Chapter 3.7). Triazine herbicides are the pesticides most frequently detected in groundwaters and several countries have introduced bans or restrictions on the use of products containing the active ingredients. There has been a significant overall downward trend in the contamination of groundwater by triazine herbicides and their breakdown product in most countries, although this is not the case with all pesticides (see Chapter 3.5).

Data on microbiological quality of recreational waters is collected in some countries, principally for compliance assessment by regulatory agencies. EU Member States cooperate to produce an annual assessment of bathing water quality but despite many attempts to collate and compare data from different locations (nationally or internationally), the quality of such data has severe limitations regarding its value in assessing hazards to human health, primarily due to different approaches to analysis and poor inter-laboratory comparability.

The quality of freshwater sites designated for bathing is considerably worse than those of coastal sites in the EU although the overall quality trend appears to be improving (Figure 3.10.4).

Other low-level contaminants of water may be a threat to health in some areas (WHO/EEA, 1999).

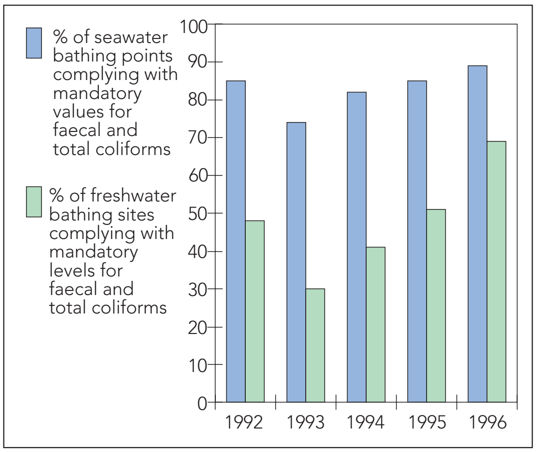
A possibly emerging threat are trace residues of pharmaceuticals, including antibiotics (Box 3.10.5), though there is little data and few studies available.

2.3. Noise
Noise can have a variety of effects which depend on the type, duration and timing of the noise and the susceptibility of the recipient (Box 3.10.6).

Reports from recent scientific research on the precise health effects of nocturnal traffic noise reveals that night-time traffic noise not only disturbs sleep but also encourages psychosomatic illnesses, shortens the period of deep, dream-rich REM (rapid eye movement) sleep, lengthens the phase of light slumber and may cause cardio-circulatory problems.

There may be some segments of the population at greater risk of adverse effects of noise. Young children, (especially during language acquisition), the blind, the hearing-impaired and hospital patients are examples of higher risk groups.

Tests of recreational water quality Figure 3.10.4



Source: WHO

Noise affects more than our health and quality of life; it even influences social behaviour and cognitive development. In 1997, studies carried out around Munich airport found that children exposed to frequent aeroplane noise do not learn to read as well as other children. Excessive background noise caused the children to tune out human voices and interfered with their language acquisition. The psychologists who conducted the study speculated that as a result of noise pollution, parents and teachers were also less willing to speak or read aloud.

Community noise needs to be assessed with respect to risks for both human health and well-being. Intensity, frequency, reversibility and avoidability are pertinent criteria for the severity of noise effects.

The knowledge about harmful impacts of noise exposure has to be transformed into environmental standards. There is also limited evidence for noise impacts on birth weight, congenital effects, and the immune system (Ministère des affaires sociales, de la santé et de la ville, 1995). However, estimated thresholds are available for only a limited range of noise impacts for which there is more substantial evidence of noise causation (Table 3.10.1).

3. Other environmental hazards of concern

Besides the recognised and relatively well-understood issues described in the previous

Box 3.10.6. Noise: some exposure/effect relationships

Exposures

Noise remains a serious environmental problem: estimates of its costs range from 0.2 to 2.0% of GDP (Quinet, 1993). It is estimated that about 32% of the EU population (approx. 120 million people) are exposed to road noise levels over 55 Ldn dB(A) at house facades and that approx. 3 million people are exposed to aircraft noise (see Chapter 3.12). Perceptions of the various types of transport noise differ between individuals and impacts can depend on the type of noise, e.g. from rail or aircraft.

Effects: Public

- Annoyance;
- Interference with speech communication;
- Sleep disturbance effects (more than 'awakenings');
- Effects on performance and productivity (reading acquisition, learned helplessness, etc.);
- Effects on residential and social behaviour (opening windows, use of dwelling area, etc.);
- Psychophysiological effects (the stress complex, hypertension, ischaemic heart disease, aggressiveness, etc.);
- Mental health effects (hospital admissions, etc.);
- Dose-effect for joint effects (e.g. annoyance + sleep disturbance + hypertension?);
- Vulnerable groups (children, hearing-impaired).

Effects: occupational

- Noise-induced hearing dysfunctions (e.g. tinnitus, temporal threshold shifts, deafness, 'impulse sounds')

Source: EEA

Table 3.10.1. **The long-term effects of noise exposure for which there is sufficient evidence**

	Observation threshold			
Effect	**Situation**	**Noise metric**	**Level in dB (A)**	**Inside/outside**
Hearing damage	work	Laeq, 8hr	75	inside
	sport	Laeq, 24hr	70	inside
Hypertension	work	Laeq, 8hr	<85	inside
	home	LAeq, 6-22hr	70	outside
Ischaemic heart	home	LAeq, 6-22hr	70	outside
Annoyance	home	Ldn	42	outside
Awakening	sleep	SEL	55	inside
Sleep stages	sleep	SEL	35	inside
Self-reported sleep quality	sleep	LAeq, night	40	outside
School performance	school	Laeq, day	70	outside

Source: Health Council of The Netherlands, 1994

sections, a number of other environmental factors create potential risk for health and cause public concerns (Table 3.10.2). In most cases, the information and scientific basis for assessment of the risk is not sufficient to confirm or deny the existence of the risk. The list of relevant issues is long, and this section provides selected examples which illustrate some general points about the identification and management of environmental health.

3.1. Chemicals and endocrine-disrupting chemicals

Low doses of some chemicals (EEA/UNEP, 1998) are associated with cancer, cardiovascular disease, respiratory diseases, neurotoxicity, and chemical sensitivity, with varying strengths of evidence, but information about exposure /effect relationships is often poor or non-existent (Box 3.10.8).

A broad class of chemicals present in the environment, such as PCDDs, PCDFs, PCBs, persistent pesticides, some detergents and some compounds used in the plastic industry, are known to have a capacity to interfere with hormonal regulation mechanisms (Toppari *et al.*, 1996; EU Scientific Committee, 1999). The Weybridge Report (EUR, 1997) concluded that while there was increasing evidence about rising trends in reproductive ill health in wildlife and humans, there were still great uncertainties about the causes of the reproductive ill health (Box 3.10.7). However, exposure reduction to endocrine disrupting chemicals was recommended in line with the 'precautionary principle'. Since then, reports by the European Parliament and others have repeated the call to reduce exposures.

3.2. Chemicals from waste disposal and treatment

Part of the still growing volume of waste generated and disposed in Europe is hazardous to health via exposure to hazardous chemicals or microbiological pollution.

Several epidemiological studies conducted in the United States have suggested a small increase in risk of a range of health impacts associated with the hazardous waste landfills, but a UK review concluded that 'The epidemiological evidence that these substances represent a cancer risk at much lower environmental levels either does not exist or is equivocal. However, data on the effects of background environmental exposures on combinations of chemicals is absent, making it difficult to assess any health impact resulting from relatively small additional exposures from incinerators (MRC, 1997). A recently published European study adds to the suspicion that the landfill operations may contribute to a small increase in risk of certain birth defects (Dolk *et al.*, 1998). However, the present studies are not powerful enough to indicate a particular characteristic of the landfill which may cause a risk, and a weakness of the exposure assessment in those studies makes any causal relation between disease and landfills difficult to establish.

An analysis of cancer incidence patterns around municipal solid waste incinerators in the UK revealed that the observed slightly increased overall incidence of cancers in the proximity of the incinerators is related to a combination of confounding factors, and not to the waste treatment operations (Elliot *et al.*, 1996). However, the need for a further study on a still unexplained incidence of liver cancer in the vicinity of incinerators was proposed.

Technical requirements of design and operation of waste treatment at such facilities aim at the elimination, or radical reduction, of the risk to population health. Whilst there is a decline in population exposure to hazardous chemicals which may be emitted from incinerators such as dioxins, the average exposure of Europeans in industrialised countries to dioxins is significant in relation to what is now known about their likely effects (see Chapter 3.3) which include cancer, reproductive disorders, neurotoxicity and heart disease (WHO, 1997d and 1998 a).

3.3. Climate change and ozone depletion-future burdens?

The potential consequences of climate change include increases in sea level, more

Box 3.10.8. Breast cancer: an 'integrated' disease?

Breast cancer rates are rising in Europe. Some risk factors are known (genetics and family history, use of the contraceptive pill etc.) and others are suggested such as some occupational and environmental causes, such as pesticides, radiation and endocrine-disrupting chemicals but these account for only 30-40% of cases (Kristensen, 1991; Davis, 1993; Woolff, 1993; Hulka, 1995; Cantor *et al.* 1995; Rachel's Environment and Health Weekly, 1997; Walleson, 1995; McPherson, 1994; Hoyer *et al*, 1998). However, the links with occupational and environmental factors may be small and the evidence for this is disputed. Disentangling the relative contributions of several factors in an inter-dependent causal chain is always going to be difficult, and prevention calls for an integrated, holistic approach, based on the precautionary principle (Davis, 1997).

Major health impacts and some associations with environmental exposures — Table 3.10.2.

Health impact	Associations with some environmental exposures
Infectious diseases	• water, air and food contamination • climate change
Cancer	• smoking and environmental tobacco smoke (ETS) • some pesticides e.g. phenoxy herbicides • asbestos • natural toxins • food, e.g. low fibre, high fat • polycyclic aromatic hydrocarbons, e.g. in diesel fumes • some metals e.g. cadmium, chromium • radiation (incl. sunlight) • several hundred other animal carcinogens
Cardiovascular diseases	• smoking and ETS • carbon monoxide (CO) • lead • inhalable particles • food, e.g. high cholesterol • stress
Respiratory diseases, including asthma	• smoking and ETS • sulphur dioxide • nitrogen dioxide • inhalable particles • fungal spores • dust mites • pollen • pet hair, skin and excreta • damp
Skin diseases	• some metals, e.g. nickel • some pesticides, e.g. pentachlorophenol • some foods (allergies)
Diabetes, obesity	• food, e.g. high fat • poor exercise
Reproductive dysfunctions	• polychlorinated biphenyls (PCBs) • DDT • cadmium • pthalates and other plasticisers • endocrine disruptors
Developmental (foetal and childhood) disorders	• lead • mercury • smoking and ETS • cadmium • some pesticides • endocrine disruptors
Nervous system disorders	• lead • PCBs • methyl mercury • manganese • aluminium • some solvents • organophosphates
Immune response	• UVB radiation • some pesticides
Chemical sensitivity?	• trace amounts of many chemicals?

Note: Most diseases are the result of several causes. These include:

- inherited vulnerability,
- factors which are related to poverty, e.g. diet, housing quality and location, stress, alcohol and substances abuse, smoking, low birth weight etc.; work; unemployment; climate, and
- other environmental exposures arising from air, water, soil and surfaces.

The link between environmental exposures and health impacts varies from known causal relationships such as inhalable particles and respiratory-system damage to suggestive but unproved associations, such as between some cancers and exposure to low levels of some pesticides. Poor diet plays a key role in the 'diseases of affluence', such as cancer, heart and circulatory diseases.

Source: EEA

Box 3.10.7. The 'Weybridge Report' on endocrine disruptors

There is increasing evidence and concern about rising trends of reproductive ill health in wildlife and humans, and some substances have been implicated, but there are great uncertainties about the causes of reproductive ill health.

Key conclusions are:

- Sufficient evidence exists that testicular cancer rates in humans are increasing.
- The apparent decline in human sperm counts in some countries was likely to be genuine.
- There is insufficient evidence to definitely establish a causal link between the health effects seen in humans with exposure to chemicals.
- The major route of exposure to Endocrine Disrupting Substances (EDS) is usually by ingestion of food, and to a lesser extent water. It is valid for terrestrial animals, birds and mammals, including humans.
- Compared with the situation in the US, there are few cases of reproductive ill-health in wildlife in the EU where the effects could be definitely associated with EDS.
- However, some cases exist within the EU area where adverse endocrine effects, or reproductive toxicity, in birds and mammals coincide with high levels of anthropogenic substances shown to have endocrine-disrupting properties in some test systems.
- The considerable uncertainties and data gaps could be reduced by research and monitoring into exposure and effects in wildlife and humans.
- Current eco-toxicological tests, studies and risk assessments are not designed to detect endocrine-disrupting activities.
- Meanwhile, consideration should be given to reducing the exposure of humans and wildlife to endocrine disrupters in line with the 'precautionary principle'.

Source: European Commission *et al.*, 1997

frequent and intensive storms, floods and droughts, changes in biota and food productivity. Changes in ecosystems may affect the growth, transmission and activity of vector-borne or infectious diseases, such as malaria and dengue fever. Human health is likely to be adversely affected, either directly or indirectly, through complex interactions of ecological systems (McMichael, 1996a, WHO, 1999b). The direct effects may result from changes in exposure to thermal extremes, and be expressed by an increase in heat-related disease and death, but also by a decrease in cold-related disease. Other extreme weather events can lead to psychological disorders, disease or death, indirectly causing an increase in morbidity. Although there are some signs of these climate effects already beginning to happen, such as shifting geographical range and longer seasons of some vector born diseases (WHO, 1999 b), much of the burden of ill health from climate change will be on our children and grandchildren. However, climate change policies based on avoiding these health impacts will have considerable secondary benefits of avoiding shorter term health impacts from fossil fuel combustion (WRI 1997).

Similarly, stratospheric ozone depletion is expected to cause increased UV radiation and thereby increased skin cancer sometime in the next century (Figure 3.10.5). The relation of UV radiation with some forms of skin cancer is well-established, though not always with respect to the specific wavelength, exposure-response or individual susceptibilities. Though the current increase in skin cancer in Europe (3 to 5% per year since the 1960s, for malignant melanoma, WHO, 1999) seems mostly related to more frequent sunbathing and other lifestyle factors, the depletion of the protective layer of ozone in the stratosphere will increase the likelihood of increased skin cancer in the future, despite the reductions in the production of CFCs and other ozone-layer-depleting substances. However, the implementation of the Copenhagen amendments to the Montreal protocols (see Chapter 3.2) on the banning and phased reduction of ozone-depleting substances has greatly reduced the future excess incidence of skin cancer.

Increased UV-radiation also reduces the response of the immune system (see Box 3.10.3), and causes eye cataracts and other impacts. It can also be beneficial, by providing extra vitamin D.

Environmental-health hazards that impact in the future via long latent periods, such as asbestos and other carcinogens, present difficult issues of public health policy that require considerations other than good science, such as appropriate levels of proof (see section 4). Decisions sometimes need to be based on 'early warnings', which often come from the world of work, where exposures are usually higher and where the monitoring and the identification of impacts is often easier. Any integrated assessment therefore needs to embrace occupational exposures, which in any case add to the sum of stresses on the body.

3.4. The occupational environment

'It is a sordid profit that is accompanied by the destruction of health'
— Bernardino Ramazzini, 'father' of Occupational Medicine, 1713

A full-time employee spends about one-half of waking time in the workplace; the other half is spent on domestic or leisure activities, and one-third of the 24 hours is spent sleeping. It follows that many environmental contributions to all health will be found in and around the workplace. This is why Bernardino Ramazzini, the father of occupational medicine, advised doctors to always ask their patients: 'What work do you do?' (Ramazzini, 1713).

A European survey found that 23% of the EU workforce were absent from work during the previous 12 months due to work-related ill health (European Foundation, 1996), and the WHO has identified a range of occupational stresses (Box 3.10.9).

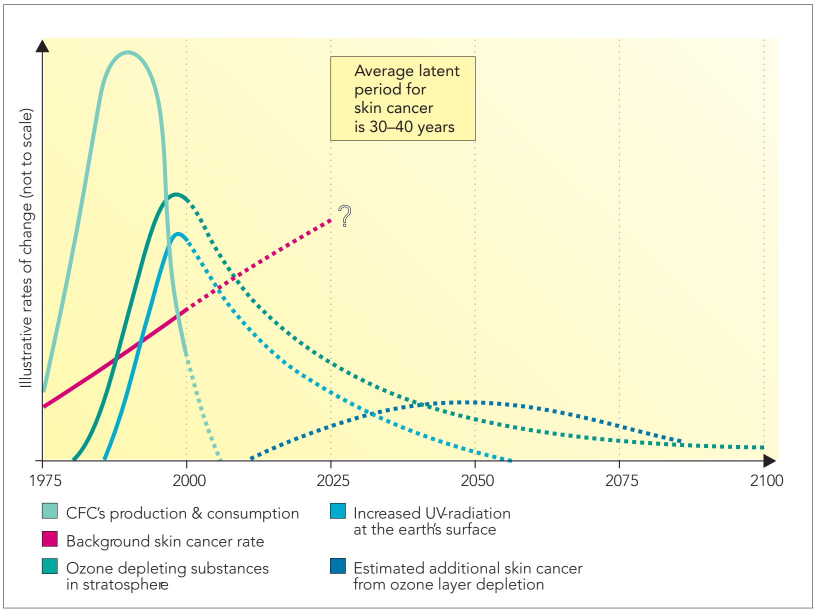
The workplace is also an effective place through which to focus efforts on health promotion, embracing occupational, environmental and 'lifestyle' factors, such as smoking, alcohol, diet and exercise. The WHO considers that 30-40% of the total disease and ill-health burden in Europe can be tackled effectively through workplace activity on either occupational factors, or on lifestyle/environmental factors that can be addressed through employee or employer activity (WHO, 1999a). Occupational accidents and ill health cost between 0.4 and 4.0 % of GNP in the EU (EASHW, 1998).

The monitoring, identification and 'proof' of the occupational origins of disease are as controversial as identification of the environmental contributions to ill health. The 'occupational' fraction of cancer has been estimated at 4-5%, or up to 25% (WHIN, 1998), but as with all diseases that have long time lags ('latent periods') between exposure and harmful effect, the conditions of exposure will always have changed by the time 'proof' of causality can be provided, some 20-40 years after exposure first began. This then affords opportunities to argue that current conditions are now harmless, and the point can only be 'proven' one way or the other some 20-40 years later (Box 3.10.10).

Both unemployment, via its link to poverty, alcohol, loss of self-esteem, etc. and overwork can cause disease and ill health.

Many environmental diseases are first identified in the higher exposure, more easily monitored world of work, e.g. 95% of the 24 known lung carcinogens and over half of all causes of cancer were identified in workplace studies, according to the WHO's

CFCs, skin cancer and time lags | Figure 3.10.5



This graph illustrates the approximate time lags between CFC production, the resulting depletion of the stratospheric ozone layer and subsequent extra penetration of UV radiation and the impact this will eventually have on increasing the background rate of skin cancer, given the 30-40 year average latent period for such cancers. Reality is far more complex than this schematic illustration. For example, there are other ozone-depleting chemicals (HCFCs, HFCs and methyl bromide); the ozone hole varies with latitude, time of the year and meteorological conditions; the increased UV radiation varies between different wavelengths and with latitude and cloud cover; and the skin cancer excess comes on top of a rising background rate of skin cancer, with differential effects on the different types of skin cancer, such as malignant melanoma and non-malignant skin cancers. Human behaviour is also a determining effect in skin cancer. Health effects also include cataracts and immune response suppression. However, the figure illustrates the main relationships and time lags between CFC production and skin cancer, and the 'success' in stopping CFC production and averting much more skin cancer from ozone depletion than what is now expected. (Slaper, *et al.*, 1996).

Source: EEA

Box 3.10.9. The dangerous world of work

The World Health Organisation says:

- Some 50 physical factors, 200 biological factors and 20 adverse ergonomic conditions, plus an innumerable number of psycho-social factors, have been identified as creating hazardous working conditions. These contribute to the risk of occupational injuries, diseases and stress reaction, as well as to job dissatisfaction and the absence of physical and mental well-being.
- The risk of cancer from work and workplace exposure is of particular concern. Approximately 300-350 different chemical, physical and biological factors have been identified as occupational carcinogens. They include benzene, chromium, nitrosamines, asbestos, ultraviolet radiation, ionizing radiation and aflatoxins. The most common cancers occurring as a result include lung, bladder, skin and bone cancer and sarcomas.
- Allergenic factors are also a growing cause of occupational illness. An estimated 3 000 allergens have been catalogued which can cause dermatoses and respiratory diseases (e.g. asthma).
- Approximately 30-50% of workers in industrialised countries complain about psychological stress and overload. Such psychological factors have been associated with sleep disturbance and depression, as well as with elevated risks of cardiovascular diseases, particularly hypertension.
- Only 20-50% of workers in industrialised countries (with few exceptions) have access to adequate occupational health services.

Source: WHO, 1997a

Box 3.10.10. Asbestos and disease 1898-1998: A 100 years of 'early' warnings...

An astute observation by a lady factory inspector in 1898 concluded: 'The evil effects of asbestos dust have also attracted my attention. A microscopic inspection clearly revealed the sharp, glass-like, jagged nature of particles and … the effects have been found to be injurious, as might have been expected' (ARCI, 1898).

Her fears were confirmed 30 years later. A government-funded study in 1929 found that one-third of asbestos workers had asbestosis, a form of pneumoconiosis. By 1955, a study of workers by Sir Richard Doll showed that asbestos also caused lung cancer, and by 1964 other cancers, including the most deadly, mesothelioma, were added to the list of 'evil effects of asbestos dust.' Table 3.10.3 summarises the history of asbestos as it moved from the harmless substance of the 1880s to the recognised killer of the 1990s, now being responsible for about 10 000 deaths a year in western Europe. Poorly-controlled asbestos use expanded right up until the 1980s, by which time it had killed thousands of people, and condemned thousands of others to die in the next 20-60 years as a result of their past exposure. The costs of failing to control asbestos early enough are not just health costs – dealing with compensation and asbestos in buildings is costing billions of pounds and was partly responsible for the bankruptcy of some Lloyds insurance underwriters in the early 1990s.

Table 3.10.3.

Exposed group	Asbestosis	Lung cancer	Mesothelioma cancer
Occupational			
Workers	(1898-1929)	1955	1960s
Mates	1964	1964	1964
Environmental			
Relatives	1960s	?	1960s
Public	?	?	1980s

Note: Asbestos also causes other cancers, e.g. cancer of the larynx

Source: EEA based on Gee, 1995

The latest study on the extent of asbestos-induced deaths 'in the pipeline' concludes that some 250 000 men (mainly) will die of asbestos-related cancer in western Europe over the next 35 years, following a doubling of the current annual total of deaths from the main asbestos cancer, mesothelioma, from 5 000 a year in 1998 to 9 000 a year by 2018 (Peto *et al.*, 1999). The study was based on the cancer registries of six European countries (France, Germany, Italy, the Netherlands, Switzerland and the UK, which account for 72% of the population of western Europe). Asbestos use in Europe remained high until about 1980, and as mesothelioma, a cancer of the lung or stomach lining, has a latent period of 30-60 years, deaths will peak around 2020 and decline slowly over the following decades.

Workers not directly employed with asbestos, such as electricians, carpenters, plumbers and maintenance men, are also at risk. Although the non-occupational risk from asbestos is very much smaller, the possibility of 24-hour exposure, and of children's exposure, contributes to a significant risk for some 'public' groups, e.g. those living in the houses of asbestos workers, where contaminated clothing has caused mesothelioma in wives, sisters and children and those living and playing in the streets near asbestos plants (Camus *et al.*, 1998).

Although there have been 'early warnings' about asbestos for 100 years, effective preventative measures were not taken until it was too late to stop deaths 'in the pipeline' of the latent period. And even accurate monitoring of mesothelioma, lung cancer and of their relationship (which may be 1:1 or 1:3 or 4) is still poor. 'It is unfortunate that the evolution of the epidemic of asbestos-induced mesothelioma, which far exceeds the combined effects of all other known occupational industrial carcinogens, cannot be adequately monitored.' (Peto, 1999).

Smoking and asbestos together have a strong synergistic effect causing a 50 fold excess of lung cancer while their separate effects are 'only' a 10 and five-fold excess for smoking and asbestos respectively (Hammond, 1979).

Synergy from smoking and other pollution is not confined to asbestos. The WHO (1998b) has concluded that smoking and other workplace contaminants can also act together to 'amplify the severity of adverse effects beyond what could be expected from smoking or the toxic hazard alone'.

International Agency for Research on Cancer. Many 'early warnings' of environmental health hazards will therefore continue to come from workplace studies (Wegman, 1996). For example, the potential human health effects of non-ionising radiation were first identified in occupational studies (Box 3.1.11).

3.5. Diet

Healthy eating plays a crucial role in disease prevention. For example, in addition to genetics, occupational and environmental factors, diet plays a key role in cancer causation, perhaps 30-40% of all cancers.

Recommendations on balanced diets have been available for many years (Figure 3.10.6). However, advice can vary, depending on scientific knowledge. Poor consumer labelling can make it difficult to make the right choice, assuming the consumer already has physical and financial access to healthy food. Contamination with chemicals, such as antibiotics and pesticides (Box 3.10.12) can diminish some of the value of healthy eating, but, as with breast feeding when the milk may be contaminated with very low levels of dioxins or PCBs, the other benefits of a healthy diet usually overwhelm the costs from micro-contaminants. Achieving a healthy diet and contaminant-

Box 3.10.11. Electromagnetic fields: an emerging occupational, environmental and consumer hazard?

The World Health Organisation (WHO) has said that research into possible adverse health effects of electromagnetic fields (EMF) should be a priority for the next four years.

The WHO's EMF project will be co-ordinating and encouraging research into the possible associations between low-frequency EMF (less than 300 Hz) and childhood leukaemia, breast cancer and diseases of the central nervous system.

WHO also recommended further research into possible associations between exposure to radio frequency fields (300 Hz – 300Ghz) and leukaemia/ lymphoma and brain and cancers.

Dr Paul Kleihues, Director of WHO's International Agency for Research on Cancer, has observed that, 'with an estimated 15 million new cancer cases each year by the year 2020, we must know if exposure to EMF is contributing to any significant extent to the incidence of disease'.

The controversial theory that electric fields like those around power lines can cause cancer has received some support from a National Institute of Health scientific panel in the US. 'This report does not suggest the risk is high', and 'The risk is probably quite small compared to many other public health risks', said Michael Gallo, chairman of the group and a professor at the university of Medicine and Dentistry of New Jersey-Robert Wood Medical School, Pistacaway.

The report comes from a National Institutes of Environmental Health Sciences panel convened to review scientific research on electromagnetic fields.

The group voted 19-9 in June 1998 that electromagnetic fields should be regarded a potential cause of cancer, using the International Agency for Research on Cancer criteria for cancirogenicity.

Eight members said that, because of conflicting studies, they could not decide whether electrical fields were potential cancer causes. One said they probably were not.

The new finding is at odds with a 1996 report by a National Research Council panel of scientists who evaluated about 500 studies on the health effects of high voltage power lines and found 'no conclusive and consistent evidence' that electric and magnetic fields cause any human disease. Studies of the incidence of disease analysed by the new NIH group found a slight increase in childhood leukaemia risk for children whose homes are near power lines and an increase in chronic leukaemia in adults working in industries where they are exposed to intensive electric fields.

The group said that there wasn't enough evidence to link household exposure to power lines to cancer in adults, or to associate electromagnetic fields to such diseases as Alzheimer's, depression and birth defects.

They found no evidence of abortion from video display terminals and no evidence of illness other than leukaemia in children (WHIN, 1998).

free food and drink may be possible if both sustainable agriculture and the reduced use and exposure to hazardous chemicals are pursued in an integrated approach to ecological and human health.

Box 3.10.12. Lindane safety re-assessed

A re-assessment of the organochlorine insecticide lindane has concluded that consumer safety limits can be exceeded by over 12 times.

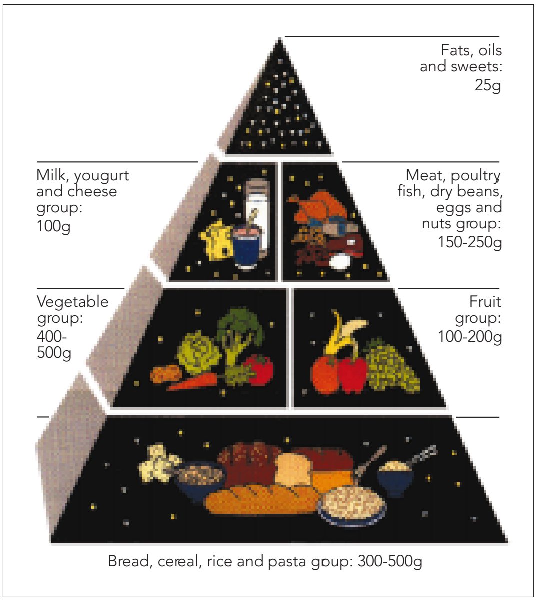
The joint FAO/WHO Food Standards Programme Codex Committee on Pesticide Residues has set a more stringent acceptable daily intake (ADI) for the insecticide lindane of 0.001mg/kg body weight.

For a 60 kg adult, therefore, the maximum daily dose should not exceed 0.06 mg in total. The ADI is the amount of pesticide that can be consumed every day for a lifetime without harm.

Codex data discussed at a recent meeting shows that any person consuming an average local diet in any region of the world could theoretically exceed the ADI for lindane by between 3.8 and 12 times if foods containing the maximum lindane residues were consumed.

Source: FAO/WHO, IN WHIN 1998

Healthy eating Figure 3.10.6



Source: CECHE, 1998

3.6. Children

As has been seen with several health hazards (air pollution, noise, skin cancer, allergies etc.) children can be particularly sensitive to environmental stresses. They are a 'biomarker' for environmental threats that require special protection, not only because they are more at risk but because they can also provide early warnings of hazards to others, as well as being effective points of intervention for the prevention of disease in their later lives.

Chemical pollutants that may affect reproductive health and new-born children include certain metals (e.g. lead and methyl mercury; Box 3.10.13), pesticides (e.g. DDT), industrial chemicals (e.g. PCBs), solvents and other substances (Foster and Rousseaux, 1995; CJPH, 1998). Exposures can occur through placenta and breast milk (Jensen, 1996; Rogan, 1996), and some may cause small abnormalities of the immune response system. However, WHO and others conclude that the benefits for breast-feeding outweigh the risks of pollutants in breast milk (Weisglas-Kuperus *et al.*, 1996; WHO, 1996b).

Children may be particularly at risk from chemicals because of their greater biological sensitivity and greater exposure to environmental pollution relative to body weight (NRC, 1993; McConnell, 1992; Bearer, 1995). Their physiological and intellectual development may be impaired by exposure to chemicals (Rodier, 1995; Rylander *et al.*, 1995; Jacobson 1996; Grand Jean *et al.*, 1997). Low-level pesticide contamination of food (infants consume eight times more food per kilogram of body weight than adults, making this a more significant exposure pathway; CICH, 1997), and of residential surfaces and toys in the UK and US, is being reported (Pesticides Trust, 1998; Gurunathan *et al.*, 1998). Some regulatory authorities are giving special attention to the higher levels of risk to children from pollution (USEPA, 1996). For example, the Food Quality Protection Act in

Box 3.10.13 Children and lead

'Lead makes the mind give way.'
— Greek physician, 2000 BC

- Lead is brought into the environment through human activities in 300 times greater amounts than through natural processes (Unicef, 1992).
- People, particularly children, may be exposed to lead from car emissions through leaded petrol, water contaminated by lead pipes, some factories (e.g. metal polishing and smelters; old paintwork in houses), contaminated soil (e.g. nurseries built on old petrol station sites), certain cultural practices (e.g. use of folk medicines containing lead), use of improperly glazed lead ceramic ware for cooking and food storage, and use of lead-contaminated cosmetics such as surma and kohl.
- Children absorb up to 50% of lead taken into their bodies, compared to 10-15% in adults. Children may receive three times the dose of adults because they have a larger surface-to-volume ratio.
- Lead in dust and dirt can be ingested via children's hands and toys, for example by thumb-sucking or by putting objects in their mouths.
- Even in the world's most developed countries, it is estimated that a large proportion of children suffer from lead poisoning. It is the most common, chemical-related, environmental child health problem. It is especially pronounced in economically-disadvantaged sections of the population. Poverty can cause malnourishment or physical stress, which intensifies disabilities caused by lead absorption.
- At low levels, i.e. 10-25 µg/dl (indicating the amount of lead in a tenth of a litre of blood) lead poisoning in children causes:
  - reduction in IQ and attention span;
  - reading and learning disabilities;
  - hyperactivity and behavioural problems;
  - impaired growth and visual and motor functioning; and
  - hearing loss.
- Exposure to these levels in maternal and umbilical-cord blood is associated with low birth weight and prematurity. The body can store lead for more than 20 years and then release it during pregnancy, harming the foetus (lead can move across the placenta with ease).
- At higher levels, i.e. 60-100 µg/dl, lead poisoning in children causes:
  - anaemia; and
  - brain, liver, kidney, nerve and stomach damage.
- According to the World Bank, countries can save five to ten times the cost of converting to unleaded petrol in health and economic savings due to reduced health costs, savings on engine maintenance and improved fuel efficiency.

Source: UNEP and UNICEF, 1997

the US requires the government to add an extra margin of safety to the risk assessment of chemicals that children may be exposed to.

Cancer in children in the US appears to be increasing (Pogoda, 1997; EHP, 1998; Rachel's EHW, 1998), and a large-scale study of childhood leukaemia and other cancers in the UK has found them to be associated with living close to industrial plants, particularly where fossil fuels were being used or processed (Knox and Gilman, 1997).

4. Approaches to environment and health

4.1. Multifactoral causes of disease

As has been seen in earlier sections much ill health and many diseases are multifactoral (Figure 3.10.7). Identifying the causes of ill health in populations is therefore very difficult and quantifying the contributions of environmental exposures to adverse health impacts is even more so, particularly at the level of the individual. Adverse health impacts are the results of varying combinations of host genetics, host state (including 'lifestyle' factors such as smoking, alcohol, diet parents etc.) and exposures to other environmental stresses, both indoors and outdoors. All these factors can operate at different times, influencing each other in various ways, and causing changes in cells, tissues and functions that may or may not lead to adverse health impacts. The same 'dose' of air pollution for example does not have the same impact because of differences between people, with sensitive groups, such as the elderly, the sick children, and pregnant women responding more than less sensitive groups. The same 'exposure' may not lead to the same 'dose' because of biological and activity differences, e.g. children and joggers who have higher breathing rates.

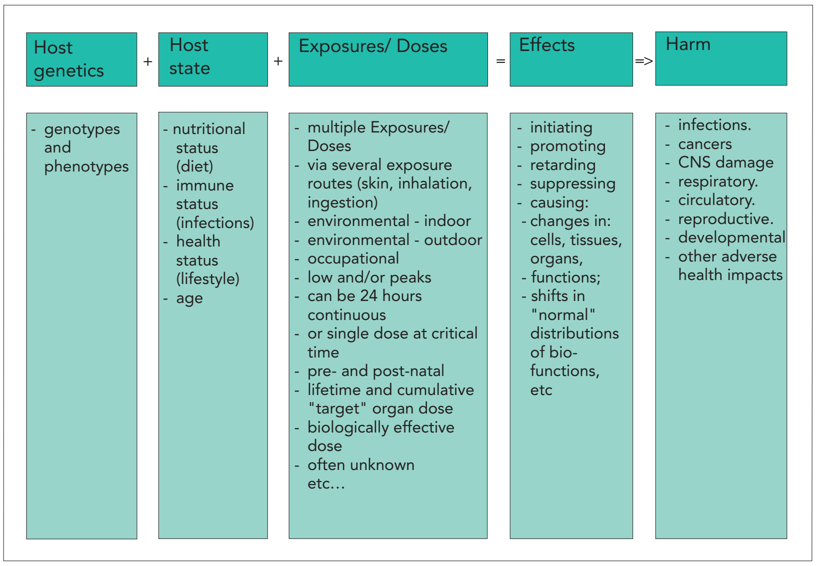
Several key questions need to be addressed in dealing with environmental health issues:

- what is the nature and strength of the evidence for an adverse impact and for the role of the environment in that impact,
- what is the nature of the impact (trivial or serious, reversible or irreversible, immediate or long term, large or small numbers affected etc.),
- what level of proof is to be used in making a decision, particularly about whether an *association* between an environmental stressor and an adverse impact is actually *causation* (Box 3.10.14),
- are exposure or effects avoidance measures available, and actors identifiable and willing to take action,
- the cost and benefits of action and inaction, and their distribution between classes, races, sexes, the regions and generations,
- how uncertainties are to be handled ,
- how informed consent and public involvement in 'acceptable risks' can to be achieved,
- and how the consequences of action/inaction are to be evaluated?

The answers to these questions require good information for effective decision-making, but in practice, a lack of data, information or understanding, or disagreements about the interpretation of the information can lead to delays in preventing public ill health. For example, one of the main weaknesses of animal evidence is the difference between the healthy young rats used in experiments (which breathe through the nose) and a population of mixed age and health status humans, who partly breathe through their mouths. These three differences (age, health status and mouth-breathing) are the main reasons why experts 'dramatically' underestimated the health impacts on humans of fine particles in air pollution in 1987 compared to 1997 (WHO, 1997b).

The level of proof used in decision-making is crucial, and it can vary from very high to low, depending on the issue being addressed. For 'sound science', a high level is required,

Multifactoral disease causation Figure 3.10.7



Source EEA:

such as 'beyond all reasonable doubt'. This means that the costs of being 'wrong' in failing to reach the high level of proof (such as new and correct, scientific hypotheses being initially dismissed, called 'false negatives'), is considered by society to be less costly than being 'wrong' in the other direction when using a lower level of proof i.e. the 'false positive' of incorrect scientific hypotheses being accepted as correct. Similarly, in criminal trials, where the 'cost' of being wrong in one direction i.e. innocent people being jailed (or sometimes executed), is regarded as being worse than being wrong in the other direction (i.e. guilty people going free), a high level of proof is also used.

For other purposes in society, such as compensating injured people through the courts, a lower level of proof, such as 'the balance of probabilities', is generally used. In this case society considers that the costs of being 'wrong' in reaching the lower level of proof, i.e. the 'false positive' of compensating injured people for injuries that were not caused by the negligence of others, is less costly than being 'wrong' in the other direction, i.e. the 'false negative' of not compensating people for the injuries that were caused by the negligence of others. Another example of the use of a low level of proof, or probability, is disaster insurance where the cost of being wrong when no disaster happens is generally considered more acceptable than the cost of being wrong in the other direction, i.e. where no insurance premiums are paid and disaster strikes. 'It is better to be safe than sorry ' is the popular expression of this sentiment.

For public health policy-making, where there may be serious and irreversible health impacts, the use of a lower level of proof than used in good science is recommended in various international agreements, via the 'precautionary principle' (Box 3.10.15).

4.2. Integrated approaches to prevention

The multi-causal disease process also offers several points at which strategies for avoiding reducing or compensating harm can be focused (Figure. 3.10.8). However, identifying and implementing the most effective strategy is difficult, and involves questions of feasibility (technical, economic and practical), cost-effectiveness and ethics. Responses can also be focused on the individual (behaviour change or medical intervention), or at the community and its environmental exposures. When the response strategy is

Box 3.10.14. Association and causality

It is often fairly easy to show that a measure of ill-health, e.g. the number of admissions to hospital per day, is associated with a possible cause, such as the day-to-day variation in levels of air pollutants. To show that a causal relationship exists, a number of guidelines or tests have been developed. These include the consistency of results between different studies, the way in which the results of different studies fit together (coherence); whether there is a 'dose-response relationship' between the proposed causal factor and the effect; and whether the sequence of events makes sense, i.e. the cause always preceding the effect.

Proof of causality is often very difficult, but by the application of these and other criteria, an expert judgement as to whether an association is likely to be causal can often be made. Where effects are likely to be serious and/or irreversible, then a low level of proof, as in the 'precautionary principle', may be sufficient to justify action to remove or reduce the probable causes (EEA/WHO, 1997).

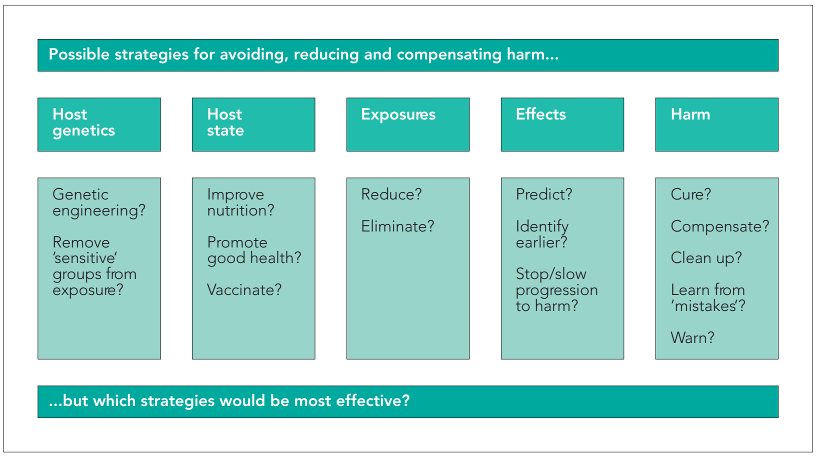
Box 3.10.15 Precaution

This principle featured in the 1992 Rio Declaration on Environment and Development (as Principle 15):

'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'

The precautionary principle permits a lower level of proof of harm to be used in policy-making whenever the consequences of waiting for higher levels of proof may be very costly and/or irreversible; the UN Intergovernmental Panel on Climate Change recently used the precautionary principle in concluding that 'the balance of evidence … suggests a discernible human influence on global climate' (IPCC, 1995).

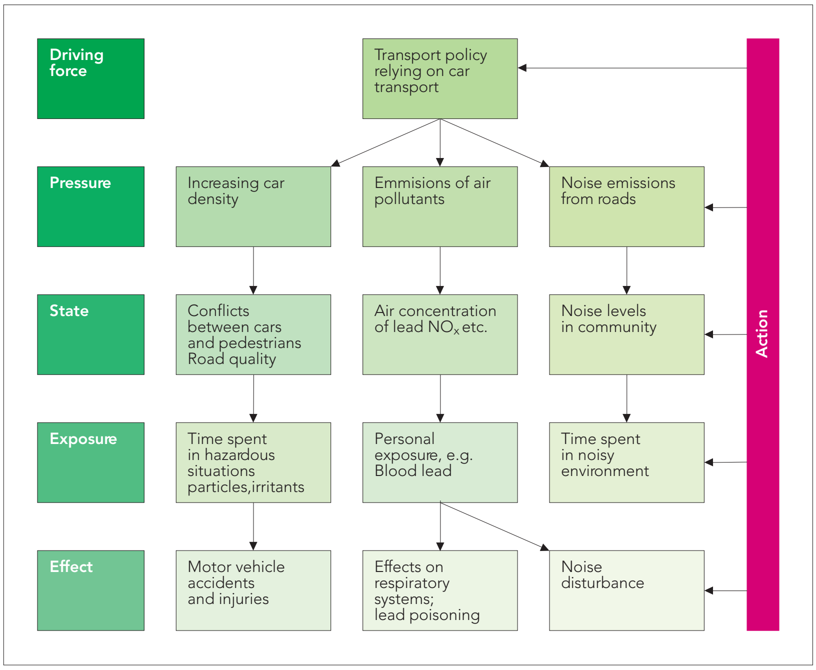
Figure 3.10.8 **Strategies: points of intervention**



Source: EEA

focused on reducing exposures, say to traffic fumes, there are many points of policy intervention, involving both 'upstream', e.g. the 'driving forces' of transport policy, and 'downstream', e.g. noise barriers (Figure 3.10.9). In general, strategies-focused 'upstream' will be more effective than those focused 'downstream', partly because of the need to take an integrated approach that embraces the linkages between different parts of transport policy. An integrated approach will also take into account the full range of benefits and costs of policy responses, and allow for adaptation to a modified transport system. For example, policies designed to reduce air pollution from traffic by reducing traffic volumes will also yield substantial benefits from reduced noise, accidents (Box 3.10.17), congestion, less divided communities and increased freedoms to play, walk and cycle in safety. Such holistic approaches can help counter the common 'tendency to over-estimate the costs and under-estimate the benefits' of policy action (WHO, 1997c).

Transport: multi-causality in transport hazards Figure 3.10.9



Source: WHO

There may also be differences between causes of ill health that are most important from a scientific point of view, and causes that may be most important from a policy response point of view. Figure 3.10.10 illustrates the differences between 'scientific' and 'social intervention' causes in multi-factoral disease processes, such as asthma in children. Whilst genetic pre-disposition, respiratory hyper-sensitivity from pre-natal exposures, diet or indoor air pollution from damp or mites, may be the most important scientific causes of asthma in children, the relatively minor role of traffic pollution may be the most important 'social intervention' cause, given the secondary benefits of a reduction in traffic growth, and the impact of removing one link in a multi-causal chain.

In practice, given the multi-causal nature of diseases like asthma, policy responses are needed in several areas: single cause approaches can not reduce more than a proportion of disease. Integrated approaches to prevention (BMA, 1998) and hazard exposure reductions, as well as more research on the links between environment and health (ESF, 1998) are needed to achieve improved health and wellbeing.

Box 3.10.17. Traffic accidents

Road traffic accidents are 1.4% of all deaths (some 45 000 deaths in 1994 in the EU) and 20% of all accidental deaths in the European Region of WHO. About 1 in every 3 deaths involves people younger than 25 years. Due to the high proportion of young victims, it is estimated that on average people killed in traffic accidents die about 40 years earlier than their life expectancy.

From 1993, it appears that the decreasing trend is levelling-off, especially in western countries, where there has been little progress in achieving a further reduction in mortality over the past few years.

The reduction in the number of fatalities has not been paralleled by a proportional reduction in the number of traffic accidents with injuries, which since 1993 have increased slightly.

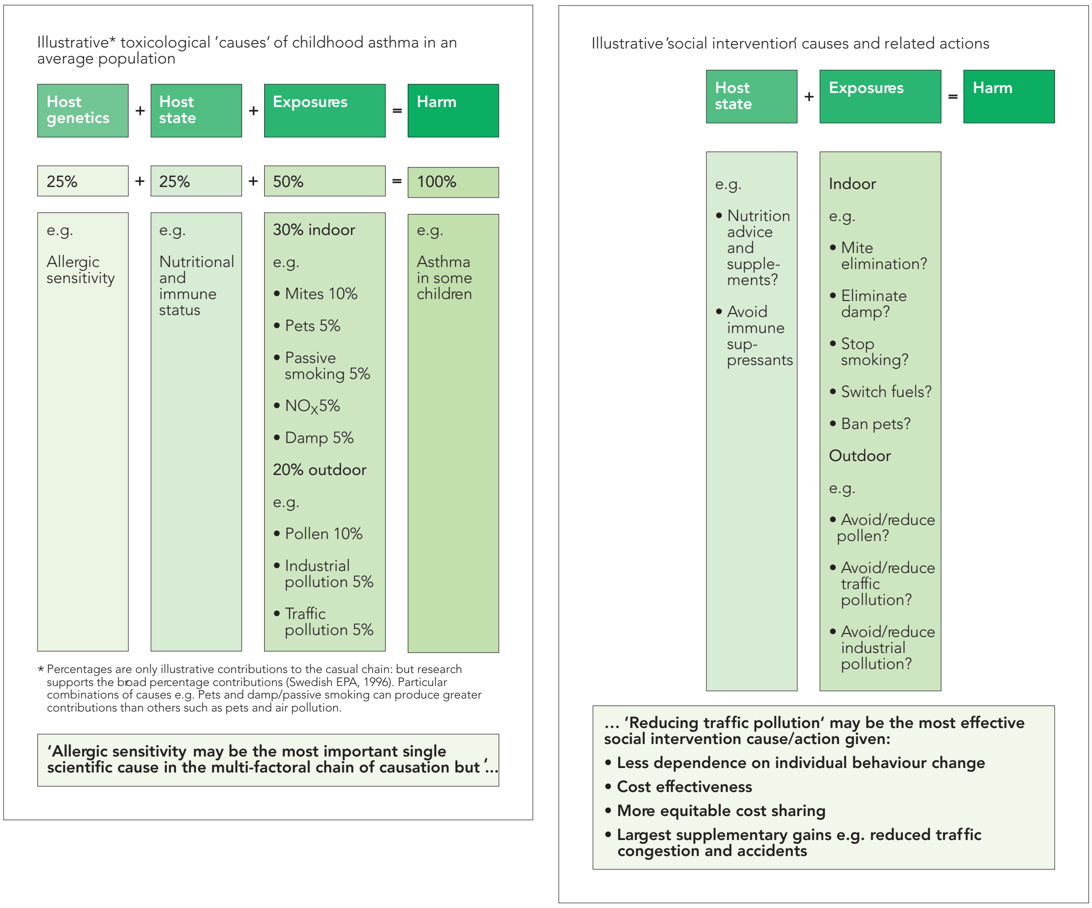
More pedestrians are killed per 1 000 accidents with injury than other road user categories.

Pedestrians account for around 13% of casualties (dead and injured) and 22.5% of deaths by road traffic accidents in the 26 countries of the ECMT. Pedestrians report the second highest number of fatalities among road users in all OECD countries, with the exception of the Netherlands, where cyclists account for more fatal accidents than pedestrians (OECD, 1998).

Cyclists are more likely to have an accident than other road users and they will sustain a greater proportion of head injuries than other road users (OECD, 1998). At least two-thirds of the cyclists killed in accidents had head injuries which contributed to or resulted in death. However, both cycling and walking have very beneficial health effects. WHO estimates that half an hour's walking and cycling a day could reduce the prevalence of heart disease, obesity and diabetes by 50% (WHO, March 1999, press release).

Figure 3.10.10 Scientific causes and social intervention causes for childhood asthma

Source: EEA



References

Andersen, H.R., Halling-Sørensen, B. and Kusk, K.O. (in press). 'A parameter for detecting oestrogenic exposure in the copepod *Acartia tonsa.' Ecotoxicology and Environmental Safety.*

ARCI, 1898. Annual Reports of the Chief Inspector of Factories and Workshop, London.

Bearer, C.F., 1995. 'How are Children Different From Adults?' *Environmental Health Perspectives*, Vol. 103, Supp. 6.

BMA, 1998, *Health and Environmental Impact Assessment: An Integrated Approach,* British Medical Association, London.

Brunekreef B., 1997. 'Air pollution and life expectancy: is there a relation?' *Occup. Environ. Med.* 1997; 54: 781-84

Camus M., *et al.*, 1998. 'Non-occupational exposure to chrysotile asbestos and the risk of lung cancer'. *New England Journal of Medicine,* 338, 1565-1571, 1998.

Cantor, K.P., Stewart, P.A., Brinton, L.A. and Dosemeci, M., 1995. 'Occupational exposures and Female Breast Cancer Mortality in the USA.' *ACOEM,* 37: 336-348.

CECHE, 1998. *Global Health and Environment Monitor* Vol 6, Issue 2. Centre for Communications, Health and the Environment, Washington.

CICH, 1997. 'Children Need Special Protection', *CICH Newsletter* Vol. 19, No 1, p. 6. Canadian Institute of Child Health, Ottawa.

CJPH, 1998 in press. Proceedings from the CICH Conference on Children and Environmental Health, May 1997, Canadian Journal of Public Health, details available from Canadian Institute of Child Health, Ottawa.

Davis, D.L., Axelrod, D., Bailey, L., Gaynor, M., Sasco, A.J., 1997. *Rethinking breast cancer risk and the environment: The case for the precautionary principle.* World Resources Institute, Washington DC.

Davis, D.L., Bradlow, H.L., Wolff, M., Woodruff, T., Hoel, D.G. and Anotn-Culver, H., 1993. 'Medical Hypothesis: Xeno-oestrogens as Preventable Causes of Cancer'. *Environmental Health Perspectives* 101: 372-377.

de Hollander, A., Melse, J.M., Lebret, E., Kramers, P. (in press). *An aggregate public health indicator to represent the impact of multiple environmental exposures.* National Institute of Public Health and the Environment, Bilthoven.

Dolk, H., *et al.*, 1998. 'Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study'. *Lancet* 1998; 352: 423-27.

EASHW, 1998, 'Economic Impact of Occupational Safety and Health in the Member States of the EU', European Agency for Safety and Health at Work, Bilbao.

Eckel, W.P., Ross, B. and Isensee, R., 1993. Pentobarbital Found in Ground Water'. *Ground Water* Vol. 31, No 5, pp. 801-4.

ECMT, Statistical report on road accidents in 1992, 1997. European Conference of Ministers of Transport, OECD, Paris.

Edqvist, Prof. L.E., 1997. Swedish National Veterinary Institute. 'Introduction to the Scientific Report on Antrimocrobial Feed Additives.' Swedish Ministry of Agriculture, 1997. *Today we defeat bacteria. What about tomorrow?* Documentation from a conference in Brussels, 13 Nov. 1997. Regeringskansliet, Stockholm.

EEA, 1998. *Europe's Environment: The Second Assessment.* European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg, and Elsevier Science Ltd., Oxford, UK.

EEA/UNEP 1998, *Chemicals in Europe: Low Doses, High Stakes?* European Environment Agency, Copenhagen

EHP, 1998. 'Childhood Cancer: A Growing Problem'. *Environmental Health Perspectives,* Vol. 106, No 1, January.

Elliot, P., *et al.,* 1996. Cancer incidence near municipal solid waste incinerators in Great Britain. Brit J Cancer 1996; 73: 702-10

Environics International, 1998. *International Environmental Monitor*, Toronto.

Environment and Health News, UK Vol 3 Edition 2, May 1998. Reported in *Workers' Health International Newsletter* July- December 1998, Sheffield, UK.

ESF, 1998. *An Environment for Better Health.* Integrated report of the ESF Environment and Health Programme, ed. Prof R Kroes. European Science Foundation. Strasbourg 1998.

EU Scientific Committee on Toxicity, Exotoxicity and the Environment. *Opinion on Human and Wildlife Health. Effects of Endocrine Disrupting Chemicals with Emphasis on Wildlife and on Exotoxicity Test Methods*, 1999. Http://www.europe.eu.int/comm/dg24/health/sc/sct/outcome/en.htm

European Commission, 1996, *Environment and Immunity*, Air Pollution Epidemiology Reports Series, Nr. 11, EUR 17 475 EN., Luxembourg

European Commission *et al.,* 1997. EC, EEA, OECD, WHO, ECEH, KEMI, IEH, BUM, CEFIC, 1997, *European Workshop on the impact of endocrine-disrupters on human health and wild-life*, Weybridge, UK 2-4 December, 1996, Cat. No EUR 17549, available from DG XII, Brussels.

European Foundation, 1996. *Second European Survey on Working Conditions, 1996.* From: European Foundation, Dublin, Ireland.

Eurostat. *EU Transport in figures – Statistical pocketbook.* Luxembourg: Office for Official Publications of the European Communities; 1997; ISBN: 92-827-9693-0.

FAO/WHO, 1998. Joint Food Standards Programme. Codex Committee on Pesticide Residues. 13th Session. The Hague, the Netherlands. 20-25 April 1998 in *Pesticide News, UK.* No. 40, June 1998.

Feurpfeil, I:, Lopez-Pila, J., Schmidt, R., Schneider, E., Szewzyk, R., 1999. *Bundesgesundheitsbl-Gesundheitsforsch-Gesundheitschutz,* 42, 37-50, Springer-Verlag.

Foster, W.G. and Rousseaux, C.G,. 1995. 'The Reproductive Toxicology of Great Lakes Contaminants', *Environmental Health Perspectives,* Vol. 103, Supp. No 9.

Gee, D., 1995. 'Approaches to Scientific Uncertainty'. In *Transport and Health* 1995 by Fletcher and McMichael, London.

Grandjean P. *et al.*, 1997. 'Cognitive deficit in seven-year-old children with prenatal exposure to methylmercury', *Neurotoxicology and Teratology,* Vol. 19, no 6, pp. 417-428.

Gurunathan S., *et al.*, 1998. 'Accumulation of chlorpyrifos on residential surfaces and toys accessible to children', *Environmental Health Perspectives* Vol. 106, No 1, January.

Halling-Sørensen, B., Nors Nielsen, S., Lanzky, P.F., Ingerslev, F., Holten-Lützhoft, H.-C. and Jørgensen, S.E., 1998. 'Occurrence, Fate and Effects of Pharmaceutical Substances in the Environment – A review. *Chemosphere* Vol. 36, No 2, pp. 357-393. Elsevier Science Ltd, UK, 1997.

Hammond EC, Selikoff IJ, Seidman H, 1979. *Asbestos exposure, cigarette smoking and death rates.* Annals of New York Academy of Sciences, pp. 330, 473-490.

Health Council of the Netherlands, 1994. *Noise and Health*, September 1994. Amsterdam.

Holm, J.V., Rugge, K., Bjerg, P.L. and Christensen, T.H., 1995. 'Effects of ivermectin treatment on the attention of dung beetles to cow pats.' *Bull Entomol. Research.*

Holten-Lutzhoft, H.-C., Halling-Sørensen, B. and Jørgensen, S.E., 1999. 'Algal Toxicity of Antibacterial Agents Applied in Danish Fish Farming.' *Archives of Environmental Contamination and Toxicology*, Springer-Verlag New York Inc., 1999

Hoyer, A.P., *et al.,* 1998. 'Organochlorine exposure and risk of breast cancer', *Lancet* Vol 352, 1816-1820, December, London.

Hulka, B.S. and Stark, A.T., 1995. 'Breast Cancer: cause and prevention.' *Lancet* 346: 883-887.

IPCC, 1995. *Climate Change: Second Assessment*, Intergovernmental Panel on Climate Change, UNEP, Geneva

Jacobson, J.H. & Jacobson, S.W., 1996. 'Intellectual Impairment in Children exposed to polychlorinated byphenols in utero', *N. Engl. J. Med.* Vol. 335, Boston.

Jensen, A. A., 1996. *Environmental and Occupational Chemicals, in Drugs and Human Lactation,* Ed. Bennett P.N., Elsevier, Amsterdam.

Jørgensen, S.E., Lützhøft, H.C. and Sørensen, B.H., 1998. 'Development of a model for environmental risk assessment of growth promoters.' *Ecological Modelling* 107, 63-72, Elsevier Science B.V.

Knox, E.G. & Gilman, E.A., 1997. 'Hazard Proximities of Childhood Cancers in Great Britain, 1953-80'. *J. of Epidemiology and Community Health*, Vol. 51.

Kristensen, T.S., Olsen, O, 1991. 'Impact of the work environment on cardiovascular disease.' *J Epidemiology Community Health,* 1991; vol. 45, pp. 4-7.

Krzyzanowski M., 1997. 'Methods for assessing the extent of exposure and effects of air pollution'. *Occup Environ Med* 1997; 54: 145-51

La Dou, J. (ed), 1998. *Occupational and Environmental Medicine*. Second edition. USA, Appleton Lange.

Lanzky, P.F. and Halling-Sørensen, B, 1997. 'The toxic effect of the antibiotic metronidazole on aquatic organisms.' *Chemosphere* Vol 35, No 11, pp. 2553-2561, 1997, Elsevier Science Ltd., UK.

Luhmann, HJ, Renate E, Roemer M, 1998. *Unevenly distributed benefits from reducing pollutants, especially road traffic emissions, via reducing road transport.* Wuppertal Institute for Climate, Enviornment and Energy. Environmental Fiscal Reform Working Paper no. 6. Wuppertal.

Macri, A., Staza, A.V. and Dojmi di Delupis, G., 1998. 'Acute Toxicity of Furazolidone on *Artemia salina, Daphnia magna* and *Culex pipiens molestus* Larvae.' *Ecotoxicol. Environ. Safety* Vol. 16, p. 90-94.

Maddison, D, 1998. 'Valuing changes in life expectancy in England and Wales caused by ambient concentrations of particulate matter'. CSERGE working paper, GEC 98-06, Norwich.

McConnell, E.E., 1992. 'Comparative Responses in Carcinogenesis bioassays as a function of age at first exposure', in *Similarities and Differences between Children and Adults: Implications for Risk Assessment*, Guzelian P.S., Henry C.J. & Olin S.S. Eds. ILSI Press, Washington.

McMichael, M., *et al.,* 1996. *Climate change and human health.* World Health Organization, 1996. Geneva.

McMichael, AJ, Anderson HR, Brunekreef B, Cohen AJ, 1998. 'Inappropriate use of daily mortality analyses to estimate longer-term mortality effects of air pollution'. *Int J Epidemiol* 1998; 27: 450-53

McPherson, K., Steel, C.M.J. and Dixon, J.M., 1994. 'Breast Cancer Epidemiology, Risk Factors, and Genetics.' *BJM* 309: 1003-1006.

Ministere des affaires sociales de sante et de la ville, Lyon 1995, REF 'Les effets du bruit sur la sante',

Moore, M.R., *et al.,* 1998.. 'Decline in maternal blood lead concentrations in Glasgow'. *J Epidemiol Community Health* 1998; 52: 672-3.

MRC, 1997. *IEH report on Health Effects of Waste Combustion Products,* Medical Research Council, Institute for Environment and Health, University of Leicester. Report R7, 1997

NRC, 1993. *Pesticides in the diets of infants and children*, National Research Council, National Academy Press, Washington DC.

OECD, 1998. Safety of vulnerable road users. http://www.oecd.org/dsti/sti/transpor/road/index.htm; 1998.

Pesticides Trust, 1998. Children at Risk: More Evidence Against OPs, Pesticides News, No. 34, March. London.

Peto *et al.,* 1999. 'The European Mesothelioma Epidemic', *British Journal of Cancer* Vol 79, 314, pp. 666-672, Cancer Research Campaign, London.

Pogoda, J.M., & Preston-Martin, S., 1997. 'Household pesticides and rsk of pediatric brain tumours', *Environmental Health Perspectives,* Vol. 105, No 11, Nov., N. Carolina.

Quinet, E., 1993. *The Social costs of transport: evaluation and links with internalisation policies in : Internalising the Social Costs of Transport.* ECMT/OECD, Paris 1993.

Rachel's EHW, 1997. 'The truth about breast cancer', *Rachel's Environment & Health Weekly* Nos 571-575, 6 November 1997 – 4 December 1997. Environmental Research Foundation, Annapolis, Maryland.

Rachel's EHW, 1998. 'Children's Cancer and Pesticides', *Rachel's Environment & Health Weekly,* March 5, Environmental Research Foundation, Annapolis, Maryland

Ramazzini, B., PhD., 1713. *The Diseases of Artisans.* For further details about Collegian Romazzini, Carpi, Italy.

Peto J *et al.*, 1999. *The European mesothelioma epidemic.* British Journal of Cancer, 1999, vol. 79 ¾, Cancer Research Campaign, London.

Rodier P.M., 1995. 'Developing Brain as a Target of Toxicity', *Environmental Health Perspectives.*

Rogan W., 1996. 'Pollutants in Breast Milk', *Arch. of Pediatr. Adolesc. Med.,* Vol. 150.

Rylander L., Stromberg U. & Hagmar L., 1995. Vol. 21 'Decreased birth weight among infants born to women with a high dietary intake of fish contaminated with persistent organochlorine compounds', *Scand. J. Work, Envir. & Health*, Stockholm.

Samuelson, O.B., Torsvik, V. and Ervik, A.,1992a. 'Long-range changes in oxytetracycline concentration and bacterial resistance towards oxytetracycline in a fish farm sediment after medication.' *Sci. Tot. Environ.* Vol 114, pp. 25-36.

Samuelson, O.B., Lunestad, B.T., Husevåg, B., Hølleland, T. and Ervik, A., 1992b. 'Residues of oxolinic acid in wild fauna following medication in fish farms.' *Dis. aquat. Org.* Vol 12, pp. 111/19.

Schneider, J., 1994. Problems related to the usage of veterinary drugs in aquaculture – a review'. *Quimica Analitica* Vol 13 (supp. 1) pp. S34-S42.

Slaper, H., *et al.,* 1996. Estimates of ozone depletion and skin cancer incidence to examine the Vienna Convention achievements. Nature 384; 256-258.

Stan, H-J., Heberer, T. and Linkerhägner, M., 1994. 'Occurrence of clofibric acid in the aquatic system – is the use in human medical care the source of the contamination of surface, ground and drinking water?' *Vom Wasser* Vol. 83, pp.57-68.

Strachan, D.P, 1995. Editorial: Time trends in asthma and allergy: ten questions, fewer answers. Clin Exper Allergy 1995; 25: 791-94

Swedish EPA, 1996. *Risk assessment, health, environment,* Swedish Environmental Protection Agency, Stockholm.

Swedish Ministry of Agriculture, 1997. *Today we defeat bacteria. What about tomorrow?* Documentation from a conference in Brussels, 13 Nov. 1997. Regeringskansliet, Stockholm.

Toppari, J., *et al.*, 1996, 'Male Reproductive Health and Environmental Xenoestrogens', *Environmental Health Perspectives* Vol 104 Supplement 4 August.

UCB, 1997. *European Allergy White Paper,* UCB Institute of Allergy, Brussels

UNEP and UNICEF, 1997. Childhood lead poisoning, Information for Advocacy and Action. ISBN 92-807-1658-0

UNICEF, 1992. *Impact of Lead and Agrochemicals on Children*, a report to UNICEF by Environmental Protection Encouragement Agency, Hamburg, 1992. Total amount of lead released into the environment is estimated at approximately 860 000 to 1 670 000 metric tons per year.

USEPA, 1996. *Environmental Threats to Children*, US Environmental Protection Agency, Washington.

Watterson, A., 1995. 'Occupational and environmental factors linked to breast cancer.' Centre for Occupational and Environmental Health. De Montfort University, Scraptoft Campus, Leicester, UK. A revised 1998 version of this publication is now available, e-mail: aew@dmu.ac.uk

Wegman, D. and Fine, L., 1996. 'Occupational and Environmental Medicine.' *J: Am Med Ass*, 1996, Vol. 275, pp. 1831-4.

Weisglas-Kuperus, *et al.,* 1996. 'Immunological effects of background perinatal and post natal exposure to dioxins and polychlorinated biphenyls in Dutch infants'. *Pediatr Res* 1996.

WHIN, 1998. Workers' Health International Newsletter (WHIN), July-December 1998, p. 30. Web info: http://www.niehs.nih.gov/emfrapid/home.htm and http://www.nytimes.com/aponline/w/AP.Electric-Fields-Cancer.html; WHO, home page: http// www.who.ch/, reproduced in *Workers' Health International Newsletter (WHIN),* January-June 1998, p. 3 and p. 5.

WHO, 1993. *The Environmental Health Criteria Document on Community Noise. Report on the Task Force Meeting, Düsseldorf, Germany, 24-28 November, 1992.* World Health Organization, WHO Regional Office for Europe, Copenhagen. [Report EUR/HFA Target 24].

WHO, 1994. Joint WHO/German Regional seminar on Drinking Water Quality. Report on a WHO seminar, Bad Elster, Germany 10-14 October 1994. EUR/ICP/ EHAZ 94 11/WS03. 25pp.

WHO, 1996a. Mc Michael, A.J., Haines, A., Sloof, R., Kovats, S. *Climate change and human health. An assessment prepared by a task group.* WHO/EHG/ 96.7.

WHO, 1996b. 'Levels of PCBs, PCDDs and PCDFs in Human milk', Environmental Health in Europe, No 3, World Health Organization, Regional Office for Europe, Copenhagen.

WHO, 1997a. *Occupational Health. WHO Fact Sheet, no 84.* Revised December 1997. Web: http:// www.who.ch/

WHO, 1997b. Update and Revision of the WHO Air Quality Guidelines for Europe, Particulate Matter (in press), World Health Organization, Regional Ofrice for Europe, Copenhagen.

WHO, 1997c, Guidance For Setting Air Quality Standards, May, World Health Organization, Regional Office for Europe, Copenhagen.

WHO, 1997d. *Health and environment in sustainable development. Five years after the Earth Summit.* WHO/EHG/97.8. World Health Organization, Geneva, 242 pages.

WHO, 1998a. 'Assessment of the health risk of dioxins: Re-evaluation of the tolerable daily intake (TDI)', Final note on consultation, December, World Health Organization, Geneva.

WHO, 1998b, 'When the smoke gets thicker: Smoking while being exposed to chemical or physical agents or biological dust is extremely dangerous' World Health Organization Factsheet No 158 (rev), Geneva.

WHO, 1999a. *An overview of Environment and Health in Europe in the 1990s.* Background paper for 1999 London conference. World Health Organization, Regional Office for Europe, Copenhagen.

WHO, 1999b. *Early human health effects of climate change.* Background document for 1999 London conference. World Health Organization, Regional Office for Europe, Copenhagen.

WHO/EEA, 1997. *Air and Health.* World Health Organization/European Environment Agency. Copenhagen.

WHO/EEA, 1999. Monograph on Water Resources and Human Health in Europe. Draft Report. In Preparation.

WHO/EURO, 1998. *Health in Europe 1997.* WHO Regional Publications, European Series No. 83.
Woolff, M:S:, Tomiolo, P:G:, Lee, E:W:, Rivera, M. and Dubin, N, 1993. 'Blood Levels of Organochlorine Residues and Risk of Breast Cancer.' *JNCI* 85: 648-652.

WRI, 1997. Working Group on Public Health and Fossil Fuel Combustion. Short-term improvements in public health from global-climate policies on fossil-fuel combustion: an interim report. Lancet 1997; 350: 1341-49.

3.11. Changes and loss of biodiversity

Main findings

- Biodiversity of genes, species, ecosystems and habitats will remain under threat in the EU. Habitats will be decreased and fragmented, endangering many indigenous, rare, endemic and specialist species populations and ecosystem functions, although generalist and invasive species will continue to spread. A continuation in the recovery of a small number of endangered species and habitats can be foreseen.

- Although concerns for nature protection are beginning to be integrated in sectoral policies, negative impacts on biodiversity are expected to continue from agricultural intensification, land abandonment (this may be beneficial in intensively cultivated areas), monospecific forestry, urban and transport infrastructure development, climate change and the introduction of alien species (and possibly genetically modified organisms).

- More positively, reductions are foreseen in acidification and eutrophication, enabling species and habitats to show some recovery, although there will not be a full return to pre-pollution conditions, even after 2010.

- Over the next decade upwards of 10% of EU territory is expected to be designated for nature protection as part of the NATURA 2000 Network and provisions taken for protection of the most threatened species in the EU.

- The European Community Biodiversity Strategy (in the framework of the Convention on Biological Diversity) will function through action plans designed to integrate biodiversity in the European Commission's activities and in policies and programmes where there is a European Community competence.

1. Main economic sectors influencing European biodiversity

Biodiversity (species, habitats and gene pools) is mostly affected not only by one single pressure, but by a combination of pressures derived from all main societal sectors: agriculture, forestry, fisheries, as well as from urbanisation, industry, transport, tourism and recreation, energy use, chemicals and minerals.

1.1 Agriculture

In most European countries, agriculture remains one of the most important activities interacting with nature through land-use, pollution, species introduction and genetic selection. The observed polarisation (towards intensification or abandonment) of agricultural activities in areas of extensive (low-intensity) agricultural practices leads to ecological conditions of less value for nature conservation, while abandonment of intensive practices may lead to conditions of increased value. The effects on biodiversity of abandonment depends on the scale at which the process occurs, on the type of habitat whose management is being abandoned and on the end-habitat evolving.

In agriculture and forestry, exchange between cultivated and natural gene pools has occurred widely. Gene traits occurring naturally through hybridisation and spontaneous mutations have been traditionally selected and further developed through breeding to develop the present cultivated and domesticated species. New techniques for more direct gene modification (GMOs: Genetically Modified Organisms) permits more intensive and widespread use of a limited number of cultivated species variants (Council of Europe, 1993) (see Chapter 3.9). Data from different countries on GMOs (still a limited range of species) indicate that genes from crops can, and already have, pass into natural populations of wild relatives, but the process has also been seen in rapes and cabbages (*Brassica*) able to break through the species barrier into other species such as White Mustard (*Sinapis alba*) and Wild Radish (*Raphanus raphanistrum*) (Akeroyd, 1998).

Box 3.11.1. We face changes and losses in biodiversity. Does it matter?

Biodiversity is the 'variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (Convention on Biological Diversity, 1992). Biodiversity in its widest sense encompasses all aquatic species and habitats as well as the species and habitats of our highly cultivated and managed fields, forests, parks and gardens and all the less intensively used and cultivated (semi-natural) and natural areas.

The approach to biodiversity is complex: it relates not only to numbers of species and habitats, but also to variability, continuity, processes and patterns. Maintaining thriving natural systems is essential not only for economic or ethical reasons, but also for ecological, social, recreational, educational and aesthetic reasons. Recognition of this is the background for the growing awareness and development towards sustainable use and management of natural resources in most countries and sectors. But the rate and scale at which the environment is being altered have accelerated in recent decades to levels which, in many areas, may be close to the thresholds for securing a sustainable biological future despite the many counter measures. The larger and more rapid the changes, the smaller the chances for natural adaptation and development in species and ecosystems. In an increasingly changing environment, principles of precaution are therefore being advocated in many international and national programmes and policies, not the least because there is still limited knowledge of the function and resilience of both ecosystems and species (Heywood and Watson, 1995).

Loss of biodiversity, considered at three scales: genes, species/populations, habitats/ecosystems, has been recognised as an issue of urgent concern both in the EU Fifth Environmental Action Programme and through the adoption of the Convention of Biological Diversity by most governments in the world. This problem ranks alongside global impacts such as climate change, ozone depletion and desertification.

Agriculture was identified as a major impacting sector on biodiversity within the 5EAP. Integration of environmental issues in agricultural policy was boosted by the 1992 Common Agricultural Policy (CAP) reforms, and the process is likely to continue with the accession of eastern and central European countries. In March 1999 global agreements were reached between the EU ministers for agriculture on a reform of CAP within the framework of Agenda 2000 on the balance between production, environmental and social function of agriculture in Europe (see below and Chapter 3.13).

1.2. Forestry

Forestry is another major driving force for biodiversity. The importance of forests and forest management may increase in the future (see Box 3.11.2), showing different directions of development simultaneously: a continuing main trend towards monospecific managed forests, often based on exotic species, while at the same time an increasing use of native species and gene pools; a continuing decrease in old forest areas while interest in their conservation increases; a potential use of genetically modified trees; a continuing fragmentation of forests, while in other areas afforestation programmes serve to link forests into complexes; a continuation of forest damage observed during the past decades; shifts in species composition of forests and foreseen changes in growing seasons due to climate change with unknown consequences for the composition and structure of related species communities (as for many other ecosystems); risks of spreading disease in forest trees both with changing climate and increasing transportation of forest products; and an increase in European forest biomass, with still unknown consequences for biodiversity.

Afforestation programmes initiated under the 1992 CAP reform (Council Regulation (EEC) No 2080/92) have been applied differently in Member States (see Chapter 3.13). Four EU countries (Spain, the United Kingdom, Ireland and Portugal) have actively implemented these programmes, accounting for more than 80% of the total area afforested under the regulation. In many cases, fast-growing species, including exotic species, have been used, often at the expense of habitats of high biodiversity value (ERM, 1996; Lierdeman and Soufi, 1997).

Box 3.11.2. Climate change: forests as carbon sinks

Measures envisaged under the Kyoto Protocol (see Chapter 3.1) for increasing the carbon sink capacity are likely to lead to changes in forest areas and stands, such as the extension of plantation area, the maintenance of young, productive stands at the expense of habitats of high biodiversity value (grasslands and pastures, steppes, old-growth forests), and the choice and development of tree species or species varieties related to carbon sink capacity. Indications are that coniferous forests have a higher carbon sink capacity than deciduous forests; but mixed forests are recognised as more healthy and damage-resistant than monospecific cultures. Active choice of tree species selection and development of genetically modified trees may have significant impacts on European forests in the future.

ETC/NC-European Forest Institute, 1998

1.3. Other impacting sectors

Urbanisation (see Chapter 3.12) and development of heavily impacting infrastructure (e.g. transport, energy and water supply) lead to a steep decrease in the extent of many natural and semi-natural habitats, and to high fragmentation and isolation. There is also increasing evidence of the impact of high noise levels such as around motorways, disturbing breeding birds. On the other hand, the plantation of trees and the use of wild and cultivated flowers create new species and often rich habitats.

Though stabilizing or decreasing, pollution – with resulting eutrophication, acidification and pesticide loads – has increasingly perceptible effects on biodiversity caused by long-term chemical influences.

Despite strict conservation measures, fisheries is still a major impacting sector with direct and indirect effects on species (by overexploitation of target species, mortality, injury and stress on other species such as dolphins, auks, terns, cormorants) and on the marine ecosystem (by disturbance of sediments, communities and the food-chain).

Marine aquaculture (see Chapter 3.14) is a rapidly expanding industry in the coastal zone where biodiversity is high (estuaries, coastal marshes) and where human pressures are increasing and complex. Though initially judged negligible, the impact on biodiversity through feeding (additional nutrients), pests and escaping species (with consequent genetic change in wild populations) is considered severe locally.

As one of the fast-growing sectors world-wide, tourism in many areas has heavy direct destructive impacts on habitats and disturbance of species, and indirect impacts through pollution and water demand, particularly in coastal and mountain areas (see Chapters 3.14, 3.15). Increasing interest in 'ecotourism' raises awareness of nature and biodiversity, but it has already had damaging impacts on areas that were once remote.

2. From awareness to policy

Biodiversity protection has evolved significantly over time:

- from protection of species, towards protection of habitats;
- from conservation in-situ towards com-

Main Community initiatives of relevance for biodiversity — Table 3.11.1.

General frame
Fifth Environmental Action Programme Towards Sustainability
Agenda 2000
European Community Biodiversity Strategy
Communication on a Forest Strategy for the European Union
European Spatial Development Perspective
Community Directives and Regulations
Directive 79/409/EEC on the conservation of wild birds (Birds Directive)
Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
Regulation (EEC) N°1973/92 establishing a financial instrument for the environment, as amended by regulation (EC) n°1404/96: LIFE funds
Regulation (EEC) N° 938/97 implementing Regulation (EEC) N°338/97 on the protection of species of wild fauna and wild flora by regulating trade therein
Directive 85/337/EEC on environmental impact assessment, as amended by Directive 97/11/EC
Directive 75/268/EEC on mountain and hill farming and farming in certain Less Favoured Areas
Regulation (EEC) N° 2078/92 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside
Regulation (EEC) N°3528/86 on the protection of the Community's forests against atmospheric pollution
Regulation (EEC) N°2158/92 on protection of the Community's forests against fire
Directive 78/659/EEC on the quality of fresh waters needing protection or improvement in order to support fish life
Directive 76/464/EEC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community
Directive 91/271/EEC concerning the protection of water against pollution caused by nitrates from agricultural sources
Framework Directive on Water Quality (under development)
Directive 77/93 /EEC on protective measures against the introduction into the MS of harmful organisms of plants or plants products
Directive 90/219/EEC on the contained use of genetically modified micro-organisms
Directive 90/220/EEC on the deliberate release into the environment of genetically modified organisms
Amendments adopted in December 1998 to the Directives related to the marketing of seeds (66/400/EEC, 66/401/EEC, 66/402/EEC, 66/403/EEC, 69/208/EEC, 70/457/EEC, 70/458/EEC) for *in situ* conservation and sustainable use of plant genetic resources, through growing and marketing of land races and varieties adapted to local and regional conditions
Regulation (EEC)N°1467/94 on conservation, characterisation, collection and utilisation of genetic resources in agriculture
Regulation (EEC) N°2100/94 on Community plant variety rights

plementary ex-situ measures;
- from protection of species and habitats, towards protection of natural processes;
- from nature protection as an isolated exercise, towards integration of nature-conservation into planning and management of terrestrial and marine environment as a whole, and into each economic sector, based on the principle of sustainability;
- from isolated local or national initiatives, towards co-ordinated programmes of international co-operation, with standards and criteria agreed internationally;
- from conservation of nature for its scientific and aesthetic qualities towards recognition of the importance of ecosystems as a whole, rather than of elements known specifically to be at risk; and,
- from habitats and ecosystems to conservation of landscape patterns.

The Pan-European Biological and Landscape Diversity Strategy (PEBLDS; Council of Europe, 1996) aims at supporting and co-ordinating national actions to maintain and enhance biological and landscape biodiversity, in conjunction with the Global Convention on Biological Diversity (CBD).

Many reports, the Dobris Report (Stanners and Bourdeau, 1995), Europe's Environment: The Second Assessment (EEA, 1998), Existing agreements and initiatives in developing the Pan-European Network (Bennett, in prep.) provide overviews on international conventions and initiatives. In addition, national reports under the Biodiversity Convention review initiatives undertaken at national level.

A comprehensive review of Community policies related to biodiversity is provided in the first report on the implementation of the Convention on Biological Strategy by the European Community (European Commission, 1998a). Some of them are summarised in Table 3.11.1.

3. What is special about Europe and biodiversity?

3.1. European issues in comparison to the world

Biodiversity loss due to fragmentation is a special cause of concern in many regions of Europe: fragmentation and coastal degradation are likely to increase, while other environmental problems such as air and water pollution are likely to remain more stable or decrease slightly (Table 3.11.2).

3.2. European influences on biodiversity in the rest of the world

3.2.1. Europe shares responsibility with other continents for migratory species

Europe is the seasonal home to and an important crossroads for huge populations of migratory species, sharing these species with other continents such as Africa, Near East and North America. This responsibility is translated, among others, through the Convention on Migratory Species (Bonn Convention) and its underlying agreements, which has provided a global frame for EU nature-protection directives. Success or failure to provide sufficient resting, feeding and breeding grounds in Europe will influence biodiversity in these other continents just as successes and failures there will influence Europe's biodiversity.

3.2.2. European trade and technology transfer

European trade and technology transfer have led to significant impacts on global biodiversity:

- Just as there are serious ongoing concerns about species introduced to Europe from other global regions becoming invasive and about the introduction of GMOs, Europe has induced radical changes in biodiversity in other continents through the introduction of European species during the past two centuries (such as birds and trees in New Zealand); GMOs from Europe may also spearhead changes.
- At present western Europe shares with the United States and Japan the consumption of half of the world's timber harvested for industrial use.
- In the Amazon area, transportation corridors created for timber products facilitate conversion of forests to agriculture for commodities bound for Europe. The total area deforested per year has increased from 30 000 km^2 in 1975 to at least 600 000 km^2 at present, with twice as large an area affected biologically (Brown, 1998).
- Trade in wild flora and fauna species effects global biodiversity. World imports of threatened wild plants and animals are regulated by CITES (the Washington Convention), and the EU has been closely involved in implementation of the Convention. However, the EU is among the world's leading importers of several groups of species and species products (Figure 3.11.1).

3.3. Species in Europe

Importance and trends of environmental issues by continent or large region Table 3.11.2.

*Importance : *** Critically important ; ** Important ; * Lower priority; 0 Negligible.*

Regional environmental trends : ↗ Increasing; → Remaining relatively stable; ↘ Decreasing ; – Not applicable

Environmental problems	Africa	Asia-Pacific	Europe & Former USSR	Latin America & Caribbean	North America	West Asia	Polar region
Land: degradation	*** ↗	*** ↗	** →	*** ↗	** ↘	*** ↗	* →
Forest: loss, degradation	*** ↗	*** ↗	** →	*** ↗	* →	* ↗	0 -
Biodiversity: loss, fragmentation	** ↗	*** ↗	*** ↗	** ↗	** →	** ↗	** →
Fresh water: access, pollution	*** ↗	*** ↗	*** →	** ↗	*** →	*** ↗	* →
Marine and coastal zones: degradation	** →	*** ↗	*** ↗	** ↗	** →	*** ↗	* →
Atmosphere: pollution	** →	*** ↗	*** →	*** ↗	*** →	** →	** →
Urban & industrial: contamination, waste	**	*** ↗	*** →	*** ↗	*** →	*** ↗	* -

Source: Modified from UNEP, 1998a

The present diversity of species in Europe results from a complex combination of species occurring naturally within their ecological range, of those used and introduced through centuries for economic or recreation purposes (agriculture, horticulture, forestry, hunting, and fisheries) and of a large range of species which follow cultivation or transport. At all times low numbers of new species spread naturally to Europe and within Europe's regions (Figure 3.11.2).

Some native species are spreading or their populations are increasing, due to protection laws, restoration programmes (Skotte Møller, 1995) and reintroductions: these include most raptors, geese, butterflies locally, and in certain areas large carnivores (wolf, bear). Some species benefit from new environmental conditions (newly created habitats as in urban areas, more availability of food), and some even have dramatic increases in their populations, such as in the case of several opportunistic or generalist species.

However, many more native species are declining, although so far the rate of total species disappearance (extinction) has been low in Europe, except for endemic species. Instances of species under pressure include:

- 64 endemic plants of Europe (including the Macaronesian islands) have become extinct in nature (8 in the 1980s and 9 in the 1990s), among which only 27 have been saved in cultivated form (conservation ex-situ) (Lesoueff, in prep.);

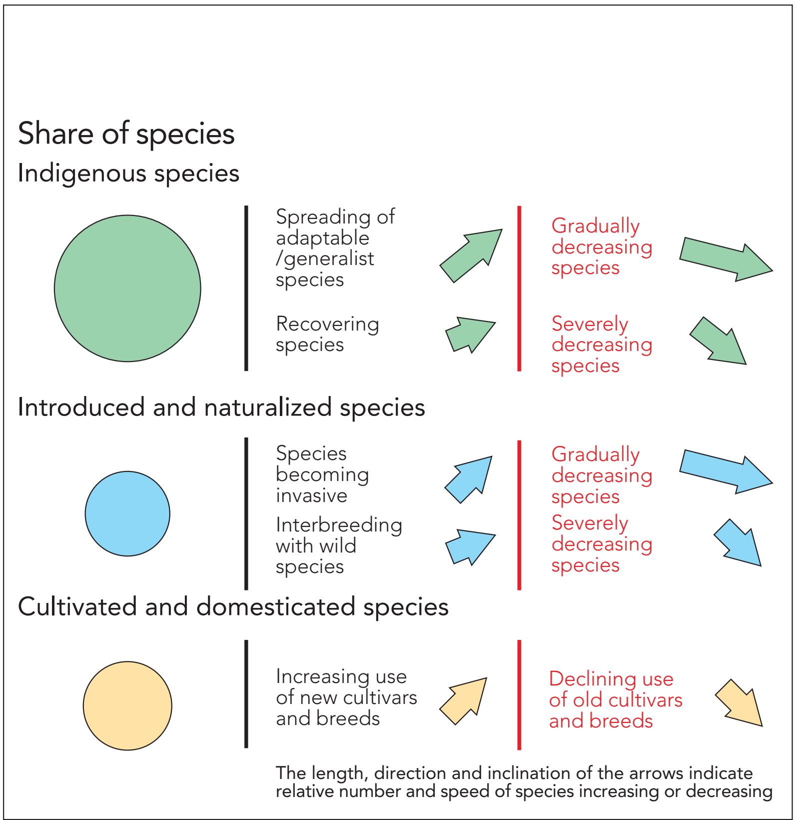
World imports of CITES specimens by the EU12 during the period 1990-1994 Figure 3.11.1

Specimen type	EU imports/ total world imports	Ranking of importance of EU imports worldwide	Origin of imports
Live African Finches	89%	1st	Africa
Live Parrots	74%	1st	
Nile Monitor skins	72%	1st	Africa
Alligator skins	59%	1st	USA
Reticulated Python skins	36%	1st	South-East Asia
Live primates	29%	2nd	
Nile Crocodile skins	28%	2nd	Africa
Caiman skins	17%	2nd	South America
Live Chameleons	13%	2nd	Africa
Live Poison Arrow Frogs	8%	2nd	South/Central America
Water Monitor skins	1%	6th	South-East Asia

Source: compiled from the annual reports of CITES Member States, Cites trade statistics; WCMC (Council of Europe, 1997)

- 38% of birds species are threatened, with vulnerable or endangered populations (Tucker *et al.*, 1994);
- 45% of European butterflies are threatened, with vulnerable or endangered populations (van Swaay *et al.*, 1997);
- of the 3 200 species of land and freshwater molluscs present in Europe, 145 species are considered as threatened at

Figure 3.11.2 **Important relative trends in vertebrates and vascular plants in Europe**



Source : ETC/NC; EEA

global level (Bouchet *et al.*, 1998);
- of the 1687 species and subspecies of Bryophytes occurring in Europe, at least 24% are threatened (European Committee for the Conservation of Bryophytes, 1995).

Meanwhile, more and more species, particularly plants, are introduced for economic or recreational purposes, sometimes with dramatic consequences in the case of invasive alien species, particularly in marine and freshwater ecosystems, and also in grasslands.

Interactions between species are disturbed, particularly prey/predator relations (herbivores/carnivores, hosts/parasites), leading to food web changes and general disturbance of the ecosystem. Species related to old habitats decline, while species related to young habitats with short rotation periods spread. There are also effects on indigenous gene pools, and increased risks of epidemics.

3.4. Habitats in Europe

In large areas of Europe, semi-natural and natural habitats are heavily affected by urbanisation and infrastructure, intensification or abandonment of agriculture, pollution, drainage and introduction of species. The small remaining area of natural, untouched habitat-types (mainly in high latitudes and mountain areas – see Chapters 3.13, 3.14, 3.15) are normally considered of very high conservation value and form central parts of national, European Union and international nature-conservation efforts. If these habitats are not secured, most of them will disappear.

But not only the untouched habitats are considered valuable for biodiversity. Many habitats of high biodiversity conservation value – the so-called semi-natural habitats – depend on long-term extensive management. Thus, out of the 198 habitat-types covered by the Habitats Directive, up to 29 are partly of anthropogenic origin and their maintenance depends on continued management in a fragile balance. These are, for example, extensive haymeadows, moorland and pastures subject to low-intensity grazing, chalk downs or scrub heathland grazed by sheep, and chestnut woods. Other habitat-types, though of natural origin such as dunes, salt meadows, steppes, bogs, several forest-types, are managed in an extensive way. Any drastic change in land use either towards intensification or abandonment, so-called polarisation, represents a threat for these habitat-types (Ostermann, 1998) (Table 3.11.3).

4. Habitats and ecosystems: integrating environmental changes

4.1. Habitat and ecosystem functionality: a condition for sustainability

Ecosystems and habitats are increasingly recognised for their functional role (Mooney *et al.*, 1996), and the need for sustainable management and use is becoming a general issue.

At global level, within the Convention on Biodiversity, major concerns focus on four types of ecosystems: agroecosystems, marine and inland waters, and forest ecosystems. At European level, the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) recognises the importance of specific actions on forests, wetlands (including rivers), grasslands, mountains, and coastal and marine ecosystems. PEBLDS also stresses the importance of landscapes, in which ecosystems such as forests, lakes and rivers form a major structuring and functional role.

Forests and wetlands are illustrative examples of the importance of ecosystem functions

(Table 3.11.4).

Ecosystems continuously react on the multiple pressures exerted upon them and in doing so integrate varying kinds of changes in the environmental conditions, while also changing functionality (see Box 3.11.5).

4.2. Threatened habitats and ecosystems

There is no available 'European Red Book' of habitats. Annex I of the Habitats Directive as well as habitats considered for the EMERALD Network (Bern Convention, see Box 3.11.4) represent only a selection of habitats of European concern (Box 3.11.3). However, regional co-ordinated assessments are now developed in the framework of Conventions on marine habitats (Helsinki (Nordheim *et al.*, 1998), Barcelona and North Sea Conferences and OSPAR).

At national level**,** Germany was one of the first European countries to produce a Red Book of endangered habitats (Rieken *et al.*, 1994). The survey, published in 1994 shows that among the 509 habitat-types (excluding habitats such as buildings) which are found in Germany, more than two-thirds can be considered endangered, mostly those established in extreme ecological conditions such as peat bogs, moorlands, coastal habitats, or those resulting from long, traditional agricultural or forestry management. Of the remaining third, not endangered habitats, only 6% are of interest for direct nature conservation (Figure 3.11.3). As a result of shrinkage of natural and near-natural habitats, especially in the past five decades, today about

Threats by change in land-use to habitat-types listed in Annex I of the Habitats Directive (EU) — Table 3.11.3.

Threat to habitat-type from polarisation of the existing land-use	Number of Annex I Habitat-types threatened by land-use intensification	Number of Annex I Habitat-types threatened by abandonment of land-use
grazing	65	26
forage/hay	6	6
crops	4	1
forestry	57	–

Many Annex I Habitat-types will be threatened if the intensity of the land-use is chan-ged (intensification or abandonment). Total number of Habitat-types in Annex I = 198
Note: Several habitat-types can be subject to more than one of the land uses mentioned.

Source: ETC/NC

Importance of ecosystem functions: Forests and Wetlands — Table 3.11.4.

Functions	Forests	Wetlands
Production	wood, resins, tannins, latex, cork and bark, game fowls, mushrooms, berries etc.	fish, shellfis and crustaceans, game fowls, peat, water reed, spartina, salt
Recreational & social	aesthetic and spiritual values, hunting, fishing, bird-watching , sports, rural and urban landscape	
Regulation	climate moderation, carbon sink (forests, peats), air quality, water regulation and quality, soil reconstitution	
Protection	against natural risks, soil erosion, landslides, avalanches, noise, visual disturbance	diminish destructive effects of floods
Conservation of biological diversity	maintenance of current, and support of future biological diversity at genetic, species, habitat levels conservation of evolution potential	
Structuring	landscape structuring and linkage of natural areas in networks	

Source: Adapted from ECOFOR, 1997 and COM(95)189 final (European Commission, 1996)

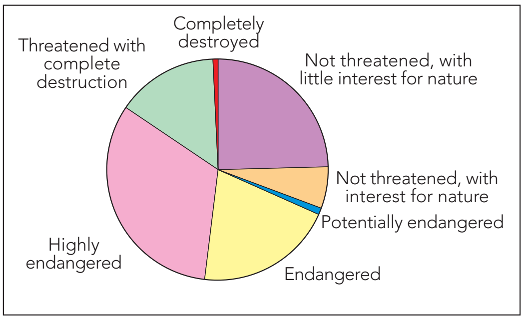
Box 3.11.3. Wetlands – a continuing cause for concern

Wetlands continue to be under particular pressure, with the drainage of extensive lowland areas for agriculture, forestry and urban development; the regulation of major river systems for power generation, water storage, navigation and flood control; and peat mining. In addition, wetlands suffer from heavy eutrophication and acidification, which was exacerbated during the 1970s, and from increasing consumption of groundwater (see Chapter 3.5). Another potential threat to coastal wetlands is a rise in sea level, due to climate change.

Wide differences in pressures exist across Europe. In general terms, industrialisation in north and west Europe has resulted in the greatest loss, degradation and fragmentation of wetlands, while agricultural intensification has reduced the area of wetlands by some 60% (European Commission, 1996). In the south of Europe, the long history of occupancy and often intensive use of Mediterranean wetlands place these areas under special stress, which in recent years has been exacerbated by low winter rainfall (Hails, 1996).

In central and eastern Europe, and in Fenno-Scandia, the lower degree of industrialisation, urbanisation and intensive agriculture means that far more extensive areas of natural and semi-natural wetlands remain. However, in Lithuania, 70% of wetlands have been lost during the past 30 years (Baskyté et al., 1998). The expected changes in central and eastern European countries – such as the expansion of industrialised agriculture – are a potentially severe threat to the many nearly intact wetlands.

Threat status of the German habitats — Figure 3.11.3



Source: Riecken, Ries & Ssymank, 1994

Species and Habitats in Europe

Compared with other continents, Europe's natural biodiversity is relatively poor, mainly due to the after-effects of glaciation. Nevertheless, the percentage of species occurring only in Europe is quite high for several groups (Table 3.11.5). This gives the continent a special responsibility for their conservation. The Mediterranean area houses an especially large part of the species.

Table 3.11.5.
Europe's share of some of the world's species groups (known orestimated)

Species group	Known species in the world	Known species in Europe	Percentage of the world's species present in Europe	Number of species occurring only in Europe	Species occurring only in Europe as % of species in Europe
Reptiles	6 500	198	3%	90	45%
Amphibians	4 000	75	2%	56	75%
Mammals	4 300	270	6%	78	29%
Freshwater fish	8 400	334	4%	200	58%
Breeding birds	9 600	514	5%	30	6%
Butterflies	30 000	575	2%	189	33%
Vascular plants	260 000	12 500	5%	3 500	28%

Source: Council of Europe, 1997; Davis et al., 1994; van Swaay et al., 1997; Walter and Gillett, 1997

The distribution of vertebrates and of vascular plants species within the different European countries concerned with the present report is as shown in Figure 3.11.4.

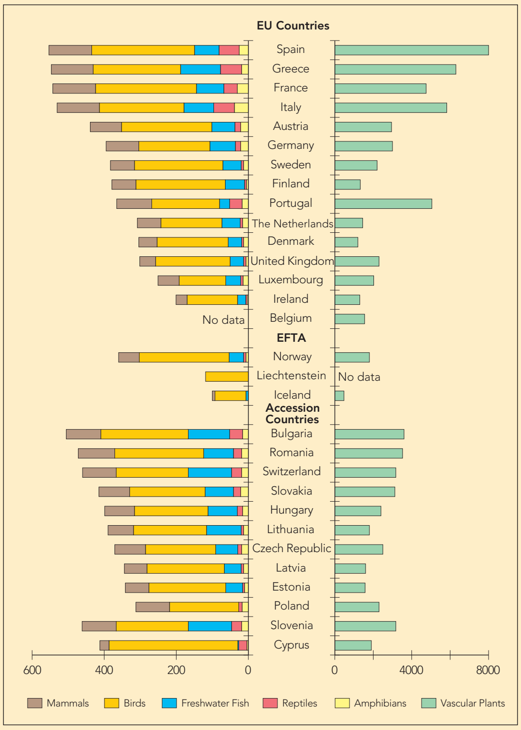


Figure 3.11.4

Number of vertebrates and vascular plants in some European countries

Source: For breeding birds: EIONET for AT, DK, FI, FR, DE, GR, LU, NL, NO, ES, SE. (Information received by ETC/NC in 1998). Other countries: European Bird Database (BirdLife International/European Bird Census Council), 1998. For other groups: EIONET information received by ETC/NC in 1997. Information on Cyprus: Cyprus Environment Service, 1998. Information on Ireland: Irish EPA, 1999

Climate, geomorphology, soil and history have resulted in variation among large biogeographic regions, recognised in the EU Habitats Directive and (for Europe as a whole) within the Bern Convention for the EMERALD Network since 1997 (Map 3.11.1).

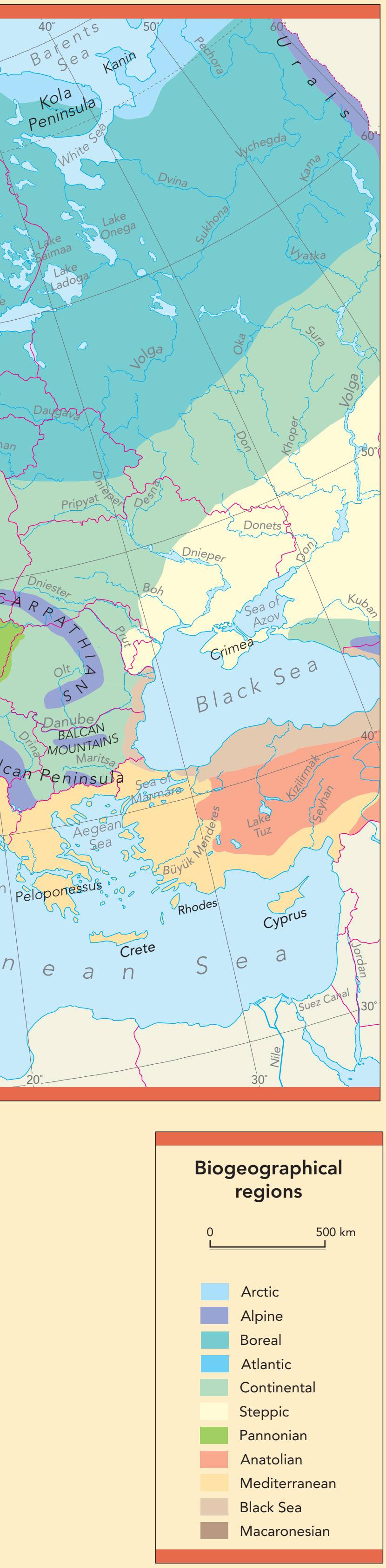
Box 3.11.4. Biodiversity: the main legal framework

- The Convention on Biological Diversity (1992):
- global
- as a contracting party to the Convention, the EU has set up a European Community Biodiversity Strategy
- The Bern Convention (1979): Europe

As a contracting party to the Convention, the EU has set up:

- Directive 79/409/EEC on the conservation of wild birds (Birds Directive 1979)
- Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora (the Habitats Directive 1992).

Map 3.11.1
European biogeographic regions



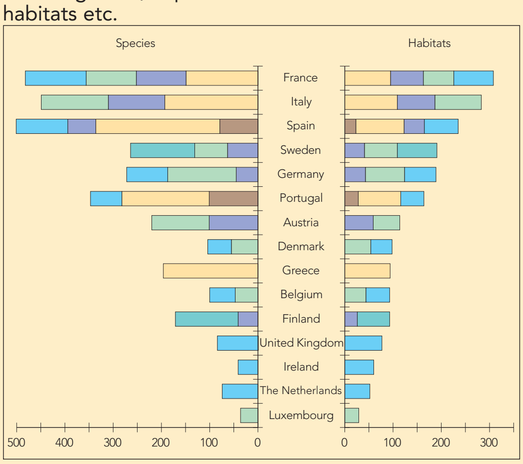
Source: European Commission DGXI; Council of Europe, 1997

Co-ordinated and harmonised information on selected species and habitats of European concern is collected at European level in relation to Community Directives (Birds and Habitats Directives for the NATURA 2000 process). Such information will soon be available also for non-EU countries, as a result of the preparation for accession and the implementation of international conventions such as the Bern Convention EMERALD Network (Resolution 4) (Kopaçi, 1998).

Distribution per biogeographic region of species and habitats listed under the Birds and Habitats Directives is shown in Figure 3.11.5; their distribution per country and per biogeographic region is shown in Figure 3.11.6. Figure 3.11.5 is not a direct indicator of each biogeographic region's richness in species and habitats, but underlines the share of European responsibility laid down in the Habitats Directive.

The full Mediterranean area – covering European, Asiatic and African coasts – is one of the most important centres of species richness in the world. More than 25 000 species, i.e. more than 10% of the world's flowering plants (phanerogams), occur in an area amounting to only 1.5 % of the earth's surface. About half of the species are endemic to the Mediterranean area. Around 200 phanerogams are in danger of extinction in the northern Mediterranean, and around 350 in the sourthern part. Animal diversity shows similar trends, though the species are less well known. The Mediterranean area is one of the worlds eight most important centres of origin for today's cultivated plants. The main pressures come from agriculture, such as severe overgrazing, and from fast-growing urbanisation and tourism. Coastal and marine habitats are especially threatened also due to water pollution, fisheries and species introduction. The impacts of climate change due to higher temperatures and less humidity may have grave effects. In half of the countries less than 2% of the Mediterranean systems are under nature protection, and for the whole region coastal protection is insignificant (Blue Plan, 1998).

In terms of number of habitats and species, three EU countries have a special responsibility: France and Spain, for four biogeographic regions, and Italy. Portugal shares with Spain an important responsibility for endemic species. The other biogeographic regions in the EU have other characteristic features of responsi- bility such as large areas for migrating and breeding birds, importance of forest or wetland habitats etc.



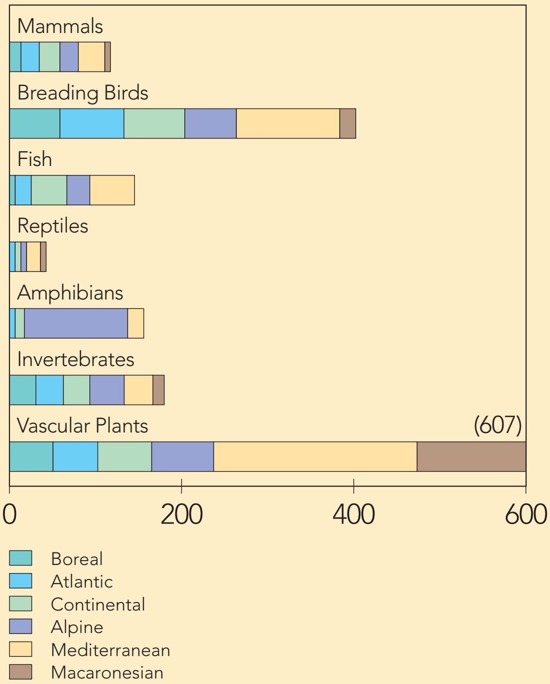


Figure 3.11.5
Number of Species and Habitats of the Birds and Habitats Directives, per biographic Region

Source: European Commission, DGXI; id, 1997; EBCC date: 1998

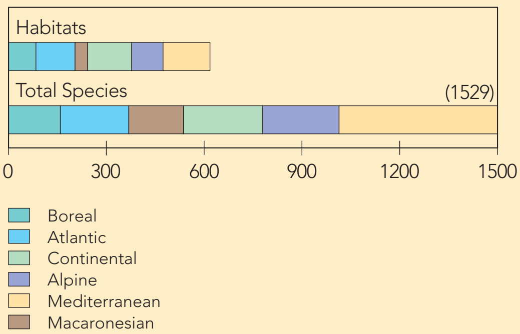


Figure 3.11.6
Share of responsibility for Annex I habitat-types and Annex II species conservation, per country for each biogeographic region

Source: ETC/NC

Box 3.11.5. Indications of forest changes in Europe

Apart from changes induced by management and silviculture, many types of changes are observed such as :

- The growing season of some tree species – i.e. the period within a year in which they grow – has slightly increased within a 30 years observation period (ETC/NC-EFI, 1998).
- Increasing growth trends (biomass production) in European forests, with possibly more vulnerability to drought, frost, diseases (ETC/NC-EFI, 1998).
- Shifts in natural forest species composition observed in two directions, towards oligotrophic acid or towards eutrophic conditions, leading to development towards other habitat-types.
- Nitrophilous plants are spreading, a favourite food of roe deer – maybe one reason for the increase in populations in large parts of northern and central Europe in the last decades (Wittig, 1992).

The condition of forests remains critical (Federal Research Centre for Forestry and Forest Products, 1998) and decline continues in large parts of Europe; minor improvements have been noted in possible response to favourable weather conditions or reduced acid deposition. In general, forest damages result from a multiple cause-effect complexity. Worsening areas are largely observed in the Atlantic (south), parts of the Mountainous (south) and in the Sub-Atlantic regions; also in the southern part of the Boreal region (regions as defined within the ICP programme – International Cooperation Programme on Assessment and Monitoring of Air Pollution Effects on Forests). Areas of improvement include parts of the Sub-Atlantic region, and most recently in eastern and central Europe. However, the trends vary considerably among species as well as locally.

110 natural ecosystem types, containing a total of nearly 73 000 animal and plant species, are restricted to 3-5% of Germany's land area. It is considered that of the 15% habitats threatened with complete destruction, 60% cannot or only can be partially restored.

4.3. What may happen to European Ecosystems in the future?

4.3.1. General assessment

As regards future pressures and impacts on biodiversity likely to occur towards the year 2010, the main assumptions are as follows:

- pressures are not uniform across regions and will continue to develop in different directions;
- over the coming decades, the global effects of land use on ecosystems and their underlying biodiversity are likely to be as or more significant as those associated with climate changes;
- influences from fragmentation are foreseen to increase;
- changes within the next decade may be less perceptible in regions which have been subject to under continuous heavy pressure and where biodiversity has already been severely altered, than in more pristine areas;
- eutrophication will continue to be an important pressure, although there may be localised reductions in nutrient levels;
- acidification of forests is likely to continue in areas already affected (central Europe and the northern Atlantic region), although some decrease is expected in the most seriously affected areas;
- intensification of agriculture can be expected to continue on a large scale in plains, notably in the Atlantic plains, and to occur locally in several regions;
- in northern countries intensification of forestry and afforestation will continue;
- land abandonment, mainly affecting grassland ecosystems, is likely to affect largely southern regions, with a consequent erosion of soil and an increase in fire risks. Land abandonment and marginalisation also concern continental and sub-continental middle mountains;
- introduction of species will continue, and use of GMOs will increase.

Pressures from land-use and pollution have different significance for habitat-types in the different regions of Europe. The maps (Box 3.11.7) based on the MIRABEL model show the predominant composite pressures on three widely distributed habitat-types: coniferous forests, dry grasslands and wet

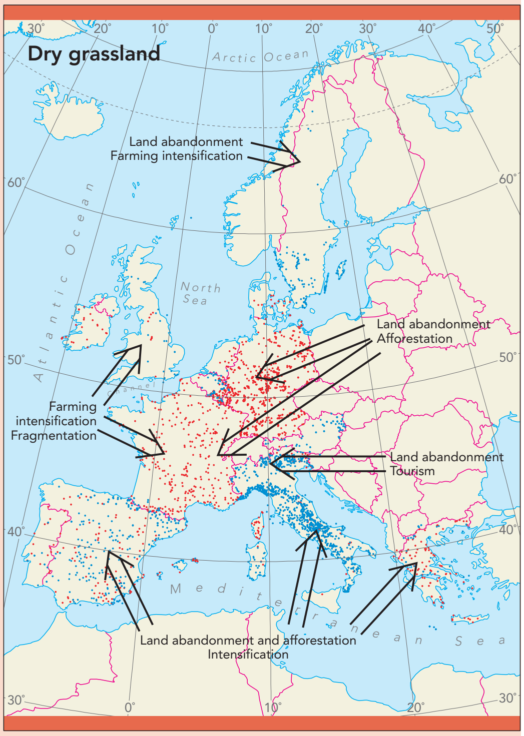
Box 3.11.6. CAUTION:

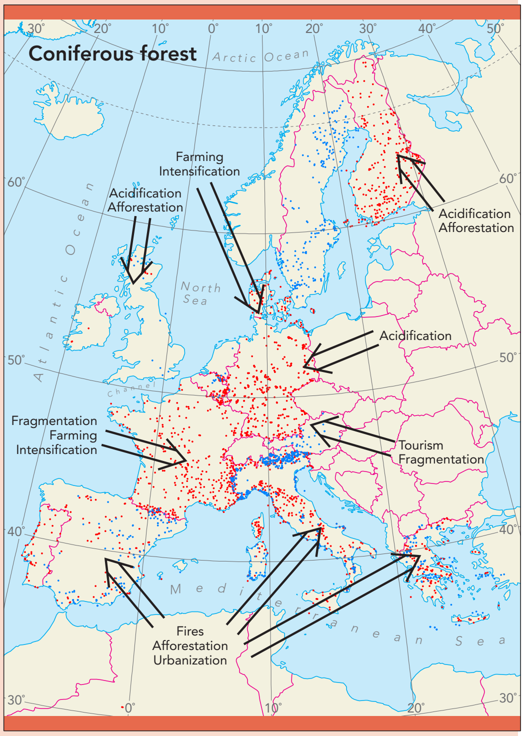
Due to the huge complexity of processes involved and our limited understanding of how the system works, it is a big challenge to try to assess ecosystem biodiversity trends through modelling. Any attempt at quantifying trends should therefore be treated with great caution.

Environmental consequences of pressures related to land-use changes, pollution and climate changes have been assessed tentatively for this report mainly through the development of a conceptual framework, called MIRABEL (Models for Integrated Review and Assessment of Biodiversity in European Landscapes, developed in UK) (Petit et al., 1998). Based on literature references, expert opinion and, where possible, on semi-quantitative modelling, MIRABEL documents and suggests foreseen changes in the status of habitat/ecosystem-types of forests, grasslands, heathlands, arable lands, etc. Examples and analyses from other sources and models are included in this chapter.

Box 3.11.7. Regional predominant pressures on coniferous forests, dry grasslands and wet grasslands

Pressures from land-use and pollution have different significance for habitat-types in the different regions of Europe. The maps based on the MIRABEL model show the predominant composite pressures on three widely distributed habitat-types: coniferous forests, dry grasslands and wet grasslands. The arrows indicate the regions where the pressure occurs. The length of the arrows has no relation to intensity.





Regional predominant pressures

0 — 1000 km

- Natura 2000 key conservation sites
- CORINE key conservation sites

Map 3.11.2.

Source: doc MIRABEL pp 84-85 (Petit et al., 1998)

The site information used as background for the analysis was extracted from 1997 information on pSCIs (proposed Sites of Community Interest) and CORINE Biotopes.

Note: Data from NATURA database (blue) and CORINE-Biotopes database (red)

grasslands . The arrows indicate the regions, where the pressure occurs. The length of the arrows has no relation to intensity.

4.3.2. Fragmentation

The increasing demand for space (for uses such as agriculture, forestry, recreation, tourism, transport, housing, industry) leads to a human-induced fragmentation of habitats, and to increased influences from adjacent intensively used areas on smaller and smaller semi-natural and natural areas (see Chapter 2.3). Even measures to create protected areas or to promote environmentally friendly agricultural production cannot prevent influences and impacts if the areas of land involved are small. The effects on biodiversity are: reduced habitat size and

Box 3.11.8. Sustainable species populations in fragmented landscapes: the LARCH model

Fig. 3.11.7.

Marshland species on sites in fragmented landscapes – potential for maintaining sustainable populations of indicator species of birds and mammals

Source: Larch. R. Foppen & P. Chardon, Institute for Forestry and Nature Research (IBN-DLO), NL

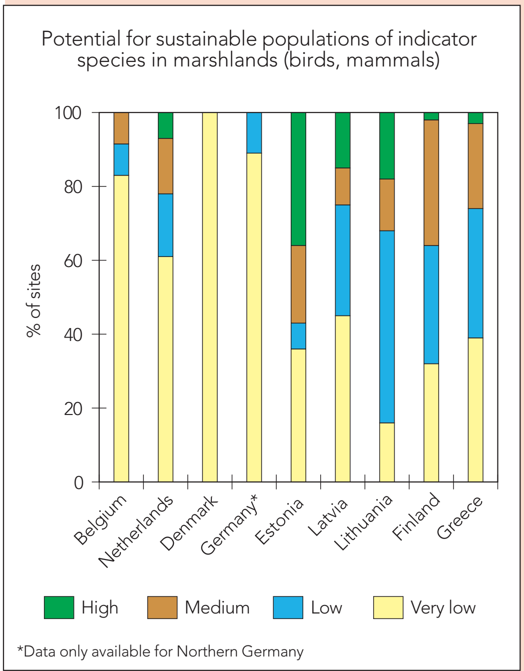
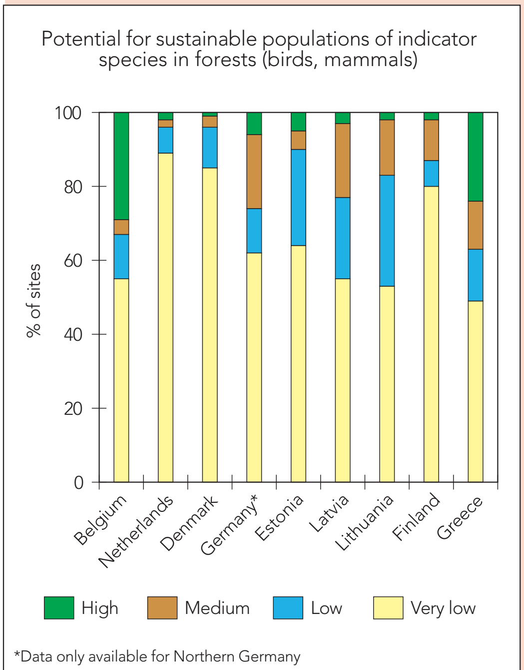


Fig. 3.11.8.

Forest Species on sites in fragmented landscapes – Potential for maintaining sustainable populations of indicator species of birds and mammals

Source: Larch. R. Foppen & P. Chardon, Institute for Forestry and Nature Research (IBN-DLO), NL



The LARCH model was developed in the Netherlands to evaluate sustainability of species populations in landscapes. It has been tentatively extended to a European scale (Foppen and Chardon, 1998). This type of support system could be applicable to the future NATURA 2000 Network. The results of a test on a selection of representative nature areas, using CORINE Biotopes data, are shown here.

The LARCH model depends on species characteristics and on landscape features: landscapes with a low spatial coherence (thus with a high degree of fragmentation) need larger key populations than landscapes with a high spatial coherence.

According to LARCH, the potentials for a high biodiversity in western Europe are low. The situation in some countries in eastern and southern Europe seems better, but is also critical (Figures 3.11.7. & 3.11.8.).

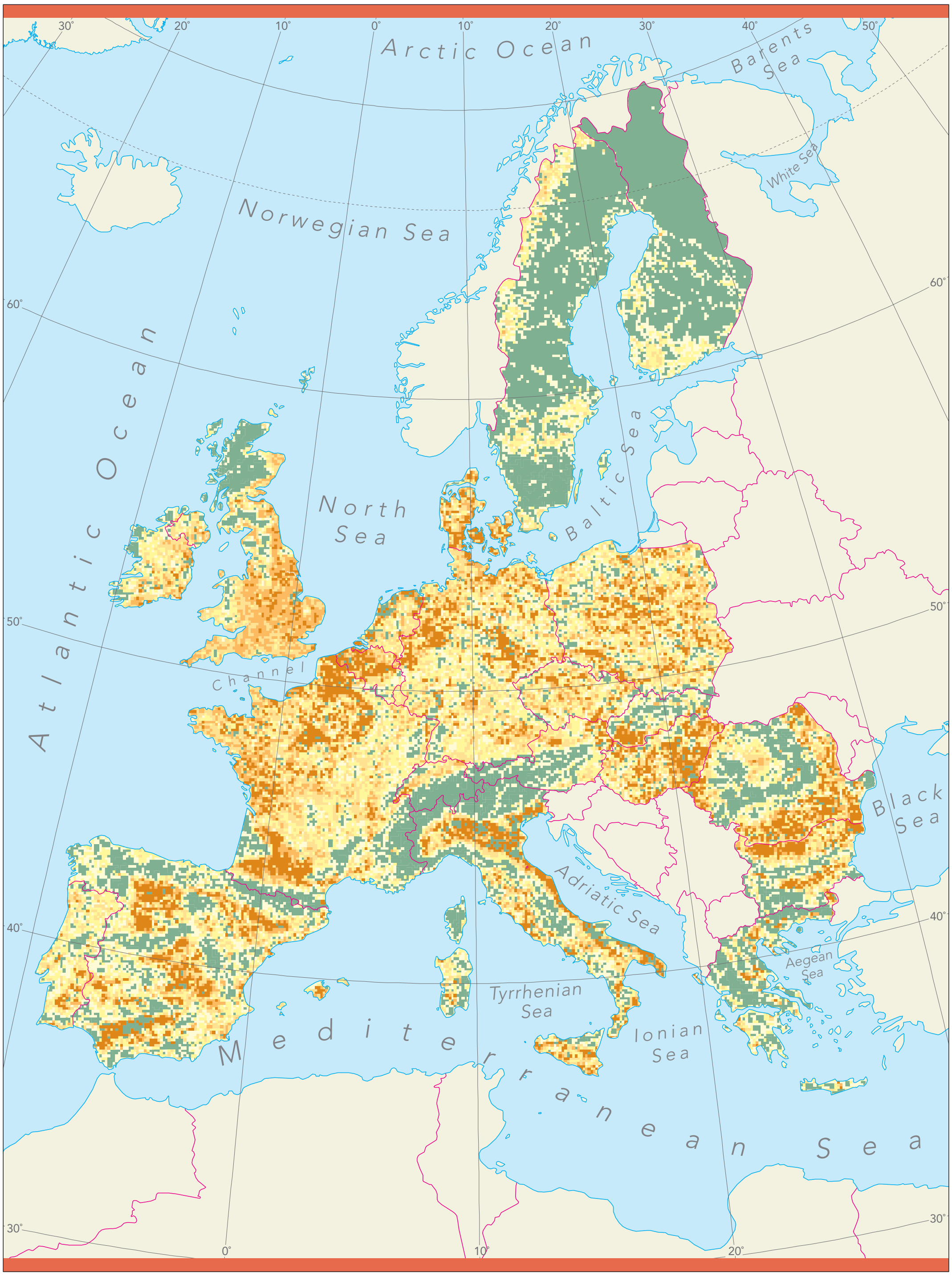
To increase the potential for sustainable populations both habitat quality and the degree of spatial coherence have to increase. To safeguard major parts of our biodiversity, it is important to ensure large nature reserves (>10 000 ha) linked in functional ecological networks.

The figures show the percentage of CORINE biotope sites with respectively very low, low, medium and high potentials for sustainable (viable) populations of indicator species in marshlands and in forests for different countries in Europe (Germany only for the Northern part):

- high potential: on the sites analysed more than ¾ of the indicator species may have sustainable populations (birds, mammals)
- medium potential: on the sites analysed ½ - ¾ of indicator species with sustainable populations;
- low potential: on the sites analysed ¼ - ½ of indicator species with sustainable populations;
- very low potential: on the sites analysed less than ¼ of indicator species with sustainable populations;

increased distance between suitable habitats for some species (barrier-effect), with detrimental consequences on the sustainability of core characteristic species and of species requiring large areas to survive (Box 3.11.8); and an increase in the perimeter/area ratio which facilitates the settlement of edge species. Opening up areas facilitates invasion of species. Chemical conditions (fertiliser, pesticides, salt, oil) and local climate conditions are influenced by adjacent areas, often up to several hundred meters. Disturbance and noise is also increasing steeply with fragmentation.

Thus multifactorial influences from fragmentation constitute a major combined pressure. Several types of fragmentation maps are being produced in Europe by different projects, showing somewhat different perspectives. The map presented here (Map 3.11.3) relates to pressures considered in detail in the chapters dealing with urban areas, coastal areas and mountain areas



Antropogenic fragmentation

0 500 km

Cell size 10km x 10km

extreme	more than 100
strong	10–100
rather strong	1–10
average	0.1–1
little	0.01–0.1
minimal	less than 0.01

Map 3.11.3

Source : EEA; ETC/NC and ETC/LC

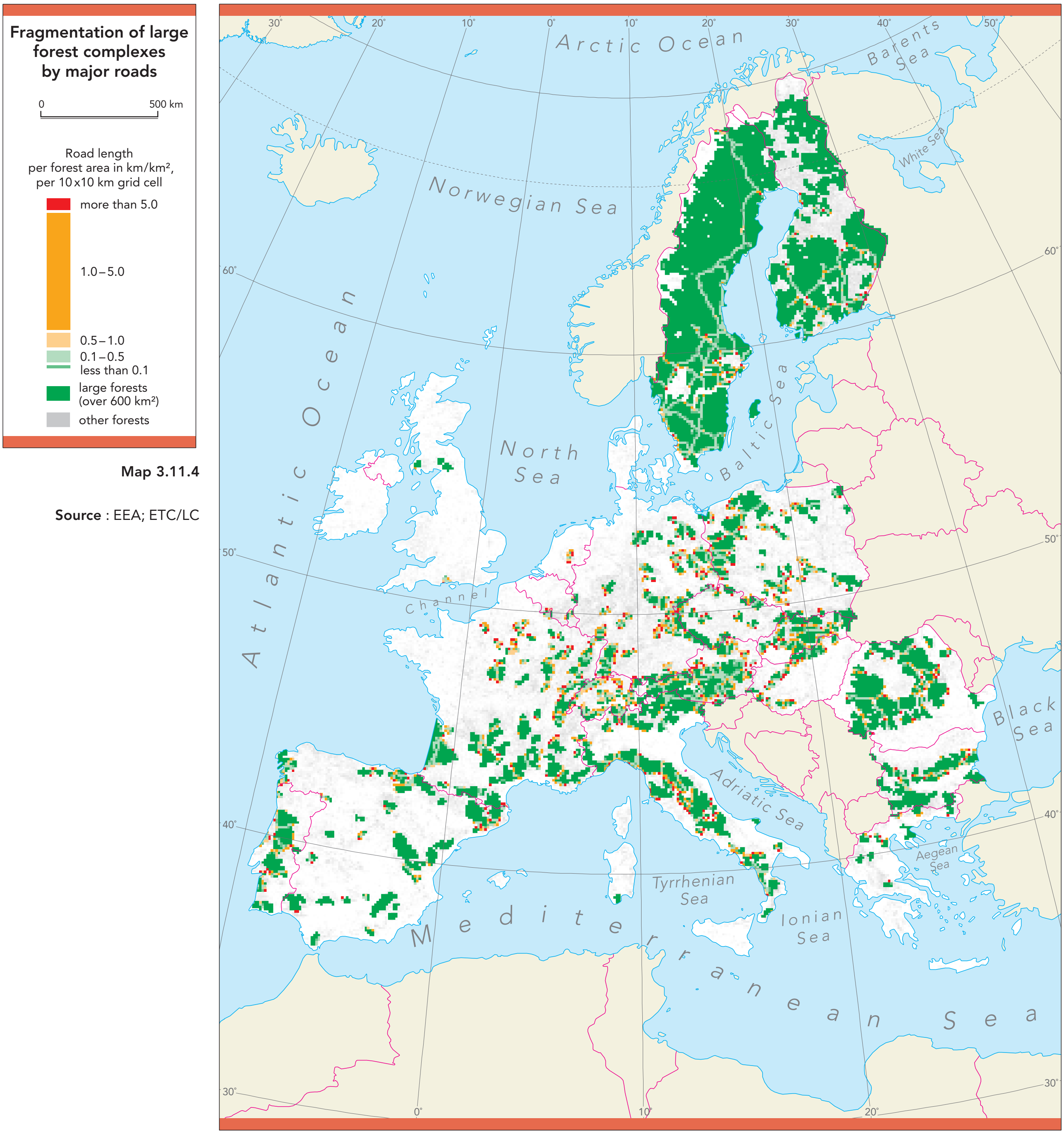
(Chapters 3.13, 3.14, 3.15).

The extent of urban areas is likely to increase by 5-8% between 1990 and 2010, while new transportation infrastructure is expected to claim 8 500 to 12 500 km² from other uses during the same period. This is likely to have a major effect. The existing fragmentation of large forest complexes in Europe is shown in Map 3.11.4.

4.3.3. Towards intensification or abandonment of agriculture: effects on grasslands – an example

The effects of intensification are normally radical, but vary greatly according to the type of agricultural area converted:

- from complex agricultural systems, often containing trees and many small extensively used habitats to arable monocrops;
- from permanent meadows and pastures to 'improved grasslands' with a high fertiliser input and in-sowing of grasses, favouring a small number of common



Map 3.11.4

Source : EEA; ETC/LC

grasses;

- from grasslands to cultivated fields, often accompanied by a changed water regime (drainage or irrigation);
- overgrazing and impoverishment of pastures, accompanied by soil erosion and compaction;
- loss of small biotopes (strips of meadows, hedges, tree stands along rivers and lakes, small ponds) related to increasing size of holdings or cultivation plot size.

The effects of marginalisation and abandonment can also vary greatly. When occurring in a previously intensive agricultural environment, abandonment can mitigate former fragmentation by creating corridors and providing new food and shelter. When occurring in extensively managed areas, abandonment can lead to development of

Box 3.11.9. Forecasted changes in pressure on grasslands from intensification or abandonment of agriculture

Maps 3.11.5. and 3.11.6. show forecast changes on pressures due to intensification and to land-abandonment on grasslands depending on 'ecological regions' as defined in MIRABEL.

The predictions were based on the following assumed rates of agricultural intensification and extensification:

- until 2005, CAP would follow the policies adopted under the 1992 reforms and developed in Agenda 2000;
- after 2005, EU would progressively liberalise its agricultural policy (Stolwijk, 1996);
- by 2005-6, the Central European countries would have joined the EU.

The intensification of agriculture is expected to have an increasingly detrimental effect on grassland habitats in eastern Europe. In regions in western Europe where grasslands have already been greatly changed in the past, the forecast changes are consequently expected to become less important. In the other regions, it is expected that the current level of ecological impacts will continue. Land abandonment occurs all over Europe albeit with significant differences in intensity and geographical distribution. In most regions, the recent trends are expected to remain the same as at present. In the Mediterranean region, as well as in continental middle mountains, land abandonment from agriculture will continue to be an important though local pressure. However, this assessment does not take into consideration the possible evolution of abandoned grasslands towards urbanisation.

Processes of intensification, extensification, marginalisation and consequent impacts on ecosystems, will be determined by local environmental and economic conditions. Experience shows however that earlier predictions of widespread abandonment in some regions seem not to have been fulfilled for example in Denmark (Bethe and Bolsius, 1995) and in France (Bontron, 1990).

Agricultural change: intensification or abandonment. Forecasted impacts

0 — 1000 km

- increasing local medium
- increasing local strong
- increasing widespread medium
- stable local medium
- stable local strong
- stable widespread medium
- stable widespread strong
- decreasing local medium
- decreasing widespread medium
- decreasing widespread strong

Map. 3.11.5.

Source: MIRABEL (Petit *et al.*, 1998)

Map 3.11.6.

Source: MIRABEL (Petit *et al.*, 1998) common highly dynamic habitat-types at the expense of specialist habitat-types often with long continuity.

Grasslands are likely to be heavily affected towards 2010 and onwards (box 3.11.9) by a combination of several pressures as a continuation of ongoing processes. Changes in the CAP set-aside rules and subsidies will be decisive in many areas.

Examples of effects of marginalisation, including consequences for species composition are shown in Table 3.11.6.

4.3.4. Climate Change

The way various pressures due to climate change combine and how they will counteract each other's impact in the future still remains very uncertain (Table 3.11.7).

The projections in the IS92 emissions scenario of IPCC – The Intergovernmental Panel on Climate Change (see Chapter 3.1) – of importance for biodiversity are:

- an increasing concentration of CO_2 from 350 ppmv presently to 500 ppmv in the year 2050;
- a rise in the global average temperature of the earth by about 1.5°C;
- a rise in sea level by about 30 cm.

Regional projections of climate are however less certain. Several models predict a roughly 2°C increase in temperature across Europe by 2050 but differ widely in their projections of precipitation change. Projections from the models should therefore be considered with extreme caution (Alcamo *et al.*, 1998; Viner

Table 3.11.6. **Selection of known examples of grasslands-types harbouring species of conservation interest and suffering effects of marginalisation**

Source: amended from Baldock *et al.*, 1996; other sources: Broyer in Bignal, McCracken and Curtis (eds.), 1994; Bruneel in McCracken and Bignal, 1995; Barret *et al.*, undated; Manrique and De Juana in Goriup *et al.*, 1991; Viejo in McCracken and Bignal, 1995.

Grassland-type and location	Type of marginalisation	Nature conservation implications	Other comparable situations
Flood meadows of Saône valley (FR)	Combination of intensification and abandonment	Threat to rare flora and birds (Crex crex, Numenius arquata)	Shannon river flood plain, Ireland
Upland grasslands of Jura (FR)	Decline in grazing of more remote pastures. Afforestation	Threat to flora	Upland pastures in several intermediate and marginal regions
Heather moorland, uplands (UK)	Abandonment of traditional management. Overgrazing	Changes to flora and vegetation	
Calcareous grassland, Nord-Pas de Calais (FR)	Localised abandonments of escarpments	Threat to flora and butterflies	Chalk grassland in south-east England
Steppes of Almeria (ES	Traditional dryland cultivation has been abandoned and converted mainly to irrigation and almond plantations	Local extinction of bird species: black-bellied sandgrouse (Pterocles orientalis) and little bustard (Tetrax tetrax)	Other steppe areas in Iberia threatened with irrigation and/or afforestation
Sub-alpine grasslands in Valle d'Aosta (IT))	Abandonment of grazing	Decline in populations of mole rat and Ursini's viper as well as some birds: chough (Pyrrhocorax pyrrhocorax), rock partridge (Alectoris graeca),	High mountain pastures in Pyrénées and Haut-Jura
Upland meadows Iberian mountains (ES)	Abandonment of transhumance and seasonal grazing	Threat to flora and endangered butterflies	Meadows in other mountain systems, e.g. Portugal, Cantabria
Lowland grasslands of Doñana National Park (ES)	Decline in grazing, partly due to restrictions imposed by Park	Threat to feeding grounds of Lynx pardina	Exclusion of grazing from afforested areas, e.g. Sierra de Gata
Olive grove pastures, Serra d'Aire e Candeiros (PT)	Abandonment of grazing	Threat to chough	Permanent pastures in many upland and coastal conditions

Predicted impacts of climate changes on various habitat/ecosystem-types depending on regions defined in the MIRABEL study

Table 3.11.7.

Source: Petit *et al.*, 1998

Habitat-type	Foreseen impact of climate change by 2050
Intertidal habitats, saltmarshes	Where coastal defences are few, will move inland.
	Possible extension of saltmarshes in areas where increase of rainfall only in summer will favour salt accumulation.
Coastal dunes	More rapid succession because of increased vigour of vascular plants (continental Hemi-Boreal).
Running waters	Increased winter flow and small spring flows will change sedimentation patterns (Boreal regions).
	40% loss of summer rainfall expected in Atlantic plains, with widespread drying-up of surface waters in summer.
	Loss of running water is expected to be widespread in southern Spain.
Bogs	Possibilities of methane release and faster ecosystem processes due to increased temperature in Boreal regions.
	Raised bogs should become less vigorous and bcome more vulnerable to other pressures. Will cease to grow at the edge of their range (sub-continental middlemountains).
	In central Europe rainfall does not rise, bogs will stop growing. According to the UK scenario, summer rainfall will increase by 30%, but due to increase in temperature, bogs may be invaded by trees.
	In the Alps, summer rainfall increasing by 41% could rejuvenate raised bogs.
Marshes and fens	Trends similar to those in running waters.
Dry grasslands	In general will be favoured, provided that grazing is maintained, except in regions where rainfall is expected to increase: central Europe, Alps, Pannonian and South European plains, Mediterranean and Thermo-Nemoral mountains. In these regions mesic grasslands will be favoured.
Alpine and sub-alpine grasslands	Will be liable to invasion by trees, but this is a slow process when grazing pressure is maintained.
Moss and lichen dominated habitats	Due to decrease of snow cover period, rapid invasion by grasses and other vascular plants.
	In high mountains can retreat to higher altitudes.
Dwarf-shrub communities	In several regions, increasingly invaded by scrubs and trees.
	In thermo-atlantic regions, sclerophyllous scrub will expand at expense of woodlands and temperate heaths.
	For arctic-alpine communities, only those in high mountain regions can retreat in higher altitudes
Broad-leaved woodlands	In all regions deciduous woodlands may expand to higher altitudes. In Boreal regions, the zone may slowly move northwards.
	In many regions, broadleaved deciduous woodlands will get more vigorous and more competitive in relation to Conifers in northern and central Europe.
	In Atlantic regions, dry summers to favour broadleaved evergreen species; viz Rhododendron ponticum on acid soils.
	In Southern Spain, it is expected to be too dry for trees to grow except in valley bottoms.
Coniferous woodlands	In all regions coniferous woodlands may expand to higher altitudes. In Boreal regions, will become more vigorous, with a higher upper limit in mountains. The process could be rapid. The Norway spruce may be damaged by excessive transpiration.
	Conifers, though growing rapidly will be in competition with broad-leaved trees but the process will be slow.
	In sub-continental middle mountains, the increase of average winter temperature will be unfavourable to more continental conifers such as Pinus nigra which may become more vulnerable to defoliation due to insects.
	In the Alps, increased rainfall should favour higher forest productivity and denser canopies.
	In general increased risk of insect attacks may occur especially in border zone of ecological range of tree species.

and Hulme, 1997).

Apart from an increase in temperature and possible changes in growing seasons, the main features foreseen are a continuous decrease of rainfall in southern Europe, and a significant increase of summer rainfall in the Alps, which represent the water reservoir of Europe, with likely important consequences on water regimes of rivers (see Chapter 3.15).

The ecological consequences will be felt through a gradual adaptation to the new conditions. Species with limited climatic adaptability and distribution as well as low dispersion capacity are likely to be severely threatened, while a large number of species may adapt through migration and selection (Box 3.11.10).

5. From policy to action

Box 3.11.10. Biodiversity change – model results for species and climate (see Chapter 3.1)

The EUROMOVE model estimates 'Biodiversity loss' based on assessment of potential changes in distribution of a selection of plant species (information on 1 492 species based on Atlas Flora Europaea) in relation to climate variables. The main trends expected are:

- Climate change will not have a dramatic effect on Europe before 2010: in most parts of northern and western Europe, the percentage of species with a stable distribution is between 80 and 100%, indicating stability. In parts of the Iberian Peninsula, France and eastern Europe, the percentage of stable species is less than 80%, which may indicate a potential significant change in biodiversity.

- Between 2010 and 2050 very pronounced changes in biodiversity can be expected. In large parts of Europe, less than 80% of the species will remain at the same locations. The southwestern part and the most eastern part (Russia) of Europe may suffer the highest changes in biodiversity; the loss of species might exceed 50%. The biodiversity in the northern part of Europe, the eastern part of middle Europe and Ireland and Scotland remains more or less stable during that period. The percentage of stable species in western Europe is between 65 and 80%.

Change in species distribution is an indicator for some biodiversity trends, but it cannot express the whole complexity of processes involved. In the case of climate change, some species are likely to disappear from specific regions, while others will find appropriate ecological conditions in the newly created environment. A critical issue is the time scale in which changes will occur.

Source : European Commission, 1999; EUROMOVE model (Alkemade *et al.*, in prep.)

A considerable number of activities for research, inventories and monitoring of biodiversity are organised at national, international and EU level, in order to improve knowledge of biodiversity. However, no general monitoring of changes in biodiversity in the EU exists at present (see Chapter 4.2), and aggregating and analysing the widespread information presents many difficulties. Among biodiversity-related policies, the following are of particular relevance for the European Union.

5.1. Birds and Habitats Directives

As stated above, a major contribution to the conservation of biodiversity at EU level is through the implementation of the Birds Directive and the Habitats Directive, setting up a coherent and representative ecological network of designated sites: the NATURA 2000 Network (European Commission DGXI, undated), including Special Protection Areas (SPAs), under the Birds Directive, and Special Areas of Conservation (SACs) under the Habitats Directive. Both Directives also regulate hunting, collection, transport and trade of some species, the latter in application of the CITES Convention. The two directives are seen as the main direct nature conservation related Community contribution to the Global Convention for Biological Diversity.

The Habitats Directive has brought new key concepts for conservation and has asserted others:

- importance of habitats;
- assessment of sites on the basis of biogeographic regions;
- the need for core area protection and for buffer zones and the importance of connectivity between core areas to ensure a real network function;
- the importance of maintaining or promoting specific human activities within the SACs in order to ensure the 'favourable conservation status' of species and habitats.

While SPAs are directly incorporated into the NATURA 2000 Network, as soon as designated by Member States, the network from SAC sites, under the Habitats Directive, is achieved through three distinct stages:

1. national inventories of sites including Annex I habitat-types and Annex II species by Member States and provision to the European Commission-DGXI of their list of potential Sites of Community Interest (pSCI);
2. assessments at European level of national pSCIs, in a biogeographic approach, and consultation between Member States and the Commision to establish the list of Sites of Community Interest (SCI);
3. once the SCI list is agreed, Member States have six years to designate the sites as SACs and to set up the corresponding conservation plans.

The emerging better co-ordination between Community or national measures from other sectors is very important, mostly in agriculture and infrastructure (Birdlife International, 1995) as well as pollution abatement (agriculture, transport, energy). As stressed in the Progress Review of the 5EAP (1996), until now, at EU level, the link between 'Nature' legislation (the Birds and Habitats Directives) and Common Agricultural Policy (CAP) has remained inadequate. Steady progress is beginning to show with the freezing of infrastructure co-financing by the EU, in case of obvious adverse effects on NATURA 2000 sites (e.g. Tagus Bridge in Portugal, estuary of the Seine River in France).

Various incentive measures which, in the future, could provide the best opportunities for implementing coherent actions in relation to NATURA 2000 (Sunyer and Manteiga, 1998) are those which, in the past years, were given the lowest funds, compared with high level funding for production, as in the case of Spain (Table 3.11.8). For afforestation programmes, their added-value to NATURA 2000 will only be effective if, contrary to the past, strict conditions of species used and location of plantations are respected.

The future progress and success of NATURA 2000 Network will depend closely on its adequate integration within Agenda 2000, including the extension of agri-environmental measures, support payments under the Less Favoured Areas Directive and the reorientation of Structural Funds (Goss *et al.*, 1998; WWF Europe, 1997). Also, since some Annex I habitat-types are forest habitat-types, sustainable forestry should be applied in a co-ordinated way.

People's involvement and partnership with land-managers and users remains a key issue as stressed during the Bath Conference on NATURA 2000 and People – a partnership conference held in June 1998 in Bath in the U.K.

5.2. LIFE-Nature

LIFE-II-Nature is the current EU financial instrument for direct nature conservation in a series starting in 1984 (ACE-biotopes), followed by ACNAT (from 1991), and LIFE-I-Nature (1992 to 1995). LIFE-II has run 1996-1999; negotiations for LIFE-III starting in 2000 were ongoing.

The amount available in 1997 was limited to 42 430 693 euros for new projects in 1997 and to 48 000 000 in 1998. Funding is given only to projects able to contribute to the implementation of NATURA 2000. The projects may also focus on the conservation of species listed in the annexes of the two Directives to carry out essential species-conservation actions which are complementary to the designation of the sites, as reflected in the two following examples:

- A co-ordinated approach to the conservation of the Brown Bear, a priority species (European Commission, 1997a) (see Chapter 3.15). Eight projects have been financed in five European countries where the bear appears in threatened populations (France, Spain, Greece, Italy and Austria).
- Action plans for Europe's globally threatened bird species prepared by BirdLife International, in partnership with Wetlands International: plans concern 23 of Europe's most endangered bird species.

LIFE-Nature supports incentive and demonstration projects and intervenes only for 50% or exceptionally 75% of the total cost of the project. Three main areas of action are concerned: to provide essential initial capital for investment works, non-recurring actions or recurring management practice, to stimulate demonstration projects, to prime larger-scale funding for long-term manage-

Opportunities for Natura 2000: available Community budgets in Spain for rural development, agricultural production and conservation — Table 3.11.8.

Community Intruments	Average annual amount between 1995-1997 (in 1 000 euro)	Opportunities for Natura 2000
Crops production premiums	2 024 380	*
Livestock production premiums	868 764	*
FEOGA Orientation for structural measures in rural area	808 356	**
Afforestation measures (2080/92)	107 718 (in 1996)	**
Agri-environmental measures (2078/92)	125 250	***
LEADER: local projects for rural development	81 264	***
Measures for Less Favoured Areas	66 492 (in 1994)	***
LIFE-Nature	6 600	****

* very little opportunity, even conflicting effect; ** some opportunity, if well targeted; *** important opportunities, if well targeted; **** very suitable opportunities

Source: amended from WWF/Adena, 1998

Progress in the implementation of the Birds and Habitats Directives

It is expected, that around 10% of the EU land area will be designated under the future NATURA 2000 Network. In addition, significant marine areas will also be designated. This will exert great influence on land development and spatial management policies not only in core areas, but also in the surroundings of the sites, to avoid the damaging effects of pressures on the site.

Thus Article 6 of the Habitats Directive provides an innovative mechanism for management of change and a framework for the balance between ecological and socio-economic interests, i.e combining conservation and sustainable use of resources.

Considering the formal entry of Accession Countries to the EU, two directives are therefore already of great interest in the enlargement process. The annexes of species and habitats to be considered in the enlargement have to be adapted to the context of the extension. Countries in accession are already preparing themselves for setting up national lists of pSCIs, such as building on the EMERALD Network initiative under the Bern Convention (The Council of Europe) as a parallel to the NATURA 2000 Network for non-EU countries. An important source of data for these countries is CORINE Biotopes data.

The designation of Special Protection Areas (SPAs) relates to 182 bird species and sub-species listed in Annex I of the Birds Directive, as well as migratory species, while the designation of Special Areas of Conservation (SACs) relates to 230 other animal species, 483 plants species (listed in Annex II) and 198 habitat-types (listed in Annex I) of the Habitats Directive.

The implementation process has proved difficult and has suffered many delays, particularly for the Habitats Directive, due to complex discussions and negotiations at national and local level between national authorities and landowners, farmers, foresters, hunters, etc.

Designation of Special Protection Areas (SPAs) under the Birds Directive

The Birds Directive has had positive impacts on restoring several bird populations by means of hunting bans (in the case of the Cormorant, *Phalacrocorax carbo*, the increase of the population is now so strong that is causes problems in several areas) and trade bans (the Mediterranean population of the Goldfinch, *Carduelis carduelis*, a popular cage-bird, is increasing in line with the steady transposition into national laws of regulations on the capture of birds and trade bans).

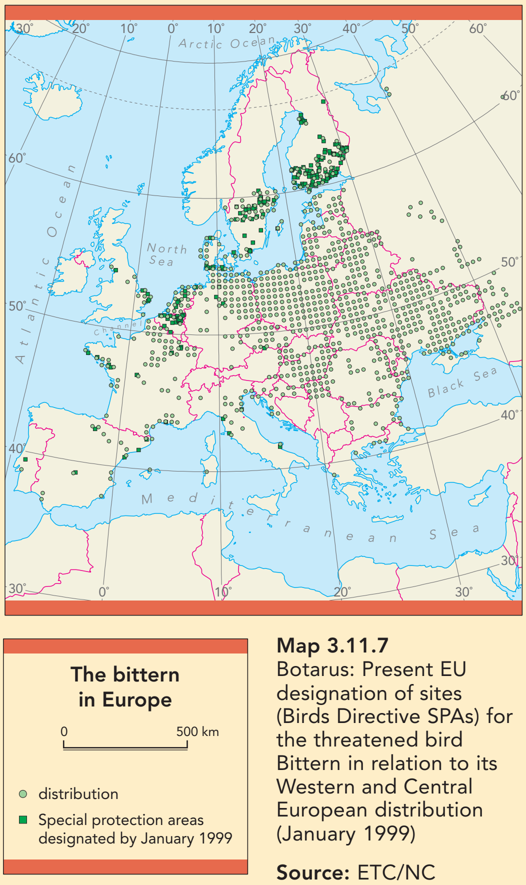
Assessment of the state and trends of Annex I bird populations within sites designated as SPAs is difficult because not all Member States have reported information about sites at the same level of detail. In several cases, sites are designated without information on the presence of Annex I birds and even less on bird populations.

By 26 January 1999, 2 406 sites were designated as SPAs at various rates and covering different proportions of Member States' territories (Figures 3.11.9 & 3.11.10).

According to available 1997 data reported from Member States, several bird species populations are well protected within the total area of designated SPAs, others not as adequately. For instance, the only existing EU population of Zino's Petrel *Pterodroma madeira* is appropriately protected by just one SPA (in Madeira); on the contrary, 114 designated SPAs protect only 5% of the total EU population of the White Stork, *Ciconia ciconia*, which occurs in 11 of the 15 Member States with major populations in Spain, Greece, southern Portugal and eastern Germany. For four Annex I bird species (the Corsican and Sardinian Goshawk, *Accipiter gentilis arrigonii*, the Sardinian Rock Partridge *Alectoris graeca whitakeri*, the Blue Chaffin *Fringilla teydea* from the Canary Islands and the Gyrfalcon *Falco rusticola* in Sweden and Finland) no SPAs have been designated yet.

Map 3.11.7 shows, as an example, that the present designation of SPAs in EU does not satisfactorily cover the distribution range of the Bittern *Botaurus stellatus*, a threatened heron.

Proposals for Sites of Community Interest (pSCIs)
Assessment of Sites of Community Interest (SCIs) is done by biogeographic regions (see Map 3.11.1). By January 1999, 8 814 proposed (pSCI) sites were put forward for inclusion in the Community List of sites, representing about 8.5% of the EU land area (Figure 3.11.11). However, only 7 540 are so far documented with information permitting recording and assessment (EEA/ETC-NC, 1998; EEA/ETC-NC, in press).



Map 3.11.7
Botarus: Present EU designation of sites (Birds Directive SPAs) for the threatened bird Bittern in relation to its Western and Central European distribution (January 1999)

Source: ETC/NC

Final establishment of the Community list of SCIs is at present only met in the smallest of the six biogeographic regions, the Macaronesian, which covers just two countries: Spain and Portugal; pSCIs represent 36% of the area of the region.

The surface area of sites proposed by Member States differs widely. This can be due to large differences in the habitat-types, such as coastal and mountain areas, to the existence of still large remote areas in the country, and the political interest of Member States to designate in future large surfaces as SACs, including buffer zones (Figure 3.11.12).

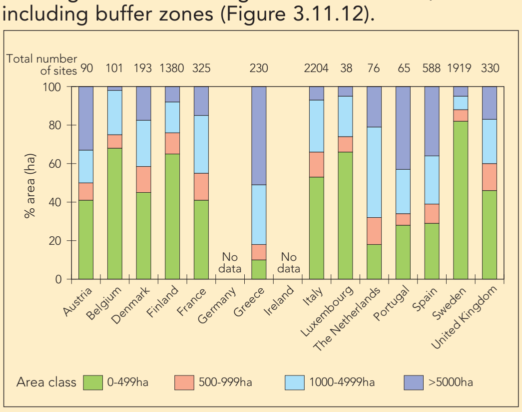


Figure 3.11.12
Number and percentage of pSCIs in Member States, shown in four categories of surface area. January 1999.

Source: ETC/NC

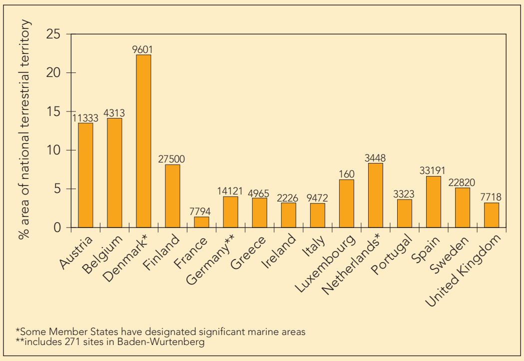


Figure 3.11.10
Proposed total area of Special Protection Areas (SPAs, including marine areas) as % of national terrestrial territory

Notes: 1. Some Member States, especially Denmark and the Netherlands, have designated significant marine areas. 2. The number of SPAs for Germany includes 271 sites (covering 86 km²) in Baden-Wurtenberg, that have been designated for nature conservation values other than the importance for birds.

Source: European Commission - DGXI, 1999

Region (area in 1000 km2) / Country	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	The Netherlands	Portugal	Spain	Sweden	United Kingdom
Boreal (total area 655.5)															
%pSCI area/biogeographic regions in country				13										3	
Number of pSCIs				1368										1563	
Atlantic (total area 780.5)															
%pSCI area/biogeographic regions in country		4	7		1	0		0			6	19	12		5
Number of pSCIs		47	48		118	0		0			76	4	70		330
Continental (total area 659.6)															
%pSCI area/biogeographic regions in country	9	8	6		1	0			8	13				9	
Number of pSCIs	46	54	146		145	0			519	38				248	
Alpine (total area 258.5)															
%pSCI area/biogeographic regions in country	12			90	7	18			21				36	36	
Number of pSCIs	42			19	74	7			518				27	109	
Mediterranean (total area 885.5)															
%pSCI area/biogeographic regions in country					3		17		13			12	13		
Number of pSCIs					77		230		1167			28	378		
Macaronesian (total area 10.5)															
%pSCI area/biogeographic regions in country												19	42		
Number of pSCIs												4	122		

Figure 3.11.11
Areas and numbers of sites of community interest proposed by Member States (pSCIs) by January 1999. Distribution in biogeographic regions.

Source: ETC/NC

NATURA BAROMETER
(As of 26/199)

Member State	Birds directive SPA classification					Habitats directive Proposed SCIs (stage 1)				
	No. of SPA's	Total area (km²)	Area maps	Inform-ation	Progress	Number of sites proposed	Total area (km²)	Site maps	Natura 2000 forms	National list
Belgium	36	4,313	[Incomplete]	[Incomplete]	[Complete]	102	913	[Complete]	[Complete]	[Substantial]
Denmark	111	9,601	[Computerised]	[Complete]	[Complete]	194	10,259	[Complete]	[Complete]	[Substantial]
Germany	551	14,121	[Incomplete]	[Incomplete]	[Incomplete]	602	8,704	[Complete]	[Incomplete]	[Partial] ⊃
Greece	52	4,965	[Complete]	[Complete]	[Incomplete]	230	25,745	[Complete]	[Complete]	[Substantial]
Spain	170	33,191	[Incomplete]	[Incomplete]	[Incomplete]	588	70,250	[Complete]	[Incomplete]	[Substantial]
France	112	7,794	[Complete]	[Incomplete]	[Notably insufficient]	652	15,200[1]	[Incomplete]	[Incomplete]	[Partial] ⊃
Ireland	109	2,226	[Computerised]	[Incomplete]	[Incomplete]	48	542	[Complete]	[Complete]	[Partial]
Italy	202	9,472	[Complete]	[Complete]	[Notably insufficient] ⊃	2,480	49,304	[Complete]	[Complete]	[Substantial]
Luxembourg	13	160	[Computerised]	[Computerised]	[Notably insufficient] ⊃	38	352	[Incomplete]	0	[Substantial] ⊃
The Netherlands	28	3,448	[Complete]	[Incomplete]	[Incomplete]	76	7,330	[Complete]	[Complete]	[Substantial]
Austria	58	11,333	[Incomplete]	[Incomplete]	[Incomplete]	90	9,215	[Complete]	[Complete]	[Substantial]
Portugal	36	3,323	[Complete]	[Complete]	[Incomplete]	65	12,150	[Complete]	[Complete]	[Substantial]
Finland	439	27,500	[Complete]	[Complete]	[Notably insufficient] ⊃	1,380[2]	47,500[2]	[Complete]	[Complete]	[Substantial] ⊃
Sweden	302	22,820	[Complete]	0	[Incomplete] ⊃	1,923	45,642	[Complete]	[Incomplete]	[Substantial] ⊃
United Kingdom	187	7,718	[Complete]	[Incomplete]	[Incomplete]	333	16,885	[Complete]	[Complete]	[Substantial]
EU 15	2,406	161,985				8,801[2]	319,991[2]			

(1) Data for some sites is missing
(2) This figure is an estimate

Notes: Some member states have designated significant parts of their coastal waters (i.e. non land area). Certain sites have been, totally or partially proposed under both Directives. Only sites that have been formally and definitely proposed are taken into account in the Natura barometer. Some Member States have however also transmitted provisional lists: these are given in brackets.

Keys:

0 No, or insignificant classification	0 List insignificant or not transmitted	0 No transmission
Classification notably insufficient	Partial but insufficient national list	Incomplete information or partial transmission
Classification incomplete	Substantial national list but information still incomplete	Complete for transmitted sites
Classification complete	Complete national list according to Member State, information transmitted is coherent	Computerised and coherent or transmitted sites

⊃ Significant progress since last Natura barometer

NATURA BAROMETER
(Situation as of 1/4/96 on the basis of information transmitted officially by the Member States)

Member State	Birds directive SPA classification			Habitats directive SAC designation (stage 1)				
	Number of SPA's	Total area (km²)	Progress	National list	Number of sites	Total area (km²)	Site maps	Natura 2000 forms
Belgium	36	4,313	[Complete]	0	–	–	–	–
Denmark	111	9,601	[Complete]	[Substantial]	175	± 9,000	[Complete]	–
Germany	494	8,537	[Incomplete]	0	–	–	–	–
Greece	26	1,916	[Notably insufficient]	0	–	–	–	–
Spain	149	25,338	[Incomplete]	0	–	–	–	–
France	99	7,069	[Notably insufficient]	0	–	–	–	–
Ireland	75	1,579	[Incomplete]	0	–	–	–	–
Italy	80	3,164	[Notably insufficient]	[Partial]	± 2,800	?	–	–
Luxembourg	6	14	[Notably insufficient]	0	–	–	–	–
The Netherlands	23	3,276	[Incomplete]	0	–	–	–	–
Austria	n/a	n/a	[Notably insufficient]	[Substantial]	94	± 3,620	[Complete]	[Complete]
Portugal	36	3,323	[Incomplete]	[Partial]	30 (Madeira + Azores only)	414	[Computerised]	[Complete]
Finland	15	n/a	[Notably insufficient]	[Substantial]	370	24,726	[Complete]	–
Sweden	75	1,460	[Notably insufficient]	[Substantial]	563	40,498	[Complete]	[Complete]
United Kingdom	126	4,396	[Incomplete]	[Substantial]	211	7,429	[Complete]	–

Note on SPA's
some member states, especially Denmark and The Netherlands, have designated significant parts of their coastal waters (i.e. non land area). Certain SPA's in Germany have been classified for nature conservation values other than their importance for birds.

Figure 3.11.9
Examples of the NATURA Barometer showing the pro- gress in Member States from 1996 until beginning 1999.

Source: European Commission, 1996 to 1998, Natura 2000. DGXI Newsletter NATURA Nos 1:1996 and 8:1999 ment of particular habitats and species through other financial mechanisms, i.e. the Agri-Environment Regulation, the Structural Funds and Cohesion Fund.

Some 335 PROJECTS have been financed under LIFE-II-Nature (1996 - 1999), largely on practical site-related actions. In 1998, 85 new projects were funded, most of them involving site related actions (75% relates to pSCIs, 22% to SPAs); to a lesser extent projects were directed towards priority species (3%).

The socio-economic environment in which projects operate is of paramount importance. Experience shows that dialogue and consultation with local communities provide more chance for conservation of biodiversity in the long run. In that sense, LIFE has an irreplaceable value for raising public awareness and encouraging innovative actions.

5.3. Agri-environmental measures

The agreement reached in March 1999 among EU ministers for agriculture on a reform of CAP targets farmers, consumers, the agri-industry, the environment and the EU economy in general (see below and Chapter 3.13) (Fischler, 1999). The reform builds upon the experiences gained by the Commission and Member States on earlier CAP and agri-environmental measures. Agri-environment measures and schemes were introduced in several EU Member States from the mid 1980s onwards. The establishment of national agri-environment programmes became obligatory for all Member States with the introduction of Regulation 2078/92/ECC as part of the CAP reform in 1992. They included such measures as reducing use of pesticides and chemical fertilisers, organic farming, protection of biotopes, maintenance of existing sustainable and extensive farming systems, protection of endangered farmed animals and plant varieties, and upkeep of landscapes (see Chapter 3.13).

There were considerable differences in the design of the 127 agri-environment programmes approved by the EU by June 1997 (European Commission, 1997b). Depending on the country, they have been prepared at either national or regional and local level, or various combinations of the two. The 2 200 different measures of the 1996 programmes fell in three broad categories, as shown in Figure 3.11.13, which gives the percentage of agriculture area in each country which was dedicated to these measures; this must be seen in relation to the total agricultural surface area of the Member States.

While the Netherlands dedicated up to two-thirds of its corresponding budget for training and demonstration projects, Finland, France, Portugal, Luxembourg, Sweden and some German Länder mostly invested in maintenance of extensive practices with significant impacts for preventing intensification, under-use or abandonment. Another interesting case is the variation in the budget dedicated to organic farming (see chapter 3.13).

Agri-cultural schemes, though important for the conservation of farmed environments of high nature value, for improved genetic diversity and for protection of agro-ecosystems, present a number of weaknesses (Petersen, 1998):

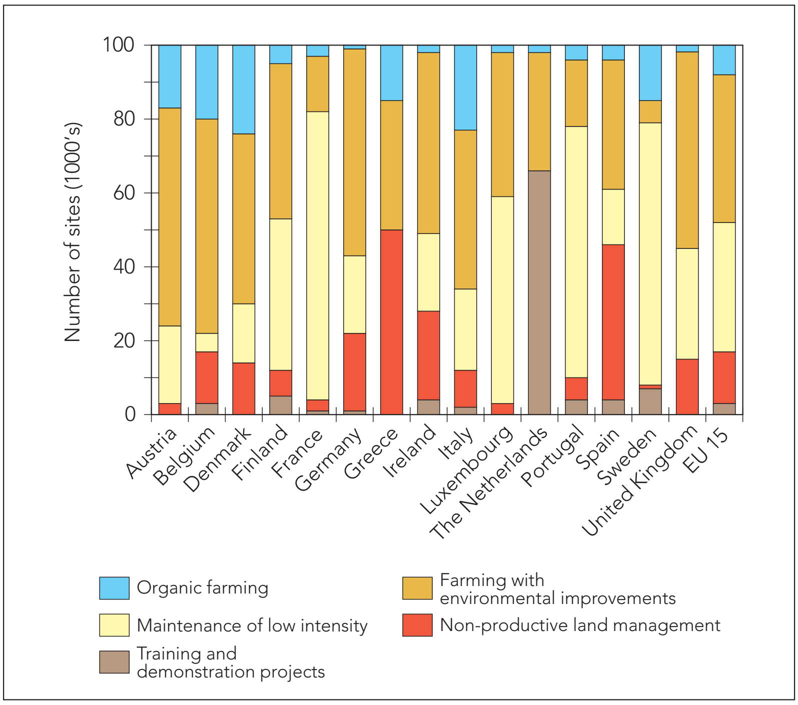
- competition with mainstream production support payments (such as the maize premium);
- insufficient administrative capacity and experience in many regions to handle this new policy;
- budget limitations (in 1997 only 3.7% of the total CAP budget, or 5% if Member State contributions were included; in some countries, a national co-financing contribution of 25% has proven difficult);
- the Regulation 2078/92 schemes remain viable only through additional measures for farmers (for example LEADER programmes; see Chapter 3.13);
- payments were not guaranteed to continue in the future;
- there was no comprehensive evaluation or monitoring of results.

A more recent assessment (European Commission, 1998d) has however indicated growing positive results, especially in organic farming, nature-protection measures and maintenance of landscapes. By 1998 an average of 13.4% of EU farmers were involved with the programmes and 20 % of the total agricultural area in EU was covered.

Results of the 1999 CAP Reform are expected have both positive and negative impacts on biodiversity, but the full implications cannot yet be foreseen. An important concern for biodiversity is how Member States will comply with the terms attaching environmental conditions to direct payments to farmers. At present 42% of the Usable Agricultural Area in EU (UAA) is used to produce arable crops of the types: cereals, oilseed and protein crops (COPs). With evolving pricing systems this area may change. The compulsory set-aside will be set at 10% only until 2002, after which it will be 0%. This may mean a re-establishment of the area of high-intensity agriculture in many regions. But voluntary set-aside will be maintained in particular to take account of environmental considerations. Grass for silage will be eligible for arable crops. The effect of the changed support to beef and milk cattle on maintenance of pasture grazing and on production of organic manure is unknown. Finally the extension of the traditional compensatory allowances to farmers in less favoured areas to areas where farming is restricted by the existence of specific environmental constraints represents an important challenge.

Estimated proportion of budgeted spending in each EU Member State (1996 programmes) by category of measure

Figure 3.11.13



Source: European Commission, 1997b

5.4. Towards sustainable forestry in Europe

With the anticipated enlargement of the EU, the importance of forest issues will be enhanced, with additional biological and cultural dimensions but also with new types of environmental problems.

The European Community at present has a number of specifically targeted regulations concerning forests (see Table 3.11.1). Following a 1997 European Parliament Resolution, the European Commission set out proposals for an EU forestry strategy, based on a recognition of the diversity of Europe's forests, their multifunctional role and the need for ecological, economic and social sustainability (European Commission, 1998). This strategy is in line with recommendations developed under the Kyoto Protocol on Climate Change, as well as with the pan-European Ministerial Conference on the Protection of Forests (Lisbon 1998) which adopted a work programme on the conservation and enhancement of biological and landscape diversity in forest ecosystems for the period 1997-2000 (PEBLDS, 1997) based on four main objectives:

- conservation and appropriate enhancement of biodiversity in sustainable forest management, including:
- adequate conservation of all types of forests in Europe;
- recognition of the role of forest ecosystems in enhancing landscape diversity;
- clarification of impact of activities from other sectors on forest biological diversity.

There is a growing interest among producers in obtaining certification of forests (in accordance with national development under the basic principles of the Forest Stewardship Council) and among consumers for information on products from certified forests presents another important path towards forest sustainability (FSC, 1999). A pan-European Forest Certification (PEFC) is foreseen to be operational in 2000.

5.5. Implementation of the global Convention on Biological Diversity by the European Community

All countries concerned with the present report have ratified the Convention on Biological Diversity (CBD) and many have consequently prepared national biodiversity strategies, to be followed up with action plans (Art. 6 of the CBD) related to specific themes. As such the Convention represents a major framework for developing integrative approaches of biodiversity into sectors. An important aspect developed within the Convention is the ecosystem approach (Lilongwe, Malawi workshop, 26-28 January 1998; UNEP, 1998) including 12 basic principles as a conceptual background for land-management planning, taking into account the importance of biodiversity for ecosystems functionality.

As a contracting party to the Convention, the EU developed a European Community

Biodiversity Strategy in February 1998 (European Commission, 1998b), which was adopted by the European Parliament in October 1998. Major themes for action are: conservation of biodiversity, sustainable use of biodiversity, sharing benefits of the use of genetic resources, research, monitoring and exchange of information, education, training and awareness. Eight 'sectors' or policy areas of relevance to biodiversity are highlighted: conservation of natural resources, agriculture, forestry, fisheries, regional policies and spatial planning, transport and energy, tourism, development and economic co-operation.

The strategy is foreseen to be implemented through Action Plans and other measures to be presented by the relevant services of the Commission (DG VI, DG XVI, etc.) by February 2000. The process will be overseen from a number of 'focal points' that will be established within the Commission.

By reinforcing some aspects of the 5EAP, the Strategy constitutes a new, major consistent approach to the integration of biodiversity concerns into other policy areas and provides a methodology for achieving environmental objectives.

The identification of practical biodiversity indicators, to monitor the effects of policies on biodiversity under the CBD, is an important part of the process. The indicators are discussed within the Subsidiary Body on Scientific, Technical and Technological Advice of the Convention (SBSTTA, 1997). The choice and development of biodiversity indicators need careful co-ordination, since several other indicator initiatives for biodiversity are ongoing at international and Community level as well as in most Member States. Lack of co-ordination may lead to confusion in data collection and reporting. At European level, the European Environment Agency, EUROSTAT and OECD are involved with Member States in developing indicators suitable for the environmental reporting process.

References

Akeroyd, J., 1998. Coping with Biotechnology's Products. In: *Plant Talk,* April 1998. Pp. 27-28 (see section 1.2)

Alcamo, J., R. Leemans & E.Kreileman (eds), 1998. 'Global Change Scenarios of the 21st century'. Results from the IMAGE 2.1 Model. Elsevier (in press).

Alkemade, J.R.M., M. Bakkenes, F. Ihle, J.B. Latour & R. Leemans. 'Determining effects of climate changes on the distribution of European plant species' (in prep.).

Baldock D., Beaufoy G., Brouwer F., & Godeschalk F., 1996. *Farming at the Margins – Abandonment or Redeployment of agricultural land in Europe.* IEEP and LEI-DLO, London UK, The Hague NL. 202pp.

Barret et al., undated. Territoires degrades, quelles solutions? Fondation de France.

Baskyté, R., P. Mierauskas and J. Virbickas (Eds) 1998. *Republic of Lithuania. Biodiversity Conservation. Strategy and action plan.* Environmental Protection Ministry of the Republic of Lithuania. 108 pp.

Bennet, G. (in prep.). 'Inventory and evaluation of existing international instruments of relevance for developing the Pan-European Ecological Network'. Council of Europe, Strasbourg.

Bethe, F. and E. Bolsius (Eds) 1995. *Marginalisation of agricultural land.* A three country study and essays. Copenhagen/Bonn/The Hague.

Bignal, E.M., D.I. Mc Cracken and D.J. Curtis (Eds), 1994. Nature conservation and pastoralism in Europe. Joint Nature Conservation Committee, Peterborough (UK).

BirdLife International, 1995. *The Structural Funds and Biodiversity Conservation: Summary.* BirdLife International European Community Office, Brussels BE. 6pp.

Blue Plan, 1998. *Working contribution to the European Environment Agency on Mediterranean environmental issues.* Sofia Antipolis.

Bontron, J-C., M. Jollivet et N. Matthieu, 1990. *Devenir des terres et fragilités des économies rurales.* AGRAL/DERF, Paris.

Bouchet P., Falkner G., & Seddon M., 1998. *Lists of protected land and freshwater molluscs in the Bern Convention and European Habitats Directive: are they relevant to conservation?* Submitted to: Biological Conservation.

Brown, L., 1998. *State of the World*, Chs 1, 2 and 3. World Resources Institute.

Bruneel, C. 1995. Abandonment and rural change: case study in the Parc Naturel Regional du Haut-Jura (Fr), pp 182-186. In: Mc Cracken, D.I. & Bignal, E.M. (eds), 1995. 'Farming on the edge: the nature of traditional farmland in Europe.' Proceedings of the fourth European forum on nature conservation and pastoralism, Joint Nature Conservation Committee, Peterborough (UK).

Council of Europe, 1993. *Proceedings of the Pan-European conference on the potential, long-term ecological impact of genetically modified organisms.* Strasbourg, 24-26 Nov. 1993.

Council of Europe, 1997. *Red data book of European Vertebrates.* Compiled by WCMC. Draft report, 153p.

Davis, S.D., Heywood, V.H. & Hamilton, A.C., 1994. *Centres of Plant Diversity.* Vol. 1, Europe, Africa, southwest Asia and the Middle East. WWF and IUCN.

ECOFOR, 1997. *Europe and the Forest (volume 3).* European Parliement, Luxembourg, p. 354.

EEA, 1998. European Environment Agency 1998. *Europe's Environment: the Second Assessment.* EEA, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EEA/ETC-NC, (in press). 'Nature Conservation'. Annual Topic Update 1999. European Environment

Agency, Copenhagen.

EEA/ETC-NC, 1998. 'Nature Conservation'. Annual Topic Update. Topic report N°7, 1998, 32p, European Environment Agency, Copenhagen.

EEA/ETC-LC. European Topic Centre for Land Cover.

ERM, 1996. Environmental Resources Management, 1996. *Effects of CAP Accompanying Measures on Biodiversity and Landscape in Northern Member States.* Final Report, Annex A Country Studies and Annex B Case Studies, by ERM, London UK, to EC-DGXI, Brussels BE.

European Commission DGXI (undated). *Natura 2000 - managing our heritage.* Luxembourg LU. 16pp. also: http://europa.eu.int/en/comm/dg11/dg11home.html.

European Commission, 1996 to 1998. *Natura 2000*, European Commission DGXI's Nature newsletter. Issues 1 to 7.

European Commission, 1996. Communication from the Commission to the Council and the European Parliament: Wise use and conservation of wetlands. COM(95) 189 final. Bruxelles BE. 54pp.

European Commission, 1997a. *Conservation of the Brown Bear in the European Union, Co-financed actions within LIFE-Nature.* Prepared by O. Patrimonio (Ecosphère). Brussels, 44pp.

European Commission, 1997b. *Report from the Commission to the Council and to the European Parliament on the application of Regulation (EEC) n° 2078/92 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside COM(97)630 final.* Brussels.

European Commission, 1998a. *First report on the implementation of the Convention on Biological Diversity by the European Community.* Office for Official Publications of the European Communities, Luxembourg. 95pp.

European Commission, 1998b. *Communication of the European Commission to the Council and to the Parliament on a European Community Biodiversity Strategy (COM (98)42).* Brussels, 30pp**.**

European Commission, 1998c. *Communication from the Commission to the Council and the European Parliament on a forestry strategy for the European Union.* European Commission, Brussels.

European Commission, 1998d. *State of Application of Regulation (EEC) n° 2078/92, Evaluation of agri-environmental programmes.* Report to the Parliament.

European Commission 1999 (forthcoming). *Economic Assessment of Priorities for a European Environ- mental Policy Plan (working title).* Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (environment, Nuclear Safety and Civil Protection).

European Committee for the Conservation of Bryophytes, 1995. *Red Data Book of European bryophytes, Parts 1, 2, & 3.* Prepared by Stewart, N., Hallingbäck, T., Hodgetts, N., Raeymaekers, G., Schumacker, R., Sergio, C., Urmi, E., Martiny, P., Düll, R., & Vana, J. ECCB, Trondheim, 289pp.

Federal Research Centre for Forestry and Forest Products, 1998. *Forest condition in Europe.* Results of the 1997 crown condition survey, Geneva and Brussels, UN/ECE and EC, p. 118 + Annexes.

Fischler, F., 1999 (CEC). *CAP Reform safeguards farmers' future.* Press Release IP/99/166 (1999-03-11).

Foppen, R.P.B. & Chardon, J.P., 1998. *LARCH-EUROPE a model to assess the biodiversity potential in fragmented European ecosystems – an expert system under the MIRABEL umbrella.* IBN-DLO Institute for Forestry and Nature Research, Wageningen, with ITE Monks Wood (UK). repert to ETC/NC, Paris. 48p.

FSC, 1999. Forest Stewardship Council, A.C. *FSC Principles and Criteria.* Document 1.2. Revised January 1999.

Goriup P., L.A. Batten and J.A. Norton (Eds), 199. The conservation of lowland dry grassland fields in Europe, Seminar Proceedings, Reading, March 1991. Joint Nature Conservation Committee, Peterborough (UK).

Goss S., Bignal E., & Pienkowski M. (eds.), 1998. *Agenda 2000 and Prospects for the Environment.* Report of the seminar organised by the European Forum on Nature Conservation and Pastoralism, at COPA, Brussels, on 3 Feb. 1998. EFNCP Occasional Publication Nb. 16. Agryll, UK.

Hails, A.J, 1996. *Wetlands, biodiversity and the Ramsar Convention,* Gland, Ramsar Convention Bureau, p 196.

Heywood, V.D., Watson, R.T. (eds.), 1995. *Global Biodiversity Assessment.* UNEP. Cambridge University Press, UK.

Kopaçi, L., 1998. The Emerald network, an opportunity for the European continent. In: European Ecological networks, *Naturopa* 87, pp 12-13.

Lesoueff, J-Y. (in prep.). 'Les plantes d'endémiques d'Europe éteintes et au bord de l'extinction'.

Lierdeman E., & Soufi R., 1997. *Evaluation des effets des mesures d'accompagnement de la réforme de la PAC et des mesures communautaires de dévelop-pement rural sur la biodiversité et les paysages dans les régions du sud de l'Union européenne.* IPEE Paris FR, CE-DGXI Bruxelles BE. 2 tomes.

Mooney H., Cushman J.H., Medina E., Sala O.E., & Schulze E-D., 1996. What We Have Learned about the Ecosystem Functioning of Biodiversity. In: Mooney H., Cushman J.H., Medina E., Sala O.E., & Schulze E-D. (eds.), 1996. *Functional Roles of Biodiversity – A Global Perspective.* SCOPE 55. SCOPE-ICSU-UNEP. John Wiley&Sons, Chichester, New York, Brisbane. pp.474-484.

Nordheim, H.v., Boedeker, D., 1998. *Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic sea, Belt sea and Kattegat.* Baltic Sea Environment proceedings, No. 75. Federal Agency for Nature Conservation, Isle of Vilm, Germany. Helsinki Commission, Baltic Marine Environment Protection Commission, 1998. 115p.

Ostermann O. P., 1998: The need for management of nature conservation sites designated under Natura 2000. In press in: *Journal of Applied Ecology 1998,* 35, Blackwell Science, Oxford.

PEBLDS, 1997. Executive Bureau of the Pan-European Biodiversity and Landscape Diversity Strategy. *Work-Programme on the Conservation and Enhancement of Biological and Landscape Diversity in Forest Eco-systems 1997-2000.* Adopted at Expert level by the third meeting of the executive bureau of the PEBLDS 20-21 Nov. 1997, Geneva, Switzerland, and by the fifth expert level follow-up meeting of the Helsinki Conference and the third preparatory meeting of the Lisbon Conference on the Protection of Forests in Europe, 8-9 Dec. 1997, Geneva, Switzerland.

Petersen J-E., 1998. *Agri-environment Schemes in*

Europe – Lessons for Future Rural Policy. Report from the Conference in Konstanz DE, 25-27 Feb. 1998. IEEP London for the British Countryside Agencies.

Petit S., Wyatt B., Firbank L., Howard D., Bunce R.G.H., Hill M.O., Swetnam R.D., Bull K.R., Morton D., Cooper J., & Foppen R.P.B., 1998. *MIRABEL – Models for Integrated Review and Assessment of Biodiversity in European Landscapes.* Report by ITE (NERC), IBN-DLO and NINA to the European Environment Agency Topic Centre on Nature Conservation, Paris.

Rieken, U., Ries, U. & Ssymank, A., 1994. *Rote Liste der gefährdeten Biotoptypen der Bundesrepublik Deutschland. Schriftenreihe für Landschaftspflege und Naturschutz,* Heft 41. Bundesamt für Naturschutz, Bonn, 184p.

SBSTTA, 1997. *Recommendations for a core set of indicators of biological diversity.* Background paper prepared by the liaison group on indicators of biological diversity, for the 3rd meeting of the Subsidiary Body on Scientific, Technical and Technological Advice,1-5/9/1997, Montreal, Canada. UNEP/CBD/SBSTTA/3/Inf.13, 22 July 1997. URL: http://www.biodiv.org./sbstta3/sbstta3-i13.html.

Skotte Møller, H. (Ed.), 1995. *Nature restoration in the European Union.* Proceedings of a Seminar. Denmark 29-31 May 1995. Ministry of Environment and Energy. Copenhagen, 130 pp.

Stanners, D. & P. Bourdeau (Eds), 1995. *Europe's Environment: the Dobrís Assessment.* European Environment Agency, Copenhagen. 676 pp. + statistical compendium.

Stolwijk, 1996. Personal communication. Central Planbureau, The Hague, the Netherlands.

Sunyer C., & Manteiga L., 1998. *Financial instruments for the Natura 2000 Network and nature conservation.* TERRA environmental policy center Madrid, ES.

Tucker, G.M., Heath, M.F., 1994. *Birds in Europe: their Conservation Status.* BirdLife International. Cambridge, UK.

UNEP, 1998. *Report of the workshop on the Ecosystem Approach.* UNEP/CBD/COP/4/Inf9.

van Swaay, C.A.M., M.S. Warren and A. Grill. 1997. Threatened butterflies in Europe – provisional report. De Vlinderstichting (Dutch Butterfly Conservation), Wageningen, the Netherlands, report nr. VS 97.25 & British Butterfly Conservation, Wareham, UK, 95 pp.

Viejo, J.L., 1995. Las mariposas y los pastizales: un problema de conservacion mutua en Espana, pp 124-128. In: Mc Cracken, D.I. & Bignal, E.M. (eds), 1995. 'Farming on the edge: the nature of traditional farmland in Europe.' Proceedings of the fourth European forum on nature conservation and pastoralism, Joint Nature Conservation Committee, Peterborough (UK).

Viner, D. and Hulme, M., 1997. 'The Climate Impact Links Project: Applying the Hadley Centre's climate change experiments for climate change impacts assessments'. Climate Research Unit, Norwich.

Walter, K.S. and Gillett, H.J. [eds] (1998). *1997 IUCN Red List of Threatened Plants.* Compiled by the World Conservation Monitoring Centre. IUCN - The World Conservation Union, Gland, Switzerland and Cambridge, UK. lxiv + 862pp.

Wittig, R. 1992. Patterns and dynamics: the example of the European Beech (*Fagus sylvatica L.*) forests. In: Teller, A., Mathy, P. and Jeffers, J.N.R. (Eds): *Responses of forest ecosystems to environmental changes.* Elsevier Applied Science, London (UK), 103-114.

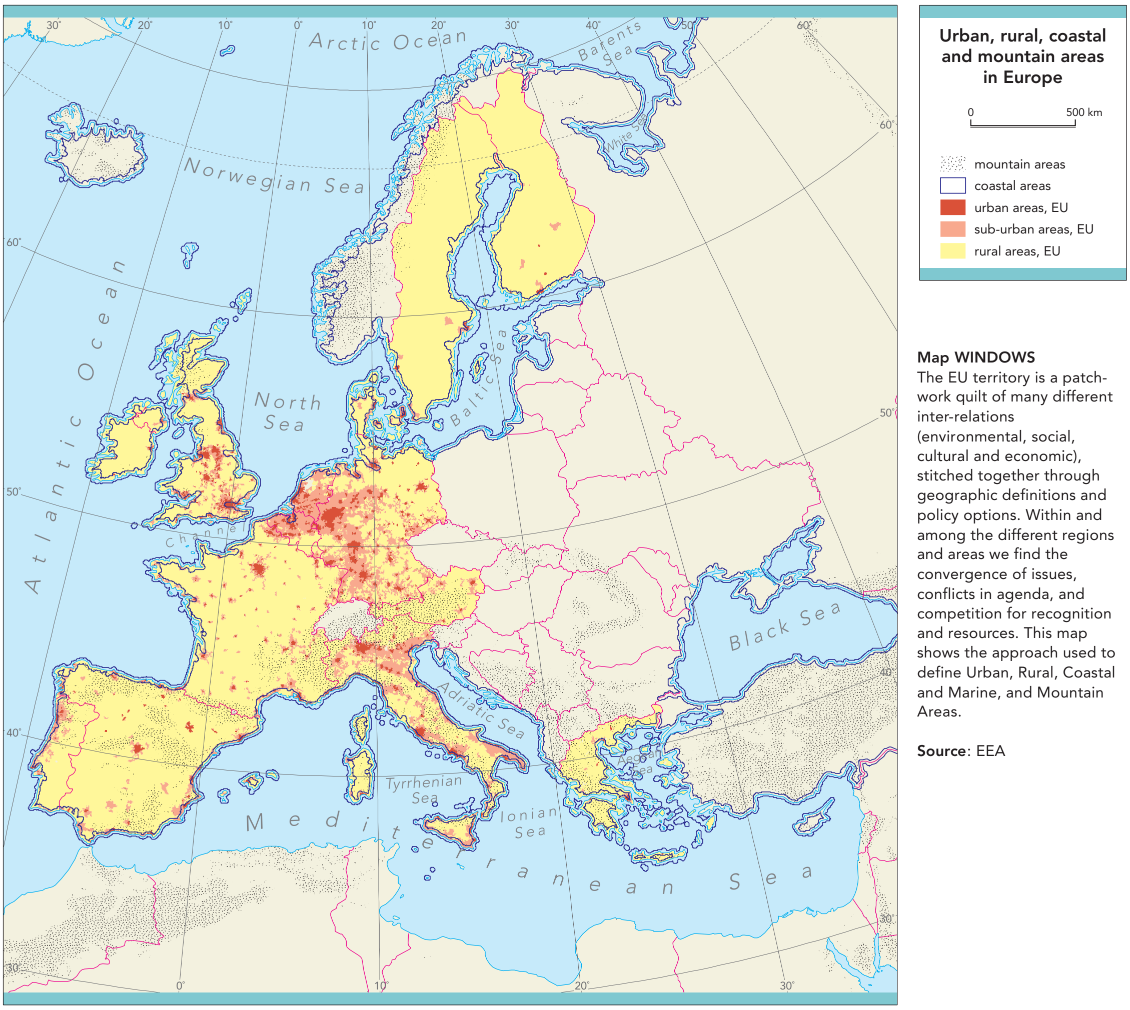
WWF Europe 1997. WWF reaction to Agenda 2000. In: La Cañada - Newsletter of the European Forum on Nature Conservation and Pastoralism, N° 8, Dec. 1997. Argyll UK, p. 8.

WWF/Adena, 1998. El gran error de Agenda 2000: las subvenciones productivistas siguen de protagonistas. in: *Hàbitats 2000* N°4, Verano 1998. p.3. Texto de G. Beaufoy. Madrid, ES.

Windows on Europe: the Spatial dimension

Setting the stage with common spatial roots
A spatial approach is essential when studying and reporting on the state of the European environment, especially when intentions are to provide support to policy framing and evaluation. Today's policy makers are expected to understand and react to a host of complex issues and the inter-relations of many processes, a number of which are touching on global concerns, regional disparities, and the local implications. To this end, the next four chapters explore and assess the state of the environment with regards to urban, rural, coastal and marine and mountain areas. These areas have been selected for study because they are corresponding to the reality of Europe's diversity, and it is this diversity which must be addressed and interpreted by territorial planning.

Although limited by a lack of proper or sufficient public systems to monitor, report and interpret environmental changes, chapters 3.12 to 15 serve to contribute to the necessary debate. The next pages, while looking into the changes in Europe's environmental quality, attempt to draw out the strong regional diversity and territorial



Map WINDOWS
The EU territory is a patchwork quilt of many different inter-relations (environmental, social, cultural and economic), stitched together through geographic definitions and policy options. Within and among the different regions and areas we find the convergence of issues, conflicts in agenda, and competition for recognition and resources. This map shows the approach used to define Urban, Rural, Coastal and Marine, and Mountain Areas.

Source: EEA

implications of these changes. The analyses within the chapters are rooted in the specific socio-economic characteristics of the different areas as defined, and the current and historical land uses of their particular geographical patterns.

In fact, there really is no clear spatial line between any of these four chapters. As vexing as this may be, this has important consequences since many policy and decision-making scenarios (both now and in the future) will need to consider numerous inter-relations: What is happening in rural-urban situations? What about the rural-coastal places? Are these different from those which are composed of rural-mountain? And are these like or unlike the urban-mountain areas? And what of urban-coastal? And so on.

In what is a modest first step, area definitions have been developed. These definitions are serving as the territorial background for each Spatial Chapter, providing generalised descriptions of the spatial dimension for Urban Areas, Rural Areas, Coastal and Marine Areas and Mountain Areas. In the latter two cases, area definitions have been based upon geomorphologic considerations, while in the first two cases administrative territories have been used to sketch spatial definitions.

3.12. Urban areas

1. Our urban lifestyle, urban sprawl: the unsustainable present

Europe is one of the most urbanised continents and today some 70% of its population (560 million) is urban (UN/ESA, 1997; Figure 3.12.1), while urban areas (with a population density above 100 inhabitants per km^2) account for some 25% of the EU's territory.

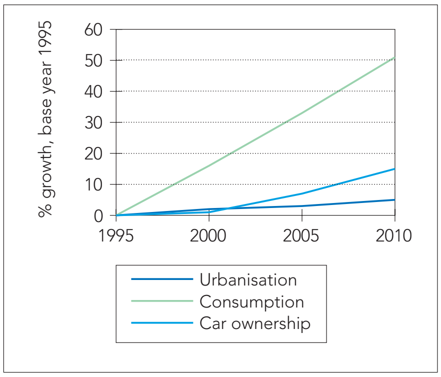
Cities, by their nature, concentrate large masses of population in small areas. This has some evident advantages in terms of economic and social development, and in some respects it is even beneficial to the environment, inasmuch as land use and energy consumption tend to be lower than for more dispersed populations; moreover, urban waste and waste-water treatment have economies of scale. Nevertheless, the urban population still suffers from severe, localised environmental problems (such as impacts of noise, pollutants and waste, and restricted availability of fresh water and open space).

Urban agglomerations are increasing steadily in the EU: it is expected that the – already high – population of 'urban agglomerations' in the EU will increase by more than 4% between 1995 and 2010 (Figure 3.12.2). As cities continue to sprawl, bringing about land use stresses and social inequities, a growing number of areas become urbanised (Map 3.12.2, Map 3.12.3; see Box 3.12.2).

Both economic activity and environmental problems are therefore intensified, with the (interrelated) pressures of extensive devel-

Cities and towns are engines of progress, the source of much of the world's cultural, intellectual, educational and technological achievements and innovations.
— Kofi Annan

Key urban trends Figure 3.12.2



The figure provides EU average forecasts (Luxembourg not included in the GDP and consumption curves), since data available for Accession Countries was not comprehensive. Urbanisation is expressed as the fraction of individuals residing in urban areas (74.5% in 1995); consumption amounted 3.3 billion euros in 1995; car ownership was calculated from data on cars/1000 heads (395 in 1995).

Source: EEA; European Commission 1999

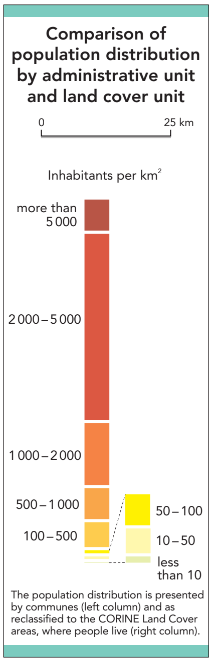
The urban presence in Europe Figure 3.12.1

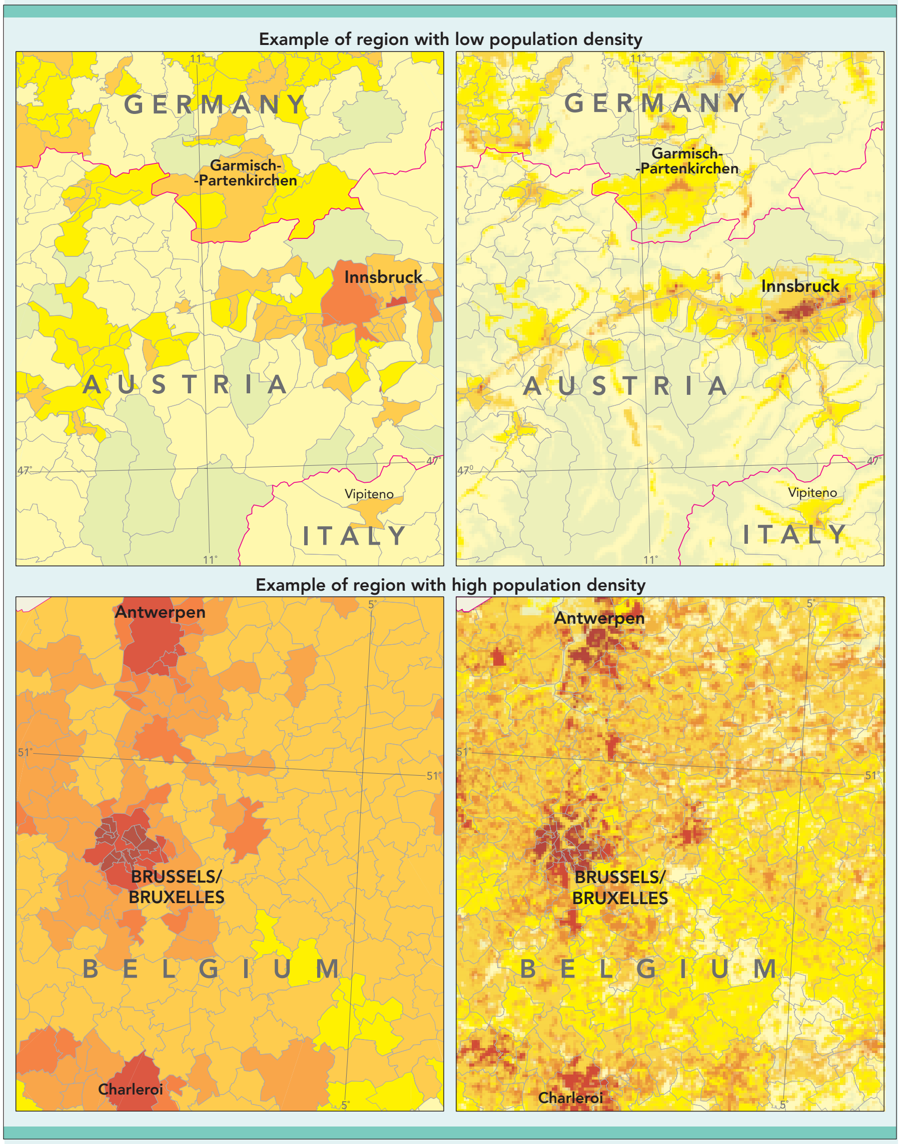
Source: USA's Defense Meteorological Satellite Program – NOAA/NGDC

Box 3.12.1. Urban definition

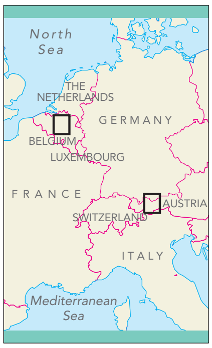
Urbanisation can be defined and expressed in different ways – for example by statistical-administrative criteria or in physical-morphological terms (Map 3.12.1). The latter relies on the physical expression of urbanisation patterns, and uses land cover information. The former relies on basic statistical and territorial building blocks to give a socio-economic and political expression of populations and urbanisation.

This chapter's area definition has been sketched out using very small territorial units and expressions of population densities. Urban agglomerations are here defined as 'territorial units characterised by the presence of buildings, transport infrastructure and public amenities, and by a minimum threshold size' (European Commission, 1998a).

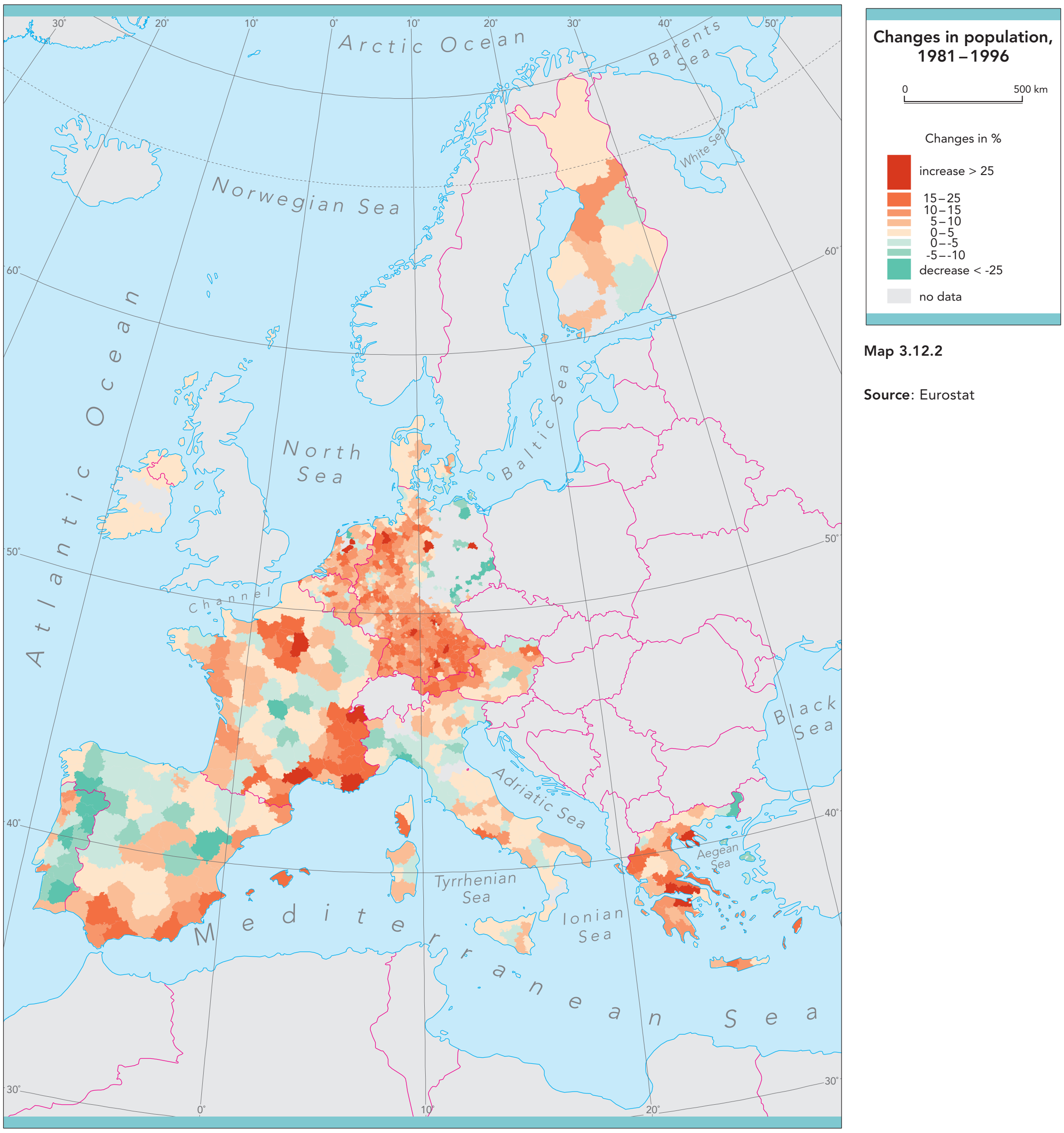




Map 3.12.1



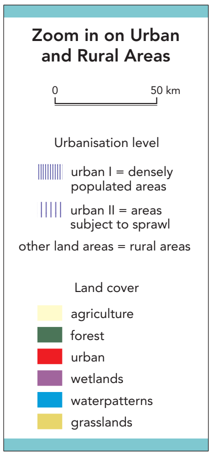
Source: EEA

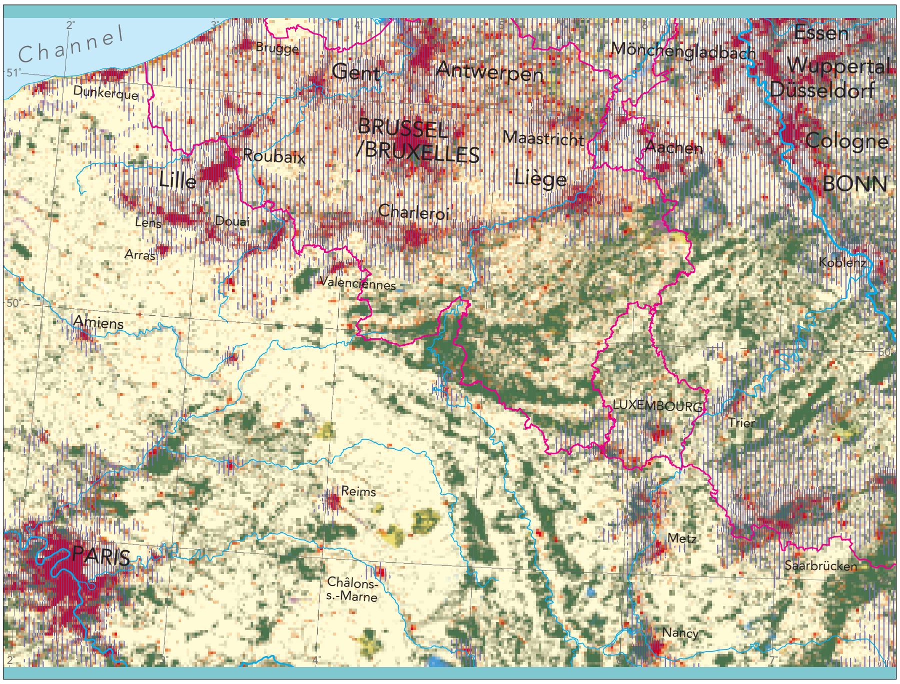


Map 3.12.2

Source: Eurostat

opment ('urban sprawl'), transport and consumption patterns. Urban sprawl is often motivated by a desire for better living conditions in more spacious sub-urban areas (Table 3.12.1), but it also leads to inner city dereliction, and increased demand for transport which continues to be a key threat to the urban environment, with few positive developments noted (EEA, 1998a). Although not entirely related to urban areas, forecasts for passenger transport demand show a 40% growth above 1990 levels in 2010 and a 25% increase in car-ownership is expected over the same period. Accession Countries will reach the lowest EU car ownership levels (366 cars per 1 000 heads in Greece) by 2010, while no further growth is expected at the high end (673 cars per 1 000 heads in Luxembourg), although additional EU countries are expected to reach this saturation level. Overall, such trends, translated into an increase in average kilometres driven per person, result in significant health threats (see Chapter 3.10) and severe noise, congestion and air-quality problems (see Chapter 3.4).





Map 3.12.3
The focus is on regions that are already very highly urbanised and the occurrence of urbanisation patterns. Of particular interest are those places likely to suffer from future patterns of urban sprawl.

Source: EEA

However, the effect of growing demand for transport is now difficult to assess, because the development of information technology may radically alter travel patterns (see Box 3.12.3).

Beyond 2010, the population of the EU15 is expected to grow by only 0,5% over the following 20 to 30 years (European Commission, 1997b). Conversely, the composition and social status of the population is changing: while the number of households continues to rise, the average number of persons per household has decreased below three. Households affect the environment through their consumption patterns, and have a key role in the land use / transport interface.

Table 3.12.1 **Land use in urban areas**

POPULATION DENSITY *(inhabitants/km²)*	URBAN FABRIC *(% of total area)*	ARTIFICIAL SURFACES *(% of total area)*	FORESTS AND AGRICULTURAL LAND *(% of total area)*
> 500	31	40	59
100 - 500	7	9	90

Source: EEA

Heavy industry has reduced its presence in cities, but remains a problem in most Accession Countries. Industrial pollution control measures are generally well underway. However, small and medium-size enterprises are overwhelmingly concentrated in urban areas and improving their environmental performance is a major challenge. Energy sector-related problems are comparable to those arising from industry and often addressed jointly. Tourism brings about intense seasonal stresses concentrated in a number of key areas (see Chapters 3.14 and 3.15). Agriculture sector-related problems are inextricably linked to the urban reality, as the urban / rural border is often loose (see Chapters 2.3 and 3.13).

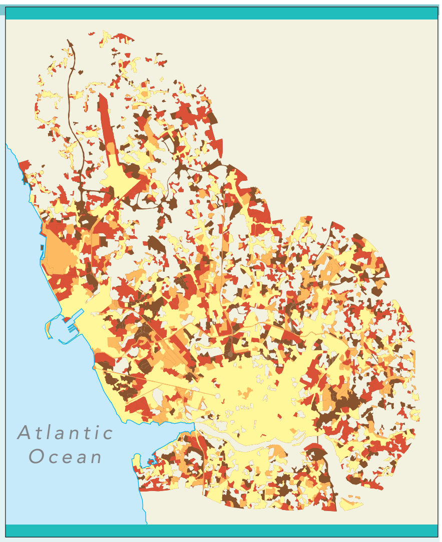
Large urban agglomerations typically manifest economic segregation, with lower-income groups tending to be concentrated in inner-city areas and/or extensive peripheral estates, sometimes in substandard dwellings, which are found throughout Europe (WHO, 1997. Box 3.12.4). Finally, traditional environmental health problems from unsafe drinking water, inadequate sanitation and poor housing have largely disappeared from the EU cities.

Box 3.12.2. Urban dynamics in Dublin and Porto

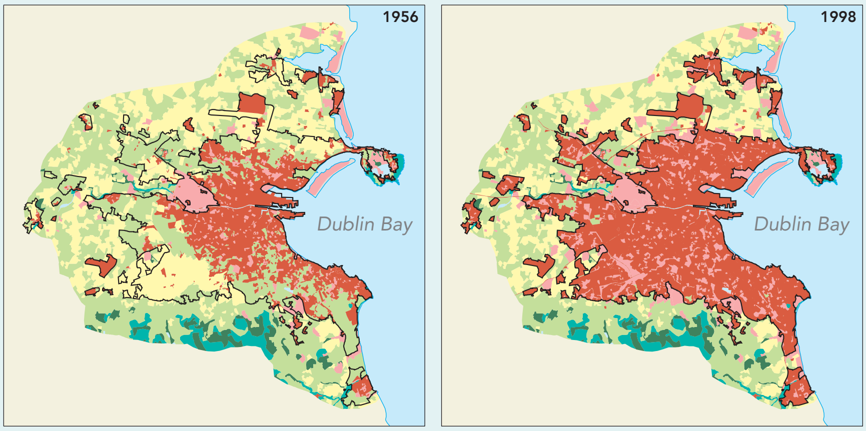
The European Commission's MURBANDY project aims (i) to study past and current land uses in cities, (ii) to monitor the dynamics of Europe's cities; (iii) to develop a number of 'urban' and 'environmental' indicators that help to understand these dynamics and the impact these cities have on the environment, and (iv) to elaborate scenarios of urban growth.

Initial results for Porto and Dublin (Maps 3.12.4. & 3.12.5.) illustrate how European cities continue to expand and increase their use of natural resources and land – even if population growth levels are relatively modest: 30% between 1960 and 1997 for Porto, 39% between 1958 and 1998 fof Dublin

Source: Area Metropolitana do Porto; Central Statistical Office; EC Joint Research Centre



Map 3.12.4.
Residential urban fabric in Porto almost doubled from 1958 to 1997, while forest and semi-natural areas and agricultural areas nearly halved; conversely, the area used for road and rail networks increased by a factor of 7.



Map 3.12.5.
Dublin shows the same pattern: the area of residential urban fabric more than doubled between 1956 and 1998, while the area used for road and rail networks increased by a factor of almost 10; the reduction in forest and semi-natural areas and agricultural areas was approximately 15%.

Box 3.12.3. Information Society: the big question mark for urban planning

The development of Information Society Services and Applications (ISSA) is expected to bring about important changes to urban systems. Telecommunications and fast transport networks are emerging that interconnect cities across long distances: the spatial dimension of communications between cities loses importance, while concerns are being raised about the exclusion of intervening areas (Graham and Marvin, 1996).

While telecommunication and infrastructure are prerequisites for the development of networks, their effects on urban expansion and densities are not known. This might encourage people to settle in rural areas; but many observers argue that networks will lead to greater concentration, both due to the costs of physical infrastructure and to the economic dynamics that can be found only in urban centres (Hall, 1997; Coyle, 1997). Indeed, there is evidence that new technologies will strengthen the already economically viable city regions (Kunzmann, 1997; European Commission, 1997a), while less favoured regions may be left out (European Commisson, 1997a).

ISSA has potential for environmental improvement. A project to evaluate the effects of teleworking was launched in the Public Administration in Rome on the basis of the following considerations: (i) traffic is very congested in Rome; (ii) more than half of Rome's workforce uses a private vehicle to reach the workplace; (iii) the majority of people who work in Rome are employed in the service sector; and (iv) technology has made decentralisation of parts of the service sector possible. The project started in 1995 and ended in 1997, covering 18% of Rome's workforce. It was found that, in the long run, teleworking could result in savings of LIT 6 billion in energy consumption and a 7% decrease in air pollution (ECTF, 1997).

Box 3.12.4. Social issues and sustainable development

The social component of sustainable development is highlighted by UN Agenda 21 and has since been echoed elsewhere.

'Poverty and environmental degradation are closely interrelated. While poverty results in environmental stress, the major cause of global environmental deterioration is an unsustainable pattern of consumption and production, particularly in the industrialised countries, which aggravates poverty and imbalances.'

— Section 1, Chapter 4, 'Agenda 21'

The European Sustainable Cities report acknowledged and put this challenge in a European perspective. 'Sustainable development is thus a much broader concept than environmental protection. [...] It embraces concerns for the quality of life (not just income growth), for equity between people in the present (including the prevention of poverty), for inter-generational equity (people in the future deserve an environment which is at least as good as the one we currently enjoy, if not better), and for the social and ethical dimensions of human welfare. [...]'

— Section 3, Chapter 1, 'European Sustainable Cities Report'

2. Pressures on environmental resources

2.1. Urban flows

In the past, rising incomes, and consequent growth in consumption, have tended to increase energy and water usage and waste generation (Slob *et al.*, 1996). The phenomenon is illustrated by changes in water consumption, energy consumption and waste generation (Box 3.12.5). To break this linkage between economic development and environmental pressures will require significant changes in attitudes and lifestyles (see section 6 'Towards an integrated urban policy?'), which are not yet apparent in the EU.

There is a strong correlation between electricity consumption and waste generation (see EEA, 1998b, p.144). Some cities (e.g. Warsaw, Cracow and Berlin), however, deviate significantly from the general pattern due to high waste generation. Electricity consumption also correlates with water consumption, although to a lesser degree. Interestingly, Nordic capitals and Zurich cluster around the high end not only for electricity consumption but also for water use. Urban waste has increased in volume and changed in composition over the past two decades: while volumes are still expected to increase, current management practices do not meet the requirements of the EU waste hierarchy (see Chapter 3.7), nor is waste generation generally subject to corrective economic instruments such as taxation.

Seasonal water shortages are already common mostly in southern European cities, and demands will generally not be met in the next century if renewable water-resources pollution and abstraction continues to increase at current levels. Water distribution is a problem in several urban areas with obsolete infrastructure and the unaccounted-for water component can reach 50% of the total abstracted volume (network leakage in Oslo, for example, amounts to 40%) (see also Chapter 3.5).

Energy consumption by both transport and households has risen steadily in the past two decades and further increases can be anticipated unless energy pricing measures provide a sufficient deterrent. Domestic energy consumption varies with income level and household size; demand is expected to grow as a consequence of the widespread penetration of household appliances, outweighing technological improvements (see Chapter 2.2).

2.2. About some urban land use …

Urbanisation exerts environmental pressures, both on the nature areas in cities (forests, large parks and wetlands) and beyond the boundaries of cities. The impacts from urbanisation around cities concern areas of high economic, recreational and ecological value such as agricultural and forest areas, through increasing run-off, deforestation, soil erosion, habitats fragmentation and change in biodiversity. In contrast, afforestation also occurs in order to enchance recreation and water infiltration (drinking water reservoirs) possibilities.

The use of the landscape around cities by the urban population depends on the accessibility and availability of nature areas, mostly forests and beaches. The amount of forests within a one-day trip (ca 50 km distance from town limit) around major urban areas varies greatly, with large areas accessible mostly in countries in central, eastern and northern Europe (Map 3.12.6). In the same countries, people in smaller urban areas also have easier access to forests.

While most people live within 15 minutes' walk of at least one green area, urban green space amounts to an average of only 1.4% in the EU (EEA, 1998b). Surveys (EEA, 1998a and WHO, 1997) show that access to green space varies considerably; the proportion of urban land taken by green areas in European cities ranges from only 2% in Seville and Bratislava to around 70% in Turku, Oslo and Gothenburg. Such areas are extremely vulnerable and exposed to fragmentation

Box 3.12.5. Size and impacts of urban flows - the case of the largest Northern Mediterranean agglomeration, Barcelona

Barcelona stretches over a total administrative area of 101 km^2 and is the largest agglomeration in the Northern Mediterranean basin (pop. 1 508 805 - Eurostat).

As a signatory of the Charter of European Cities and Towns Towards Sustainability, Barcelona committed to adopting its own Local Agenda 21 by the end of 1999. This has brought significant challenges to the municipal political agenda, some of which are summarised below.

a) Waste flows
Waste streams
- household waste (600 000 t/year)
- household-like waste (125 000 t/year).

Waste treatment capacities
- landfilling (555 000 t/year)
- incineration (150 000 t/year)
- recycling (20 000 t/year).

It is the aim of the Metropolitan Waste Plan to stabilise waste generation at 1996 levels by 2006. If accomplished, such an ambitious goal would result in both lesser waste volumes and reduced greenhouse gases (GHG) emissions. To this end, Barcelona will have to extend its capacities as follows:

- composting (167 000 t/year)
- methanisation (337 000 t/year)
- incineration (370 000 t/year)
- recycling.

Such an extension would bring about substantial (more than 20%) reductions in the GHG emissions from waste treatment, thereby allowing for compliance with the Heidelberg compromises (15% reduction in 1987 values by 2006).

b) Energy flows
Barcelona's energy flow is far from being sustainable (Table 3.12.2). The electrical efficiency of the city's energy suppliers is below 35% and the losses in the distribution system account for approximately 9% of the total produced.

Similarly, growing mobility trends have resulted in the transport sector being the largest energy consumer, with around 40% of the total.

Finally, greenhouse gas emissions showed an increase of 400 000 tons of CO_2 equivalents over the 10 year period studied (up 35% of the city's contribution to the greenhouse gas effect result

For Barcelona's energy balance for the years 1985 and 1995, the results are evaluated against qualitative sustainability values developed under the auspices of the Charter of European Cities and Towns for Sustainability.

c) Water flows
Barcelona's water flow is largely unbalanced (Table 3.12.3). This is further underlined by comparing the drainage area required by the city with its extension, which increases by a factor of 3.5 for an average year, and by a factor of 8 for a dry year. (Based on data from a number of water-management agencies and on estimates when data were not available).

1 Eurostat (Pressure Indices Project), 1995
2 Fòrum Cívic Barcelona Sostenible, 1996
3 European Environment Agency, 1995
4 Working proposals for Barcelona, 1998

Source: Ginés, Noguer, Nogués, 1997

Energy flows Table 3.12.2.

Indicator	Value 1985	1995
Per capita energy consumption (GJ/person)	23.4	34.8
Co-generation in electricity production (%)	1.7	9.4
Electricity production from nuclear power stations	52.8	71.8
Electricity production from renewable – aeolic and photovoltaic – energy sources (%)	0.008	0.308
Energy – liquid fuels – consumed by transport (GJ)	16 990 660	20 013 740
Average travelled distance (km/vehicle)	3 600	4 400
Energy consumption per vehicle (GJ/vehicle)	23.3	19.5
Energy 'ecological footprint' (Barcelona's surface=1)	69.3	75.3
Per capita net greenhouse-gas effect (t CO_2 equ./person/year)	2.3	2.7
Transport generated CO_2 emissions (t CO_2)	1 212 121	1 487 603
CO_2 absorption by the city (t CO_2)	27 016	22 435

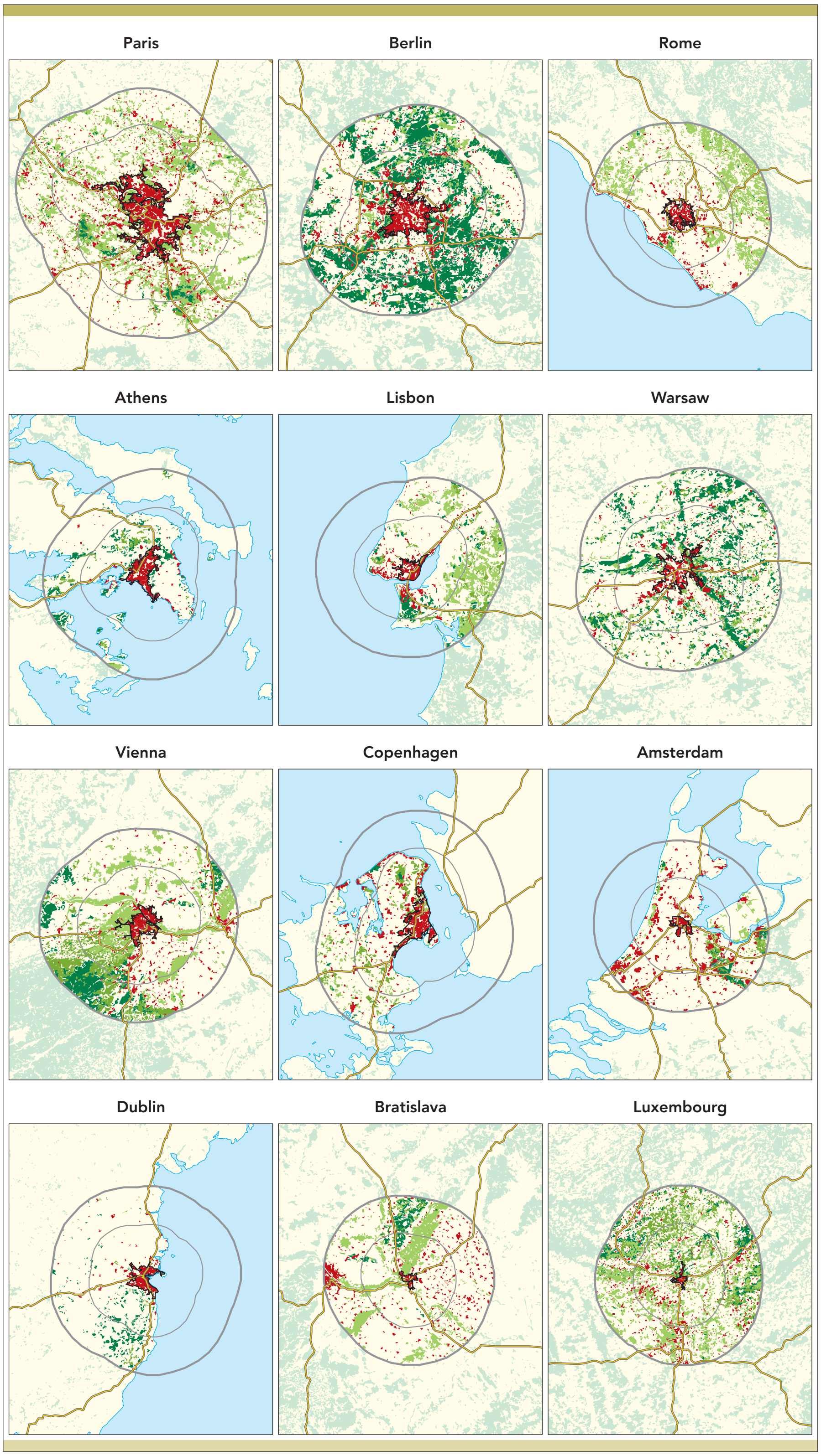
Water flows Table 3.12.3.

Indicator	Indicator source	Value	Indicator characteristics
Water origin Imported water (%)	4	47,4	Reflects dependence from foreign sources
Groundwater (%)	3	6.5	Shows degree of exploitation of aquifers
Water inputs Water abstraction (l/inhab/day)	1	271.5	Reflects losses and savings over time Up to 22.6% of the distributed water is not billed
Water supply (l/inhab/day)		210.1	Supply figures fluctuate between 60 l/inhab/day in Belfast (UK) and 607 l/inhab/day in Milan (Italy)
Consumption by sector (l/inhab/day)	2	hous.: 135 ind.: 60 pub.: 15	Highlights trends in de/industria-lisation, de/population, etc. Use has increased for households, decreased for industry, and remained stable for the public sector
Water outputs Evacuated waste-water (m^3/sec)	4	4.6	Illustrates the potential impact on the receiving body
Dwellings connected to sewer systems (%)	3	100	Values fluctuate in Europe between 83% in Reggio-Emilia (Italy) and 100% in most European cities
Water quality Non-treated wastewater (%)	1 2	38	On average figures fluctuate between 77% in Greece and 3% in Germany
Treated rainwater (%)	4	0	Illustrates CSO phenomena problematics
Reused water (l/inhab/day)	2	0	Shows the usefulness and degree of purification achieved
Reused sludge (%)	4	0	Shows the usefulness and degree of purification achieved
BILL-ecological index	2	0-1	Illustrates quality of main water-bodies at final stretches Does not show improvements over the past 10 years

Forest around capitals in Europe

0 20 km

- urban morphological zone
- 25 kilometer zone
- 50 kilometer zone
- roads
- urban fabric
- broad leaved forest
- coniferous forest
- mixed forest
- forest outside selected zone



Map 3.12.6

Source: EEA

and conversion to urban uses unless planning guidelines are observed (adapted from Soulé, 1991):

- natural open-space elements ought to be as large as possible and be made continuous;
- a single large habitat fragment is superior (in most cases) to small fragments;
- development configurations ought to minimise adverse edge effects;
- corridors between green areas and between green urban areas and the countryside ought to be maintained and developed.

Subsurface conditions are also affected by the combined pressures of increased urbanisation and the accumulation of planned and unplanned impacts on the natural environment. There are risks to lives and property, even in those countries not at first sight affected by geological hazards (see also Chapter 3.8). Urban areas and their hinterlands are becoming increasingly vulnerable to geo-problems controlled by geological processes, the total cost of which to society ranges from major (hazards such as volcanic eruptions, earthquakes, floods, land subsidence, landslides) to minor (local swelling or shrinking of clays in foundations). Reworking and removal of the soil surface by construction can unbalance watersheds and landscapes, contributing to the loss of biological diversity, of ecosystem integrity and productivity as well as to land degradation and erosion (see Box 3.12.6; also Chapter 3.6).

Land-use planning systems play a central role in encouraging a more sustainable use

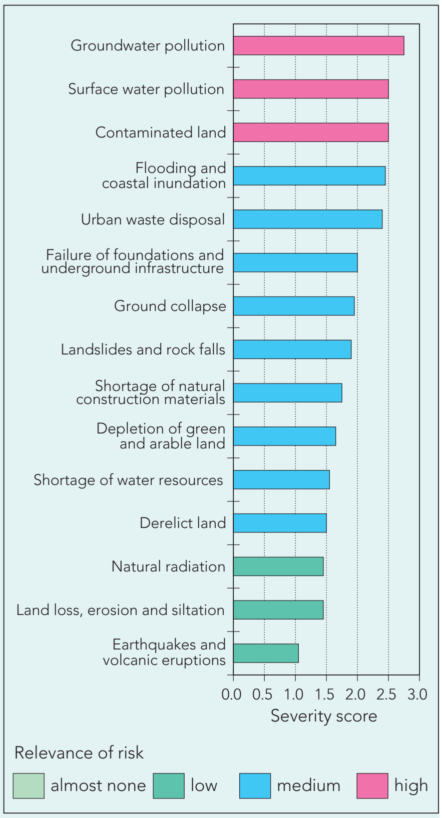
Box 3.12.6. Urbanisation: the geological risk

EuroGeoSurveys, an advisory group of all geological surveys in the EU Member States and Norway, believes that integration of the geosciences into holistic urban environmental planning can alert decision makers to the wide range of geo-problems relevant to urbanisation and other pressures resulting from human activities. The indicative matrix shown below (Figure 3.12.3 a and b) lists the relevance of fifteen geo-problems for cities in the EU Member Countries and Norway and indicates that cities are at greater risk from geo-problems in the southern European countries than in northern Europe. The recent disastrous landslides near the city of Naples (Italy) show that geo-problems related to deforestation and poor hill-slope management are relevant to expanding urbanisation.

…/…

Geo-problems of urban areas in the European Union and Norway

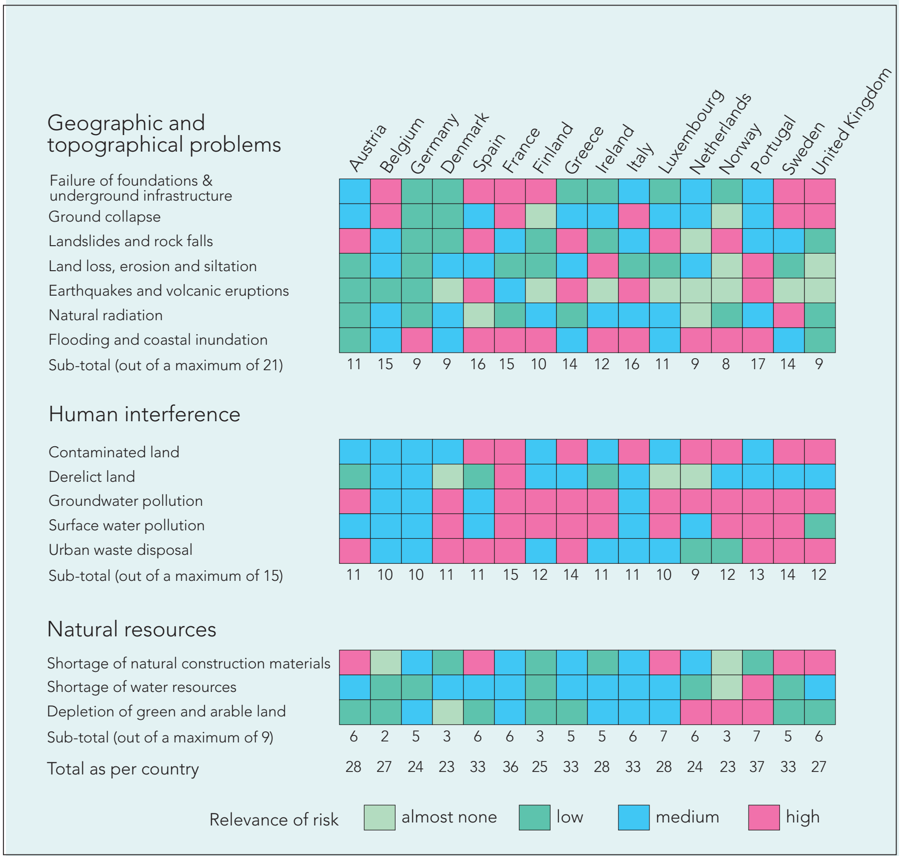
Figure 3.12.3 a



Source: EuroGeoSurveys

Figure 3.12.3 b **Geo-problems of urban areas in the European Union and Norway**

Source: EuroGeoSurveys



of land resources: at the Community level spatial policies (European Commission, 1997b) call for a reduction of urban sprawl and transport demand; they further advocate a common European spatial planning perspective that provides a framework for the national, regional, and local levels.

3. Transport and the urban environment

Transport – and specifically road traffic – has major external impacts which diminish the quality of life, particularly within urban areas. The main such impact is from congestion (causing economic losses in terms of time and fuel utilised), which arises when transport infrastructure is used beyond its capacity (Map 3.12.7); other impacts include the costs of accidents, visual intrusion (caused by billboards, signage, and pylons), and the contribution of road transport to global warming (overall, estimated at a quarter of man-made emissions - Figure 3.12.4 (see also Chapter 4.1).

The costs of congestion arise mainly from road transport (costs estimated at 2% of GDP), but also from air and rail transport (respectively some 0.04% and 0.01% of GDP) (European Commission, 1995). To date, policy action has failed efficiently to address congestion, as (i) road transport continues to grow and (ii) its environmental costs are only covered partly or not at all (European Commission, 1998b).

Both freight and passenger road transport in the EU have increased by around 50% (EEA, 1998a) since the early 1980s, with motor cars representing the predominant passenger mode. Increased car ownership trends will

Average daily motor road traffic, 1995

0 500 km

Number of vehicles per day

- more than 100 000
- 50 000 – 100 000
- 30 000 – 50 000
- 10 000 – 30 000
- less than 10 000

Map 3.12.7

Source: UN-ECE

cause a growth of road transport, although this may be offset to some extent by a growth in rail transport in congested cities (Figure 3.12.5).

Ideally, the costs of environmental impacts would be borne by those whose activities generate the cost (a process of 'internalisation'). In the case of congestion this would involve taxes to recover the costs: however, in practice there are serious technical and implementation problems, because congestion costs vary over time and space, and

Transport related externalities as % of GDP Figure 3.12.4

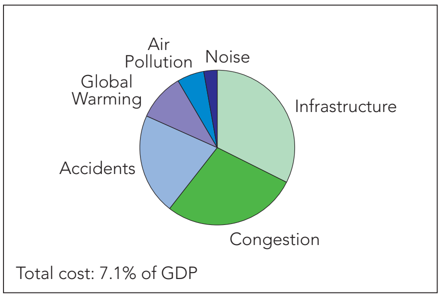
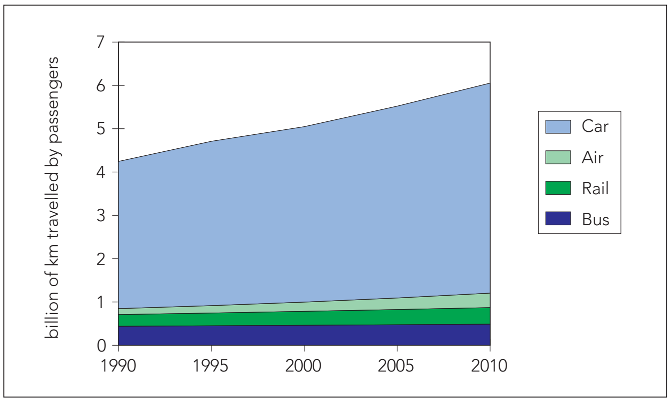


Figure 3.12.5 **Passenger transport modal split in EU (EU averages)**



Growing car usage brings about increased traffic intensity (and hence congestion) and fosters urban sprawl: for a given city size, low population densities lead to augmented car usage patterns with respect to higher density areas, where average distance travelled is lower.

Source: EEA

congestion charges at present internalise only a small proportion of the total cost (OEIL, 1997) (see Chapter 4.1).

Policies to reduce car dependence must promote alternative modes. These include public transport and also cycling. It is estimated that cyclists in the EU covered a total distance of about 70 000 million km in 1995 (approximately 1.5% of the total distance covered by all land transport), an average of 200 km/year/head (ECF, 1998). There is considerable variation between countries: Denmark and the Netherlands exceeded 900 km/year/head; Austria, Belgium, Finland, Germany, Ireland, Italy and Sweden are in the range of 100-400 km, while France, Greece, Luxembourg, Portugal, Spain and the UK are below 100 km. In general, cycle use has been fairly stable in the recent past, with only a small increase in western Germany and Denmark, and a small decrease in France, Ireland, Finland, the UK and the new German Länder. The exception have been the Netherlands and Sweden, which has seen a marked increase.

Compared to the EU15, the transport system in the Accession Countries is presently characterised by a relatively high freight transport intensity, a large share of rail transport, and a relatively low – although growing – level of private car ownership. A strong growth in road transport, largely at the expense of rail transport, is expected for the next decade (EEA, 1999).

4. Urban air pollution: road transport takes the lead

Urban air pollution is the source of a range of problems both within cities as well as outside as emissions from cities lead to an increase in the regional background concentration levels of many pollutants. These problems include damage to flora and fauna, decomposition of materials, buildings, historical monuments, weather and climatic changes, as well as health risks mostly associated with inhalation of gases and particles (see also Chapters 3.1, 3.4 and 3.10).

Health effects which arise from exposure to air pollution can be classified as: irritation and annoyance, loss of organ functions (e.g. reduced lung capacity), morbidity and mortality. Some of these effects can be acute and reversible, while others develop gradually into irreversible chronic conditions. Low-level exposure to a complex of pollutants in air, water, food, consumer products and buildings may be affecting overall quality of life or significantly contributing to asthma, allergies, food poisoning, some cancers, neuoro-toxicity and immune-suppression. Particulate air pollutants possibly cause, per year, 40 000 to 150 000 deaths in adults in EU cities. The population in rural areas is also affected, although to a lesser extent, as the urban pollution spreads across regions.

Many historic monuments and buildings are affected by air pollutants and in particular sulphur compounds, especially buildings made of marble, calcareous sandstone, or other materials susceptible to damage. Many of these edifices are situated in heavily or moderately polluted areas and thus are subject to serious deterioration. Examples from the UNESCO cultural heritage list are the Acropolis in Athens, Cologne Cathedral, and whole cities, such as Cracow and Venice.

4.1. Past and present situation

Although air quality in Europe and particularly in the large European urban areas has improved in recent decades, nearly 40 million people residing in the 115 larger European cities still experience exceedance of the WHO air-quality guidelines for at least one pollutant every year (EEA, 1998a).

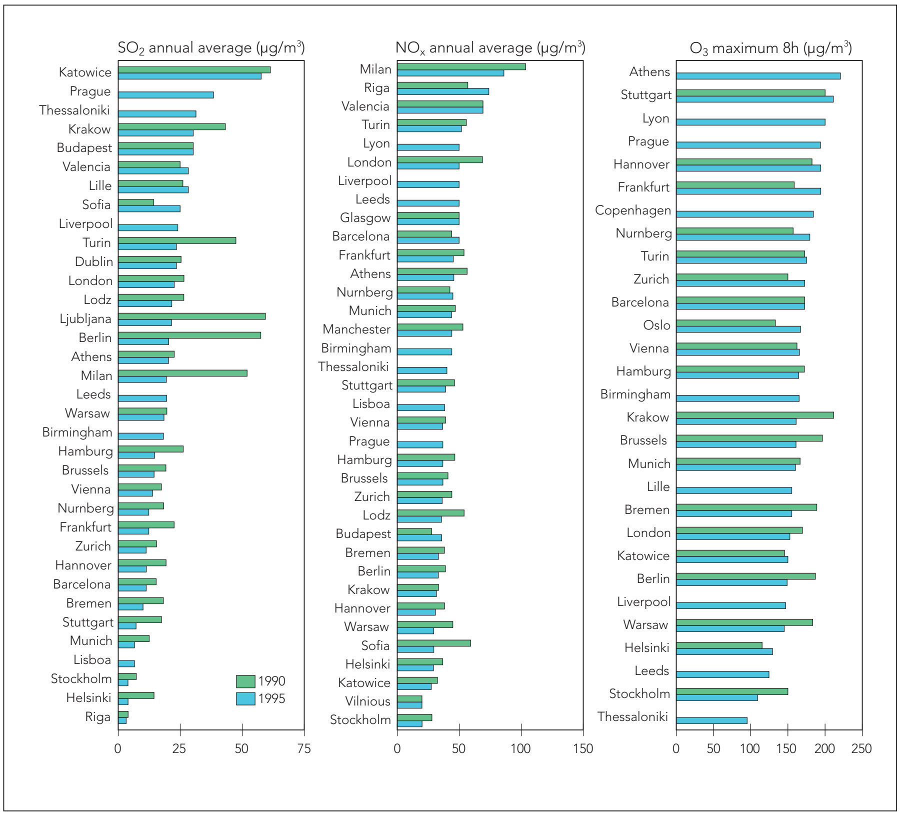
The past decade has seen considerable improvements in the ambient concentrations of sulphur dioxide (SO_2), lead and particulates. The main sources of SO_2 and particulates in the past being industry and energy production from coal and heavy fuels combustion, emission reduction mostly relied on the emergence of new clean energy sources and more efficient combustion technologies. In a similar way, lead levels in the atmosphere were controlled by reducing lead content in fuel as a result of the EC Directive for unleaded petrol coming into force; lead concentrations have dropped sharply after 1986 in the majority of the European cities and in 1995, no city experienced exceedance of the long term WHO air quality guidelines.

SO_2 concentrations are decreasing in line with the reduction in emissions. In 1995, the long-term SO_2 guideline was exceeded only in Katowice although many European agglomerations experienced exceedances of the short-term WHO air quality guidelines for winter-smog (EEA,1998a).

However, the levels of so-called 'photochemical pollutants', nitrogen oxides, non-methane volatile organic compounds, carbon monoxide and ozone (NOx, NMVOC, CO and O_3) remain high in most European cities (EEA, 1998a). Exceedances of the short-term WHO air-quality guidelines are recorded in the majority of the large European cities (Figure 3.12.6). Road traffic emissions constitute the dominant source category for this new form of air pollution. At the European level, road traffic causes 44% of NOx, 56% of CO and 31% of NMVOC emissions (EEA, 1998c), while at city level these percentages are much higher; in Reykjavik, for instance, traffic is the only source for NOx emissions (EEA, 1998a).

A comparison of several annual average concentrations of particulate matter monitored in European cities over the past decade shows mainly downward trends (EEA, 1998c) despite the fact that, in 1995, the short-term WHO air quality guidelines were exceeded in the majority of the large European cities (EEA, 1998a). Atmospheric

Annual average SO_2, NOx and maximum 8-hour O_3 concentrations for a number of large European cities Figure 3.12.6



Source: ETC/AQ

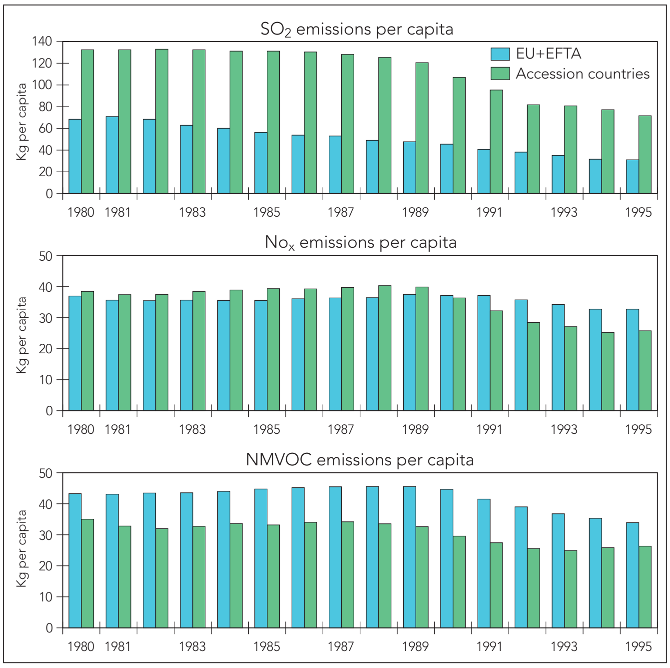
aerosol consists of particles with different sizes and chemical composition. Particles with less than 2.5 µm aerodynamic diameter are generally referred to as 'PM2.5' while particles with an aerodynamic diameter smaller than 10 µm are referred to as 'PM10'. PM10 can enter the upper parts of the human respiratory tract whereas PM2.5 can penetrate the lungs. There is increasing evidence that the health effects of particles are due principally to fine particles (PM2.5 or smaller).

Table 3.12.4 **Estimated effect on road transport from the package of measures derived from the Auto Oil Programme (Directives)**

Pollutant	Emissions in 2010 as % of 1990 level without Auto Oil measures	Emissions in 2010 as % of 1990 level with Auto Oil measures
urban NOx	37	23
urban PM	79	37
urban CO	20	10
urban VOC	23	23

Source: Auto-Oil programme

Figure 3.12.7 **Trend in NO_2, NMVOC and SO_2 emissions per capita at country level**



Source: ETC/AQ

Long-term air-quality guidelines for nitrogen dioxide (NO_2,) were exceeded in many European cities in 1995. Ozone concentrations show extreme seasonal and even diurnal variations, and in 1995 many cities exceeded the maximum hourly concentrations specified in WHO air-quality guidelines.

Data on concentrations of volatile organic compounds (VOCs) is relatively scarce, because the monitoring of VOC levels is demanding in terms of equipment and analytical methods, and is not undertaken on a regular basis. Benzene is the most frequently monitored individual compound as benzene concentrations have increased with the introduction of unleaded petrol leading to high emissions from vehicles not equipped with catalytic converters. With one exception, exceedances of the long-term WHO air-quality guideline were observed in all 10 cities for which data was available (EEA,1998a).

In contrast to the clear and continuous downward trend in SO_2 emissions per capita, NOx and NMVOC emissions increased until about 1990 (Figure 3.12.7). Their decline from that year on is much smoother than the SO_2 emission decrease. It is important to note that the SO_2 emission decrease in the 10 Accession Countries starts much later than in the EU and EFTA countries, while for NO_x and NMVOC approximately the same trend is recorded for both country groups. For NO_x in particular, the reduction of emissions in the Accession Countries is faster than in EU and EFTA countries as a result of the relatively more recent renewal of the vehicle fleet.

Controlling air pollution from road traffic (including NOx, VOCs and, indirectly, O_3 levels) is identified as the single biggest and most complex issue (European Commission, DGXI, the European Air Quality Management Project), notwithstanding a modest and statistically disputable downward trend in NOx and O_3 levels from 1990 to 1995. A variety of methods include improving public transport, diverting traffic from city centres by building ring roads, reducing car use by means of parking policies or stimulating bicycle use, have been used with varying degrees of success. National and EU-level regulations aiming at automobile emissions reduction, such as the introduction of catalytic converters (EC Directive 91/441/EEC), or unleaded petrol (EC Directive 85/210/EEC), resulted in considerably lower vehicle emission factors.

The European Commission's Auto Oil Programme was aimed at improving air quality by means of evaluating cost-effective measures to reduce emissions from road transport. The process involved the car manufacturing industry and the oil industry and resulted in a number of Commission proposals in 1996, and final agreement in 1998 between the Council and the European Parliament on measures for passenger cars, light commercial vehicles and quality of petrol and diesel fuels. The measures are laid down in Directives 98/69/EC and 98/70/EC:

- a two-step tightening of vehicle emission limit values for passenger cars and light commercial vehicles with the first step in the year 2000 and the second step in 2005;
- new environmental specifications for petrol and diesel fuels to take effect from the year 2000; very low-sulphur fuels to be mandatory from 2005;
- provision made for earlier phase-in of very low-sulphur fuels;
- leaded fuels to be phased out by 2000 (with the possibility of derogation up to 2005);
- proposals to be brought forward by the Commission for further complementing measures to take effect from 2005.

The estimated effect on road transport emissions of the Auto Oil measures is substantial (Table 3.12.4).

To evaluate the impact of the Auto Oil measures on urban air quality in European cities and to assess possible further measures to reduce emissions from road transport, as well as non-technical local measures, the Auto Oil 2 Programme was launched by the Commission. This is expected to result in Commission proposals by the end of 1999.

4.2. By 2010, expectations to improve the situation

Most air quality guidelines were exceeded in 1990, the base year for the projections under the baseline scenario. The policies in place are expected to improve the situation considerably (Table 3.12.5): the average exposure of inhabitants of large agglomerations in the EU to concentrations above the recommended level is expected to be halved in 2010 in comparison with 1990.

For SO_2 and benzene a substantial improvement can be expected in the EU. Nevertheless for SO_2 in some cities, short term air quality guidelines are likely to be exceeded

Urban air quality trends Table 3.12.5

Indicator	EU 1990	EU 2010	Accession Countries 1990	Accession Countries 2010
Emission per capita				
Sulphur dioxide (kg)	38	13	103	45
Nitrogen dioxide (kg)	28	14	31	19
Benzene (kg)	0.75	0.44	0.84	0.43
PM10 (kg)	2.6	2.1	8.8	6.8
B(a)P (g)	0.58	0.53	0.77	0.59
Average population weighted concentration				
Sulphur dioxide (max. day, ug/m3)	220	75	760	540
Nitrogen dioxide (annual average, ug/m3)	56	41	59	58
Benzene (annual average, ug/m3)	8.1	3.0	12.5	3.8
PM10 (annual average, ug/m3)	42	29	68	44
Ozone (max. hour, ug/m3)	289	253		
Ozone (AOT-60, ppm.hr)	9.8	1.7		
B(a)P (annual average, ng/m3)	2.7	2.1	5.3	4.3
Average exposure				
Sulphur dioxide	80%	7.9%	96%	77%
Nitrogen dioxide	86%	40%	98%	83%
Benzene	58%	4%	83%	23%
PM10	53%	16%	94%	56%
Ozone	82%	73%		
B(a)P	88%	62%	100%	96%
Average exceedance (ratio, compared to threshold value)				
Sulphur dioxide (125 µg/m3 daily maximum)	0.8	0.15	5.1	4.1
Nitrogen dioxide (40 µg/m3 annual average)	0.45	0.13	0.48	0.46
Benzene (5 µg/m3 annual average)	0.78	0.02	1.5	0.10
PM10 (40 µg/m3 annual average)	0.18	0.03	0.71	0.21
Ozone (180 µg/m3 hourly maximum)	0.65	0.48		
B(a)P (1 ng/m3 annual average)	1.7	1.3	4.4	3.3
Maximum (2x2 km2) exceedance (ratio, compared to threshold value)				
Sulphur dioxide	1.4	0.26	6.3	5.7
Nitrogen dioxide	0.60	0.21	0.60	0.61
Benzene	1.1	0.03	2.0	0.16
PM10	0.30	0.06	1.1	0.35
Ozone	0.96	0.72		
B(a)P	2.5	1.7	5.2	4.4

Source: Eerens et al, 1999; ETC/AQ

for a limited number of days a year in 2010. The most significant exceedances expected in 2010 are PM10, ozone, NO_2 and Benzo(a)pyrene. For accumulated ozone exposure above a threshold of 60 ppb (AOT60), exposure decreases of approximately 60% are predicted for an aggregate of 50 European cities between 1990 and 2010. Nevertheless, the hourly maximum average weighted concentration of ozone of 253 $\mu g/m^3$ expected in 2010 is well above the EU target of 180 $\mu g/m^3$. The EU guidelines for NO_2 require an average concentration reduction of 30% by 2010 compared to 1990 levels. This will probably not be achieved in all EU cities under existing policies.

In Accession Country cities, the frequency of exceedances of air quality guidelines will probably be significantly higher in 2010 than in the EU. This could be countered through the application of EU guidelines, although at significant cost. The application of EU vehicle emission standards and other measures, for example, could effectively constrain projected increases in NO_x emissions, but at an anticipated cost of about 6 billion EUR/year, 2.5 times current levels.

5. Urban noise issues

Noise remains a serious environmental problem: it is estimated that about 32% of the EU population (about 120 million people) is exposed to road noise levels over 55 Ldn dB(A) on house facades; this is despite reductions in vehicle noise limits by 85% for cars and 90% for lorries since 1970 (Figure 3.12.8). Estimates of noise-related costs range from 0.2% to 2.0% of GDP (Quinet, 1993).

The latest reduction of 74 dB(A) for cars and 80 dB(A) for lorries has led to significant applications of low-noise technology. Aircraft and rail noise levels also cause annoyance although the aircraft noise footprint for modern jets around an airport has been dramatically reduced by a factor of nine compared with aircraft from 1970. Based on data from 35 major European airports that accommodate about 85% of the total air traffic, it is estimated that approximately 3 million people in Europe are exposed to aircraft noise over Ldn 55 Ldn dB(A). However, a complication is that perceptions of the various types of transport noise differ between individuals. For example for the same noise value of Ldn 60 dB(A) the sensitivity can be different: typical proportions of highly annoyed people are: aircraft noise 15%, road traffic noise 10% and railway noise 5% (Box 3.12.7).

In spite of the considerable tightening of EU-type testing limits since 1972 the actual effect on the reduction of noise emission by motor vehicles was negligible. Although the reasons for that inadequacy are known and mentioned in the Green Paper on Noise (COM(96)540), little progress has been made so far to improve the state of the urban acoustical environment.

5.1. Where do we stand?

A contemporary trend in urban planning is to direct through traffic to ring roads and away from already congested urban areas. Many ring-road systems and urban highways have noise barriers and tunnels; such measures are also promoted by the EU environmental impact assessment procedure.

However, anti-noise measures are hampered by a lack of harmonisation at European level (indices, methodologies and limit values) and international standards for the calculation and measurement of transportation noise, as well as inadequacies in testing methods for vehicles, tyres and road surfaces. The cost of mitigating existing noise problems can be very high, although it should not be underestimated the noise reduction potential through traffic management, traffic calming, parking policies and other low-cost measures that can shift mobility from private car to walking, biking and public transport. In fact the improvement of the modal split in favour of the low-noise/low-emission transport modes is considered one of the best ways to tackle the urban traffic noise problem.

Incentives are needed to motivate manufacturers to develop vehicles and aircraft with even lower noise emissions, and – importantly – for local administrations to promote anti-noise resurfacing of roads.

5.2. What does the future hold?

Under the baseline scenario, noise levels adjacent to major European road networks are expected to worsen towards 2010 because of growth in traffic, especially freight transport (see Chapter 2.2). The same applies to aircraft noise, particularly after 2010 when air traffic is projected to increase while major technological improvements in aircraft appear unlikely.

Box 3.12.7. Grim reminder of the issue

Noise is defined as unwanted sound because it affects people in both physiological and psychological ways. We are exposed to noise before birth and throughout life and it is a problem that affects everybody. At levels over 40 dB(A) it starts to influence our well being, at levels over 60 dB(A) it may well be detrimental to health (Berglund and Lindvall, 1995).

Modern lifestyles have resulted in increased mobility, with more vehicles, more roads and more travelling, and although noise is associated with all human activities it is caused mainly by the various transport modes i.e. road, rail and air traffic. So noise is spreading, both in duration and geographical coverage, in European cities.

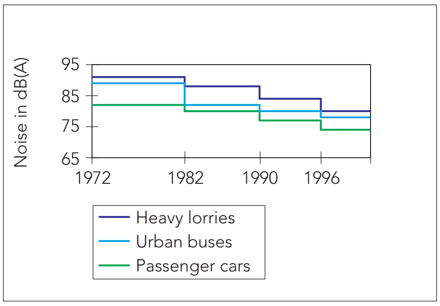
Population exposure to traffic noise is therefore unlikely to diminish significantly. This is shown by estimated projections for three European cities: Amsterdam, Madrid and Munich (Figure 3.12.9), and corroborated by expert estimates of noise reduction potential (Nordic Council of Ministers, 1994). These expert estimates suggest no significant noise reduction at speeds exceeding 60 km/hr where tyre noise is dominant; and 2 dB (A) and 1 dB (A) reductions at speeds between 0-40 and 40-60 km/hr respectively due mainly to decreased engine noise. Traffic noise exposure is expected to increase markedly in the Accession Countries from rapid growth in road traffic (including freight) and public transport decline.

New vehicle standards have a lead time of several years and require compliance by around 90% of the vehicle fleet (which can take 7-15 years) before there is a significant effect on measured road noise levels. Regulations could secure a 3 dB(A) cut in emissions from road tyre noise although the effect would not be noticeable until after 2010. Reductions in road surface noise by 5-7 dB(A), depending on the operating speed, can also be cost effective (Miljønyt, 1998).

Aircraft noise exposure at major European airports is unlikely to increase up to 2010 mainly due to phasing out of noisier aircraft, scheduled fleet renewal and noise optimisation of flight procedures and air strip geometry. At Paris CDG and Amsterdam airports, for example, significant improvement is expected with the introduction of new runways, with flight paths away from populated areas (Figure 3.12.10).

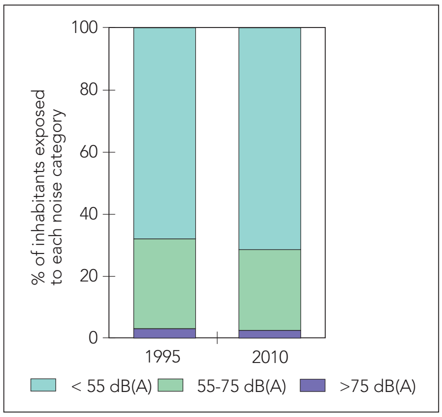
However, noise exposure may increase at European regional airports, which are

Noise-Stand: Development of EU noise standards, 1972-1996 — Figure 3.12.8



Source: European Commission

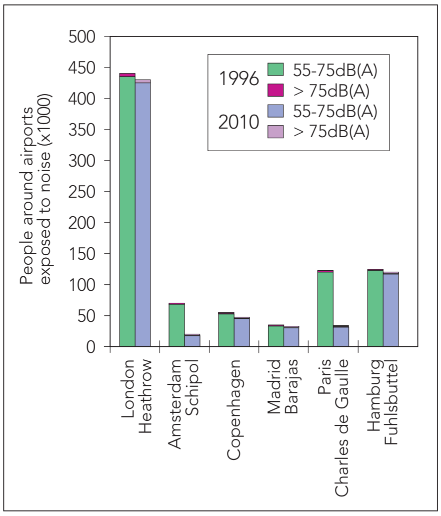
Percentage of inhabitants exposed to Ldn noise categories for Amsterdam, Munich and Madrid (1995 and 2010) — Figure 3.12.9



Estimated road traffic noise in the present and in the future situation 2010 taking into consideration traffic growth, technical developments on vehicles, tyres and road surfaces, traffic circulation plans and population developments.

Source: EEA

Population in Ldn 55, 65 and 75 dB(A) contours around the six studied airports. Existing situation and 2010 forecasts — Figure 3.12.10



Source: EEA

anticipated to accommodate a considerable proportion of the expected growth in aircraft operations, and in the Accession Countries due to air-traffic growth and more frequent use of noisier aircraft.

Ongoing research programs, in Europe and the United States, are trying to develop low-noise aircraft technology with the objective of a 10 dB (A) reduction in aircraft noise by the end of the century. However, even after new technologies are sufficiently developed to be introduced into service, it will take many years to incorporate these technologies into the commercial transport fleet.

5.3. Action to combat noise

Some local actions to deal with individual noise sources are presented for Athens and Amsterdam (Box 3.12.8). In Germany, local noise-abatement plans are enforced by national law and since 1990: 300 cities have started implementing such plans.

Nevertheless, action is also needed at European level, to supplement local and national measures – 'the local nature of noise problems does not mean that all action is best taken at local level' because 'generally the sources of environmental noise are not of local origin' (European Commission, 1996a. Box 3.12.9). Furthermore, single market requirements can inhibit national regulation, because any measures involving trade barriers will be unlawful unless they can be 'justified by considerations of public health and environmental protection' (see European Court of Justice Case C-389/96, which upheld Germany's stricter noise limits for aircraft engines than those specified in EU legislation). To date, European Community noise policy has essentially consisted of directives, primarily concerned with single market or social policy objectives, fixing maximum sound levels for vehicles, aeroplanes and machines.

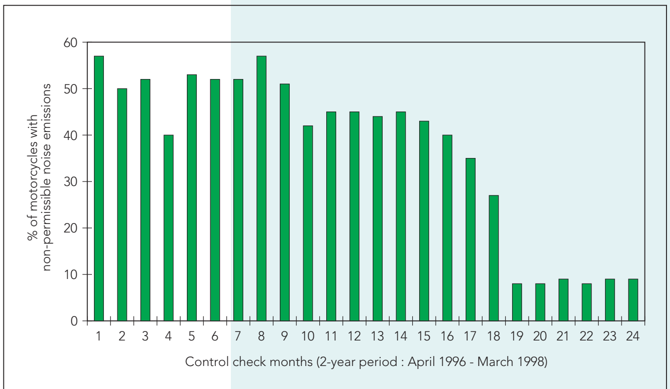
Box 3.12.8. Examples of local action

Athens urban traffic noise control

Due to car traffic restrictions on the city inner ring road many Athenians have turned to motorcycles and mopeds as their daily transport mode. The noise problems from the motorcycles and mopeds, especially due to tampering and lack of maintenance, were enormous.

As a consequence, the Ministry of the Environment and Athens Police Force jointly began spot measurement controls on motorcycle noise in April 1996. Results available until March 1998 show the potential benefit from the controls according to EU 78/1015/EEC Directive stationary motorcycle noise method.

Figure 3.12.11 **Effects of measurement control on motorcycle noise, Athens**



Apart from receiving heavy fines, offending drivers had to prove that they had dealt with the problem of their vehicle in a re-examination process usually two weeks later. The sample covered about 30 000 motorcycle checks.

The trend shows that initially (for a nine-month period) over 50% of the noise emissions were found to exceed the permissible limits. After another nine-month period the percentage had dropped to a quite constant 9% (Figure 3.12.11).

Source : Ministry of the Environment, GR

Amsterdam: Application of low noise two-layer drain asphalt on major road segments

Source : M+P Consultants

In 1996 the central city council of Amsterdam decided that when they examine renewals of major roads, they should investigate the feasibility of low-noise, two-layer drain asphalt application. Such a surface can significantly decrease traffic noise levels at low city speeds, without jeopardising safety and durability.

Until mid-1998, eight street sections of major roads, with traffic intensity of more than 15 000 vehicles, undergoing major renewal, were examined and in seven cases low noise road surface was selected, about 15 km in total. The result was that 9 000 inhabitants were exposed to noise levels 5 dB (A) less than before. It should be mentioned here that a 10 dB reduction in noise is perceived as a 50% reduction.

The costs per km, comprising the costs of the road surface, the rain-water drainage system and the yearly maintenance costs over a period of 15 years, were estimated to be about 350 000 euro. The extra costs involved are financed by the central city council.

These directives can be grouped into three main areas:

- Vehicles (and tyres): noise emissions from motor vehicles and motorcycles are covered by two directives introducing sound level limits under specified test circumstances and continuously updated to be in line with technological developments.
- Aeroplanes: this category comprises three directives. The first two, which are amended once, lay down limits on noise emissions for aeroplanes registered in the territory of Member States. The third prohibits the use of Chapter 2 (ICAO noise category) aircraft after 2002.
- Others: machinery, construction plant equipment, lawn mowers and household appliances: permissible noise emission limits and limits on the operators position.

At EU level, the basic strategic noise policy actions have been the following:

- The 5th Environmental Action Programme (5EAP): in 1993 the 5EAP set out a strategic approach by setting out a number of targets for noise exposure levels to be achieved by 2000, and outlined action to be undertaken by the major players; a recent proposal on the review of the 5EAP announced the development of a noise abatement programme for action to meet these targets. The 5EAP target of stabilisation of the fraction of EU population exposed to >65 dB(A) and avoidance of exposure to >85 dB(A), is realistically attainable, although differences between countries in procedures on noise exposure appraisal will make it difficult to assess progress in achieving the target.
- The 1996 Green Paper (European Commission, 1996a) outlining a possible step-by-step approach to the development of a new framework for Community noise policy. The orientations for the future European policy on noise and the proposed response to the Green Paper have been developed bearing in mind that the objective is to identify the noise problems and to put in place the necessary framework needed to remedy them.

Box 3.12.9. Policy developments on noise issues

The future EU strategy for noise policy (Copenhagen Conference, September 1998) is to be established in a coherent system of directives consisting of a framework directive for environmental noise and directives on noise emission: this could provide what has been missing until now, a co-ordinated approach. Working Groups have already started dealing with issues that need to be clarified and harmonised throughout Europe such as indices/indicators, dose/effect relationship, computation and measurement, noise maps, noise abatement and emission control. The following action plan was agreed:

1999	common indices/indicators proposed by Working Groups
	proposal of the Commission for a Framework directive on Noise, obligation to assess with existing methods, obligation to fix national or local targets, actions in case of exceedance of targets
2001	harmonised methods and EU targets
2002	Framework Directive in force
2006	harmonised methods in force
2006+	EU targets in force

The European Commission had to ensure that hush-kitted Chapter 2 (ICAO noise category) aircraft cannot be added to the registers of the European Union and the reason is the potentially high number of those aircraft on Third country registers. For these reasons, the EC decided to propose a directive to ensure that hush-kitted Chapter 2 aircraft cannot be added to the registers of the European Union as from 1 April 1999.

A proposal (COM (97) 680 final) has been prepared by European Commission on vehicle tyre noise, meanwhile European Commission and ISO technical groups study the modification of the standard test method for the noise production of vehicles. Other proposals such as (COM(98)46 final) deal with the emission of noise by equipment used outdoors. It is intended to replace nine existing directives for seven families of equipment and to extend the number of families of equipment to more than 50.

6. Towards an integrated urban policy?

There is now a double challenge facing policies which affect, and contribute to, urban development and planning: to promote sustainable development, and at the same time to remedy the effects of mistaken policies of the past. A supportive framework is emerging at the EU level which attempts to link effectively with national and local government policies and initiatives, and action is now needed to implement specific measures within this framework. Non-governmental organisations (NGOs), community groups, and the private sector are, indeed, active partners to ensure that policies are tailored to local needs and priorities. Furthermore, because many urban problems are universal, networking between cities, which has flourished over the past 10 years, is to be further exploited.

For the three areas highlighted in this chapter (sprawl, transport and consumption patterns), the effects of policies are overshadowed by the size of the phenomena. Initiatives currently in place are in general insufficient to curb the pressures derived from noise and energy consumption. Furthermore, they are insufficient to tackle the growing threats arising from sprawl (i.e. land use stresses and social inequities), growth in consumption (i.e. waste generation and water consumption), and transport (i.e. congestion, air pollution and noise).

6.1. Weaknesses of existing policy approaches

Policies to address urban environmental issues show serious weaknesses (see Box 3.12.10): existing measures are sectorally oriented, focusing mainly on transport and industry; cross-sectoral integration is badly needed, particularly with regard to the land use / transport interface and environmental impacts of consumption patterns (Slob *et al.*, 1996 and UNCED, 1992) (Figure 3.12.12). Policy making also requires 'vertical integration' so that responses can be tailored to unique local circumstances and priorities.

Box 3.12.10. Main weaknesses in the understanding of EU urban environmental issues

- Urban growth is inextricably linked with economic growth, although it is not clear which fuels which.
- The spatial impact of telecommunications and computerised information networks is not yet known.
- The spatial impact of policies is difficult to measure (OECD, 1996), particularly due to the lack of adequate indicators for urban areas and of area typologies (European Commission, 1997b).
- Time lags associated with air pollutants exposure impacts compound to monitoring shortcomings and knowledge gaps, and make prioritisation and targeting difficult.
- The lack of Community agreed standard methods for assessing acoustic quality seriously limits the use of current EU legislation.

At EU level, urban environmental policies still lack a common implementation framework that brings together the diverse initiatives. This reflects, in a sense, the absence of direct EU competence in urban planning which has resulted in a lack of a prioritised urban agenda – only noise- and air-related targets have been set at the EU level (EEA, 1997a).

Internalisation of external costs is under slow development for the industry, energy and transport sectors, with even less progress in withdrawal of perverse subsidies (see Chapter 4.1). Economic instruments are being aimed at behavioural change (and revenue raising in the energy, transport, and – especially – tourism sectors). Strategic spatial assessment of policies must be developed, from pioneering EU initiatives in the TENs programme and URBAN project (for transport and households, respectively).

6.2. What is the challenge ahead?

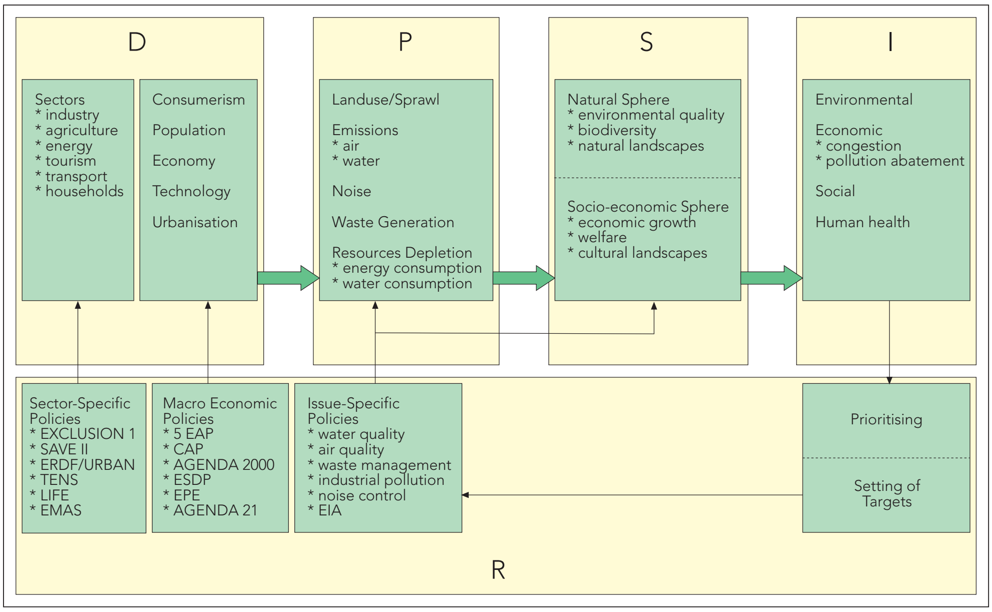
Table 3.12.6 is intended as a summary of the broadening spectrum of policy instruments, noting the trends in their application to the issues of sprawl, transport and consumerism.

Policy instruments should be geared to integrated strategic policy targets, particularly in relation to transport and land use planning. Public consensus, support and participation are of vital importance in this

Figure 3.12.12 **DPSIR for urban issues**

The EEA's DPSIR causal framework for urban stresses, showing the interconnections between driving forces [D], pressures [P], states [S], impacts [I], and responses [R]

Source: EEA



Policy instruments for urban environmental problems — Table 3.12.6

	SPRAWL		CONSUMERISM			TRANSPORT		
	land use	social inequities	waste generation	water consumption	energy consumption	air pollution	noise	congestion
award / recognition		●						●
public information / education		●	●	●	●	●		●
life-cucle analysis			●	●	●			
environmental accounting / reporting			●	●	●	●	●	
eco-audits / management	●		●	●	●	●	●	●
product labelling								
„right to know"	●							
environmental agreements			●		●	●		
demand side management								
regulatory reform	●			●				●
liability rules			●					
subsidy removal	●			●	●			
marketable permits						●		
eco-taxes / tax reform	●		●	●	●			
environmental impact assessment	●						●	
trade restrictions			●					●
ambient emissions standards						●		
licensing / permitting	●		●			●	●	
bans	●		●				●	●

The table lists policy instruments for environmental protection commonly used in OECD countries. They are listed according to their character (i.e. from regulatory measures – on the bottom – to public awareness and education initiatives – on top). It is worth noting that some measures are not initially conceived to target urban areas; nonetheless, they may bring about positive developments tangentially.

Source: EEA; EEA, 1997b

context, by enhancing a sense of partnership and common cause. The recent Aarhus Convention requires signatory nations to establish legislation which gives citizens the right to quick access to environmental information. Improved reporting on urban environmental issues will increase public interest, and participation in the development of urban environmental policy and initiatives (see Chapter 4.2).

The challenge to political leaders is to take a long-term view and ensure that urban initiatives promote social integration while optimising environmental protection. As articulated by the EC Expert Group on the Urban Environment, 'In the social field... this requires that basic services and amenities, education and training, health care, housing and employment become available to all' and that '...in the environmental field an ecosystems approach is recommended which regards aspects such as energy, natural resources, waste production and information flows as chains of activities that require maintenance, restoration, stimulation and closure in order to contribute to sustainable development'.

An increasing number of local authorities in Europe have taken initiatives to implement a Local Agenda 21 and about 400 European local governments have adopted the Charter of European Cities and Towns, which emphasises integrated approaches towards sustainability and the need for better networking and collaboration between European cities. The Charter calls for action in the following four areas:

- promoting economic competitiveness and employment;

- favouring economic and social cohesion;
- improving transport and Trans-European Networks (TENs);
- promoting sustainable development and the quality of life.

While there are numerous local 'sustainable city' initiatives across Europe they remain pilot projects. The question is whether the environmental and social imperatives of these models can be politically viable and whether meaningful participatory and consensus-based approaches can be sustained in the long-run.

6.3. Urban policy initiatives at European level

It can be said that the EU has had several urban policies, as numerous European Commission services have attempted to address urban issues in their individual programmes. But the need to consolidate efforts into a single framework for strategic action for urban policy was noted in the Commission's Mid-term review of its Fifth Environmental Action Programme.

The 1990 *Green Book on the Urban Environment* (European Commission, 1990) marked the start of efforts to establish an urban dimension of EU environmental policy. Numerous initiatives followed, notably the establishment of the EC Expert Group on the Urban Environment in 1991, the initiation of the European Sustainable Cities Project in 1993, the launch of the European Sustainable Cities & Towns Campaign in 1994, and the May 1997 Communication on the urban agenda (European Commission, 1997c) (see Box 3.12.11). The EC Expert Group has already prepared an comprehensive response to the Communication which together with numerous other documents can be found on the Internet:

(*http://www.inforegio.org/wbdoc/docoffic/communic/ville/home_en.htm;*

and the EC Expert Group response:

(http://europa.eu.int/en/comm/dg11/urban/respons-en.htm).

In parallel, the European Spatial Development Perspective (ESDP) has been under development for over seven years through a concerted effort by Member State ministers responsible for spatial planning and EC authorities (see Chapter 2.3). Recognising the growing interdependence between geographic areas, sectoral policies and the various levels of government resulting from the social and economic changes in Europe, the ESDP aims to integrate the goals of economic and social cohesion, sustainable development and balanced competitiveness in the European territory. It is intended as a shared vision of the European territory as a whole, a reference framework for action.

The recognition of the importance of cities and towns in offering quality of life for European citizens has grown alongside these initiatives, with for example, the introduction of the Community Initiative URBAN and the recent commissioning of work on an Urban Audit to measure the quality of life in European cities and towns.

References

Berglund, B. and Lindvall, T, 1995. *Community noise!* Document prepared for WHO. Stockholm University and Karolinska Institute, Archives for the Center for Sensory Research, Vol. 2, Issue 1.

ECF, 1998. *Transport demand study for European Commission, DG VII*. European Cyclists Federation. Brussels, Belgium.

ECMT/OECD, 1997. *Social Costs of Transport*. European Conference of Ministers of Transport – Organisation for Economic Co-operation and Development. Paris, France.

ECTF, 1997. *Sperimentando Oggi il Lavoro di Domani*. European Community Telework/Telematics Forum. Comune di Roma, Rome, Italy.

EEA, 1997a. *An Inventory of European Policy Environment Targets and Sustainability Reference Values*. European Environment Agency, Copenhagen, Denmark.

EEA, 1997b. *Environmental Agreements: Environmental Effectiveness.* European Environment Agency, Copenhagen, Denmark.

EEA, 1998a. *Europe's Environment: The Second Assessment*. European Environment Agency. Copenhagen, Denmark.

EEA, 1998b. *Europe's Environment: Statistical Compendium for the Second Assessment*. European Environment Agency. Copenhagen, Denmark.

EEA, 1998c. *Urban Air Quality*. European Environment Agency. Copenhagen, Denmark.

EEA, 1999 (Forthcoming). *Environment and European enlargement. Appraisal of future trends: agriculture & transport* (working title). Scenarios and prospects n° 2. Technical report. European Environment Agency.

Eerens, H.C., Sluyter, R., Kroon, I.C., Oss, R.F. van, Hootsen, H., Claesens, E., Smeets, W., Hammingh, P., *Urban Air Quality in Europe: 1990-2010.* RIVM Report #481505001, Bilthoven, the Netherlands.

European Commission, 1990. *Green Book on the Urban Environment* European Commission, Brussels, Belgium.

Box 3.12.11. Recent policy framing developments

European Sustainable Cities (Report by the Expert Group on the Urban Environment, European Commission, 1996b).

The report is one of the main outputs of the Sustainable Cities Project and focuses on the application of the concept of sustainability to urban areas. It is not only concerned with cities but also urban settlements of different scales, and it embraces the question of the sustainability of urban regions and of the urban system as a whole.

The report has an institutional as well as an environmental focus. It is concerned with the capacity of local governments to deliver sustainability. It recognises the importance of capitalising upon the good general management practices now increasingly characteristic of local governments in Europe. The report stresses that successful progress is dependent upon active involvement of local communities and the creation of partnerships with the private and voluntary sectors within the context of strong and supportive government frameworks at all levels.

Towards an urban agenda in the European Union (Communication from the Commission, COM(97)197 final).

This document examines the possibilities for improving urban development and for increasing the effectiveness of existing Community intervention in urban areas. It is pointed out that the intention is not to develop Europe-wide policies for matters that are best dealt with at a local or regional scale. However, it is clear that the European urban areas are facing a number of common problems, and there are thus opportunities at the European scale to share and to facilitate potential solutions. One of the document's main points is that much can be achieved through a more focused approach using existing instruments at national and Community level and enhancing co-operation and co-ordination at all levels.

Two additional elements are emphasised: first, the challenges related to urban development provide an opportunity for the EU to become a more meaningful body for its citizens by bringing tangible benefits to daily lives. Second, cities play a crucial role in underpinning a European model of society, based on equal opportunities regardless of gender and ethnic origin. Urban authorities cannot be the sole agencies to act on these issues, but their active participation is paramount.

Agenda 2000: For a Stronger and Wider Union (European Commission, 1997).

Agenda 2000 maps out the Commission's views on the way in which the EU should address the major challenges of the next 10 years. It reaffirms the centrality of economic and social cohesion to European policy and points out that, with the prospect of enlargement to countries whose levels of prosperity are below those of the poorest Member States, even greater efforts will be needed to promote cohesion.

Although urban polices are not as such discussed in the Agenda, for the first time there is clear recognition that any measures aimed at promoting social and economic cohesion also need to specifically address the urban environment. With the current growth of urban areas, the social economic and environmental problems in these areas are increasing as well. The kind of key issues that Urban Pilot Projects address, such as high unemployment, social exclusion and environmental decay, are given prominence in European policy. Agenda 2000, through several structural measures such as Objective 2 and the Article 10 ERDF programme, offers the possibility to improve the quality of life of citizens in European cities.

Sustainable Urban Development in the European Union: a Framework for Action (COM (98) 605 final)

Sets out a Community strategy to:

- increase the effectiveness of environmental policies within an urban perspective;
- foster an integrated urban development.

To this end it relies on four basic pillars:

- strengthening economic prosperity and employment in towns and cities;
- promoting equity, social inclusion and regeneration in urban areas;
- protecting and improving the urban environment;
- contributing to good urban governance and local empowerment.

The Commission's triennial report on economic and social cohesion will serve to assess progress in the implementation of the framework for action.

Source: Williams, 1996; European Commission, 1997d, 1998c

European Commission, 1995. *Towards and Efficient Pricing in Transport – Policy Options for Internalising the External Costs of Transport in the European Union – Green Paper COM(95)691 final*. European Commission. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1996a. *Future Noise Policy – Green Paper* European Commission COM(96)540 Final, Brussels, Belgium.

European Commission, 1996b. *European Sustainable Cities*, Expert Group on the Urban Environment. European Commission. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1997a. *Territorial planning and the information society (ECSC – EC – EAEC).* European Commission. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1997b. *Meeting of Ministers Responsible for Spatial Planning of the Member States of the European Union: European Spatial Development Perspective*. European Commission. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1997c. *Towards an urban agenda in the European Union*. European Commission, Brussels, Belgium.

European Commission, 1997d. 'Agenda 2000 and Urban Issues'. In *Urban Pilot Projects Newsletter* winter, 1997. European Commission, Brussels, Belgium.

European Commission, 1998a. *Territorial breakdowns and terminology to be used in urban statistics in Eurostat*. European Commission. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1998b. *Transport in Figures*. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1998c. *Sustainable Urban Development in the European Union: a Framework for Action (COM (98)605 final)*. European Commission. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1999 (Forthcoming). *Economic assessment of priorities for a European Environmental Policy Plan* (working title). Report prepared by RIUM, EFTEC, NTUA and IIASA for Directorate General XI (environment, nuclear safety and civil protection).

Ginés, F.R., i Noguer A.P., Nogués, H.B., 1997. *Greenhouse effect reduction possibilities in Barcelona with specific reference to waste management,* F:R: Ginés*; Barcelona's Water* Flow*: a tool for environmental analysis,* A.P. i Noguer; *the Energy flow of Barcelona: analysis and environmental sustainability,* H.B. Nogués. Paper presented at the Nagoya Conference, November 1997.

Graham, S. and Marvin, S., 1996. *Telecommunications and the City*. Routledge Publishers. London, UK.

Kunzmann, K., 1997. 'Contemporary Challenges to European Spatial Planning'. In *Nordic Centre for Spatial Development* No 8, 1997. Stockholm, NordREFO. Sweden.

Miljønyt, 1996. 'Begraensning af trafikstj' Trafikminsteriet, COWI, nr 30.

Nordic Council of Ministers, 1994. 'Vehicle noise emissions in the time period up to year 2010' , Expectations of a Nordic Group of Experts, TemaNord 512

OECD, 1996. *Innovative Policies for Sustainable Development – The Ecological City*. Organisation for Economic Co-operation and Development. Paris, France.

OEIL, 1997. *Road Congestion Costs in the Paris Area*. Observatoire de l'Économie et des Institutions Locales, Université Paris XII. Paris, France.

Quinet, 1993, 'The social costs of transport : Evaluation and links with internalisation policies' ECMT/OECD P31-76, Paris

Slob *et al*., 1996. *Report on a Study for VROM on Trend-analysis Consumption and Environment*. The Dutch Ministry of Housing, Spatial Planning and the Environment. The Hague, the Netherlands.

Soulé, M. E., 1991. 'Land Use Planning and Wildlife Maintenance'. In *American Planning Association Journal* No 3, Summer 1991. Chicago, USA.

UN/ESA, 1997. *Urban and Rural Areas 1996*. United Nations Department of Economics and Social Affairs, Population Division. New York, USA.

UNCED, 1992. *Agenda 21*. United Nations Conference on Environment and Development. Conches, Switzerland.

WHO, 1997. *Healthy Cities Indicators: Analysis of Data from Cities across Europe*. World Health Organization, Copenhagen, Denmark.

Williams, R., 1996. *European Spatial Policy and Planning*. Paul Chapman Publishing. London, United Kingdom.

3.13. Rural areas - our link to the land

Rural areas in the EU (80% of the territory and approximately 25% of the population) have undergone and are undergoing major adjustments. These changes are partly the result of agricultural policies, but there are other driving forces (spatial and sectoral) which affect rural areas – in this context EU and national policies for regional development, tourism, forestry and transport are particularly important. Additionally, rural areas close to major urban centres are still showing progressive urbanisation trends (Map 3.12.3, Chapter 3.12). The environmental impact of these different policies and trends is expressed in terms of land use and landscape changes, environmental pollution, changing demographics, reduction in agricultural employment, biodiversity loss, and diversification of the rural economy.

To many observers it is now clear that the long-term viability of rural areas and the rural environment can no longer be achieved simply by support for agricultural production or through compensatory measures alone. Rural policies need to take a multi-sectoral approach within a territorial or spatial framework and to pay attention to other internal and external trends which interact in a dynamic way.

1. The changing nature of the rural world

1.1. What is 'rural'

A number of principle features generally associated with each type of rural area can be identified, derived from Europe 2000+ (European Commission, 1994) and the OECD classification (OECD,1994a) (Table 3.13.1) (see Box 3.13.1).

An important factor in defining 'what is rural' is the importance of small and medium-sized towns as factors within the rural economy. The interplay between these smaller urban centres and their rural hinterland is vital for both, yet there is still a tendency to treat them as discrete homogenous units within a territorial space.

There are various definitions and classifications of rural areas but no agreed EU categorisation; most Member States use classifications based on socio-economic criteria.

1.2. What drives the changes?

Rural areas are extremely diverse in nature and character – for example with respect to land use and economic development – and are subject to a variety of different pressures and societal trends, although public policies do not always acknowledge this (Sallard, 1998). The impact of highly centralised sectoral policies in this context varies widely as do the environmental consequences, and analysis of these trends in rural areas to date has tended to be contained within global discussions on the impact of agricultural policies and practices or the effects of urbanisation, forestry, tourism and economic development. This has ignored the underlying territorial dimension of such trends and impacts.

Their effects on rural areas cannot be uniformly characterised nor can they be examined in isolation as they invariably interact with each other, the impact of which can only be observed at a regional or local level.

The impacts of agricultural policies on farming practices are manifested in changing demographics, economic activities and land use (section 2.1 below), or in terms of impacts on environmental media such as soils and water (section 2.3 below), and nature/biodiversity (see also Chapters 3.5, 3.6 and 3.11).

Principal features generally associated with rural areas based on spatial and functional issues — Table 3.13.1

Predominantly rural regions	Significantly rural regions	Predominantly urban regions
high relative importance of agriculture	agriculture is the main form of land use	intensive agriculture
low productivity	variable productivity	high productivity
high biodiversity	fragmented habitats	urbanisation
shifts in land-use to forestry, tourism and non-farm activities	diversification away from farming	recreation
remote in time or space	stable/variable population	growth in traffic flows
decreasing and ageing population		increasing/stable population

Source: after European Commission, 1994 (Europe 2000+); OECD, 1994a; and Hengsdijk, 1990

Box 3.13.1 Defining 'Rural'

The European Commission regards **'rural areas'** as a spatial phenomenon that extends across regions, landscapes, natural areas, agricultural land, villages and other larger urban centres, pockets of industrialisation and regional centres. It encompasses a diverse and complex economic and social fabric. It is the home of a great wealth of natural and cultural resources and traditions. It is becoming more important as a place for relaxation and leisure activities. This definition illustrates the breadth of the issue, but is not useful from an analytical point of view.

Both the OECD and EUROSTAT define rural areas in terms of population density. For the OECD, rural areas are those with less than 150 inhabitants/sq. km while EUROSTAT uses a figure of 100 inhabitants/sq. km.

In its report *Europe 2000: Co-operation for European Territorial Development (1994)*, the European Commission attempted to describe changes and trends in rural areas on the basis of dominant activities or characteristic spatial features:

Rural areas close to highly urbanised areas – characterised by:

- residential, recreational, industrial overspill
- growth in population
- intensive agriculture
- growth in traffic flows.

Rural areas used for tourism – characterised by:

- predominantly coastal and mountain areas often equipped for mass tourism
- reduction of agricultural activity
- development of agglomerations
- fragmentation of habitats.

Rural areas with diverse activities – characterised by:

- continuing highly dependence on agriculture
- development of complimentary activities.

Rural areas that are predominantly agricultural – characterised by:

- agriculture either highly productive or efficient
- traditional or weak with low productivity.

Rural areas where access is difficult – characterised by:

- areas of mountains, islands, forests
- high out-migration
- inward migration of retirees/second homes.

While providing a trends-oriented characterisation of rural areas, it does not provide a specific spatially referenced context for analysing trends in economic, social and environmental issues in rural areas.

To try to address this, the OECD has developed a classification of rural areas based on the **percentage of the population of a country living in rural communities**. Essentially, three broad classes of rural areas or regions have been distinguished. Predominantly rural (>50% of the population living in rural communities), significantly rural (15% – 50% of the population living in rural communities) and predominantly urban (<15% of the population living in rural communities). This classification can be spatially referenced with a reasonable degree of accuracy throughout the European Union and has been used to analyse a variety of socio-economic trends.

EU Regional policies including Less Favoured Areas (LFAs – see box 3.13.2)) payments, are focused on promoting economic and social cohesion and reducing regional disparities in terms of specific economic and physical indicators such as water supply, transport and telecommunications.

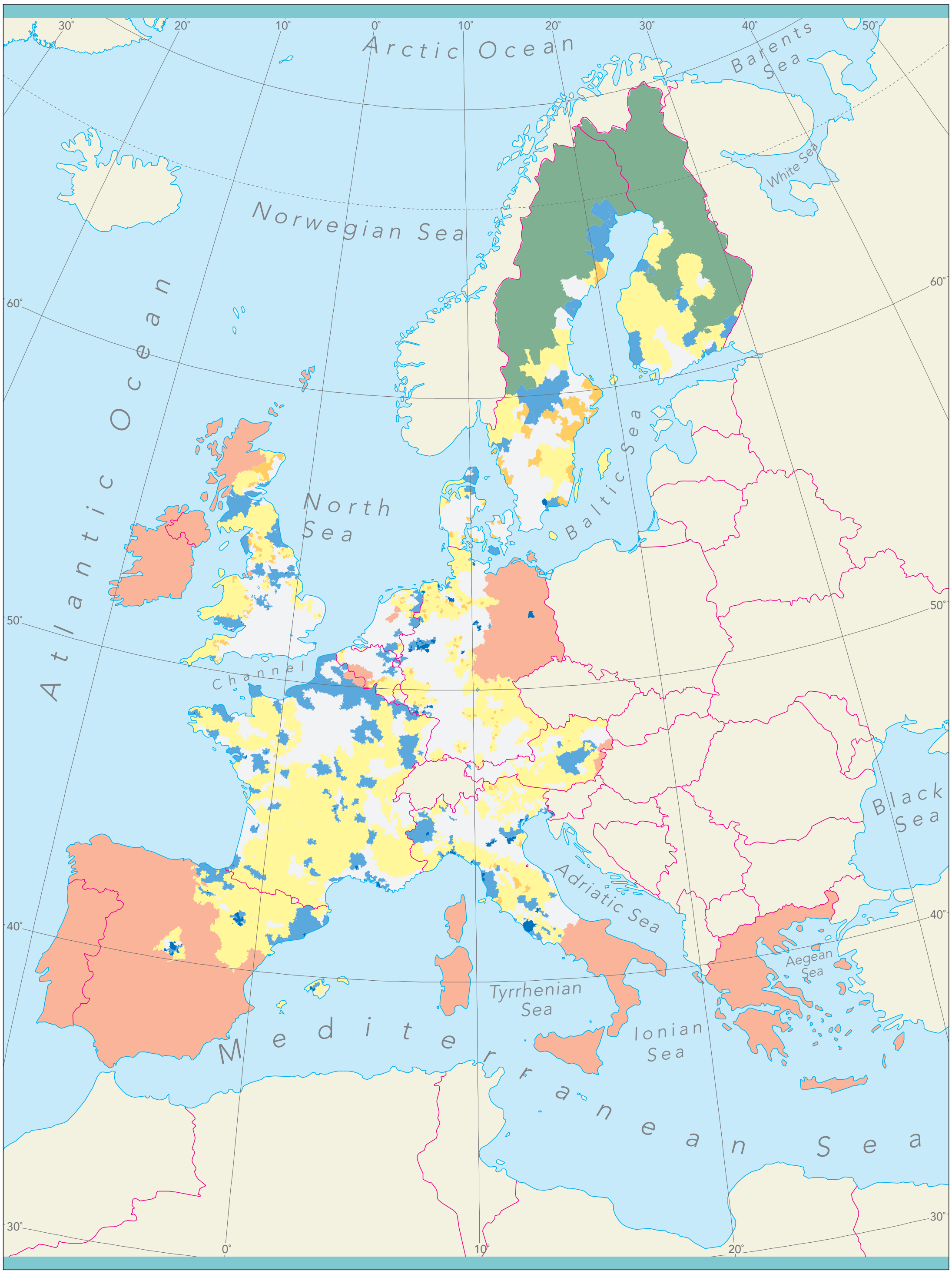
Rural areas and rural development are also an important part of the EU's regional policy instruments, the Structural Funds, and are included in specific, territorially defined regional objectives (Map 3.13.1). Altogether these objectives cover nearly 75% of the territory of the EU and almost 35% of the population (European Commission, 1997a).

Box: 3.13.2 Less Favoured Areas – a definition

Set up in 1975, the Less Favoured Areas (LFAs) schemes provide 'compensatory allowances' to farmers in mountainous areas or in other areas where the physical landscape results in higher costs. In future, LFA schemes will also cover areas subject to specific environmental constraints, ensure greater coherence with environmental needs and contribute to enhancing biodiversity.

EU transport policies including the Trans-European Networks (TENs) have the potential to affect rural areas in both socio-economic and environmental terms. By creating or improving linkages between major urban or economic centres and dynamic regions, these networks could encourage the 'emptying' of the countryside. Conversely, they could increase trends in commuting and actual migration of population into rural areas. Both of these trends have environmental consequences.

EU environmental policies are becoming more important in rural areas particularly with respect to the protection of important biodiversity resources and water resources management. For example, the designation of protected areas – such special protection areas (SPAs) under the Birds Directive (79/409/EEC) and special areas of conservation (SACs) under the Habitats Directive 92/43/EEC) are designed to protect and



Map 3.13.1

The most relevant of these objectives from a rural areas perspective are:
- Objective 1, applying to regions which are lagging behind economically, with a GDP of less than 75% of the EU average;
- Objective 5a providing support for downstream processing of agricultural produce as well as investment aid and compensatory allowances in less favoured areas;
- Objective 5b, applying to rural areas with a low level of socio-economic development, high dependency on agricultural employment, low agricultural incomes and population problems (low density or declining population);
- Objective 6, applying to regions north of the 62nd parallel with a very low population density (<8 inhabitants/sq. km).

Source: European Commission

conserve important areas of biological diversity that are either greatly reduced or are under threat from human activities. These policy instruments can have significant implications for agricultural and forestry practices. However, it is possible to view them positively within a broader multi-functional approach to agriculture. For instance, while being less specific than the Directives mentioned, agri-environmental measures (see section 3 below) and measures in LFAs contribute on a broader scale to the preservation of landscapes and semi-natural habitats.

The full implementation of such measures will mean that large areas of the territory of the European Union (and ultimately the prospective Accession Countries) are influenced by specific environmental or agri-environmental policies. The implications of this is variously seen as being a constraint and an opportunity for rural areas within the Member States, depending on their agricultural situation and existing land use policies.

Figure 3.13.1 **Employment structure in European rural areas**

Source: OECD, 1996

2. The effects on the rural environment

2.1. The regional diversity of Rural areas

2.1.1. Population
Nearly 17.5% of the EU's working population live in rural communities, of which about 10% live and work in pre-dominantly rural areas while about 60% live in predominantly urban areas which represent less than 16% of the EU territory. In recent years there has been a continuing decline in the population of predominantly rural areas, while in predominantly urban areas and some intermediate areas population levels have been generally stable (European Commission, 1997a).

The proportion of the population living in rural communities varies from less than 10% in the Netherlands and Belgium to over 50% in Sweden and Finland. Some countries – notably Spain, France and Italy – have large populations categorised as 'significantly rural', or – especially in Ireland, Portugal and Greece – a population distribution which displays a strong urban/rural dichotomy (OECD, 1996).

These differences in population trends are closely related to the changing nature of rural economy and the changing nature of the rural-urban interface. Enhanced mobility is the key factor with regard to the latter in significantly rural and predominantly urban regions (see Table 3.13.1).

In areas with rising populations and rapid economic growth, increased pressure on environmental resources is observed in the form of waste generation, increased water and energy consumption and declines in air quality largely from growing traffic movements. In declining areas it may result in abandonment of land, shifts in land use (e.g. towards forestry) and possible loss of traditional landscape management practices with consequences for the cultural and natural heritage.

2.1.2. Economic activities
Being 'rural' is not synonymous with economic decline. Rural development paths can take many forms and that the dynamics of rural areas are more complex than would first appear. While some rural areas still struggle with agricultural restructuring and population decline, others have been more successful in re-organising agricultural production or have continued to develop their agri-foodstuffs sector. Other areas are benefiting from the re-location of enterprises and population away from congested urban areas to rural areas (Sallard, 1998).

The agri-foodstuffs industry is an important employer in rural areas of the EU (and in the EFTA and Accession Countries), accounting for 7.9% of the jobs in industry and over 2.3% of the total level of employment within the EU in 1996 (EUROSTAT, 1997).

This industry is particularly important in the UK, France, Greece, the Netherlands, Denmark and Ireland and its continued development will promote agricultural activity and rural employment.

The rural economy is increasingly concerned with non-agricultural sectors (industry and services) which are experiencing strong employment growth. Agriculture now accounts for only 5% of employment in the EU (EUROSTAT, 1998), although the proportion is much higher in predominantly rural areas in Spain, Ireland, Greece, Portugal and Italy (OECD, 1996). There has been a net increase in employment in all non-metropolitan regions with the exception of Greece and Finland where employment growth is still strongest in metropolitan areas. These trends in employment are closely correlated with changing demographic trends. Fig 3.13.1 shows the situation in predominantly rural areas where at least every second job is in the service sector (OECD, 1996).

Tourism is emerging as the new 'cash crop' for rural areas, and as an alternative to farming employment (as for example in the Alpujarras region of Spain – Sharpley & Sharpley, 1996). Such trends could have implications for continued traditional farming practices related to nature conservation and landscape management.

2.1.3. Land use

Agriculture accounts for over 40% of the total land area within the EU. Forestry accounts for a further 36%. Despite being a minority activity, agriculture still retains a dominant role in relation to land use and the appearance of the countryside. However, over the past 20 years, the area of land in productive agriculture fell by 5% while at the same time there has been a small increase in forested land. Much of the land lost to agriculture has been through urbanisation and – in marginal areas – by abandonment of land (Chapter 2.3).

Over the years, trends related to agricultural policy – intensification, marginalisation, specialisation and concentration – have resulted in an increasing spatial differentiation of rural areas in terms of economic, social and environmental outcomes.

In terms of concentration and intensification, the most striking spatial feature is the fact that 80% of the EU's intensive agricultural production occurs in coastal areas of the North Sea and the English Channel, in a corridor stretching from Brest to Copenhagen and around Rouen and Rotterdam (IEEP, 1998). Why has this happened? A combination of physical, biogeographic and economic factors have essentially conferred a substantial competitive advantage on these regions from an agricultural point of view. This combination has also had environmental consequences in terms of water, soils and biodiversity.

Marginalisation is another consequence of current and expected agricultural developments. This has spatial consequences inasmuch as the most vulnerable areas are regions with extensive agricultural systems such as the *dehesas* and *montados* in Spain and Portugal, as well as regions with a pre-dominance of small-scale farm holdings such as Western Ireland, Scotland and Wales (Baldock *et al.*, 1996). In some predominantly rural areas, the problem is further compounded by out-migration to urban centres, often permanently. This has consequences for the remaining population (usually the aged), the maintenance of essential social services and environmental and landscape management. These phenomena frequently occur in mountain areas (Chapter 3.15).

In the future, climate change could further distort the impact of agricultural practices on rural areas. Extension of growing seasons, climate variability and changes in productivity are all predicted to affect agriculture (EEA, 1998) with consequent effects on the nature and shape of rural areas.

Alongside the changes in agricultural practices which have affected agricultural land use, urban growth and afforestation are contributing to the shifting land-use pattern in rural areas in most EU Member States.

The EU forest area is currently stable or even increasing in some countries (for example in Ireland, the forest cover is now almost 9% – up from 1% at the turn of the century). Much of the forest area is managed as exploitable forest (wood and non-wood products and services). The accession of Austria, Finland and Sweden has made the EU the world's second-largest paper and sawn-wood producer and the third-largest exporter of forest products.

2.2. Opportunities and threats

2.2.1. Rural-urban interface

Urbanisation, with increases in built-up area/capita (see Chapter 3.12), has various causes and impacts. Employment has increasingly concentrated in towns, with centralisation of services to the rural hinterland, thus contributing to increased urbanisation. The changing population patterns (reflecting the changing economic situation in rural areas) and the changing nature of the rural-urban interface are leading to enhanced mobility and differential development whereby some urban settlements in rural areas are doing well but others are doing very badly (Bryden, 1996).

Mobility has become a key factor: commuting enables workers in cities to derive the perceived benefits of living in the 'unspoilt' countryside. However, migration to rural areas extends urbanisation, leading to fragmentation of open areas and loss of typical rural functions dependent on a high degree of continuous open countryside, such as extensive agriculture or nature conservation. Furthermore, the associated infrastructure requirements generate environmental impacts including air pollution, fragmentation of habitats and greenhouse-gas emissions.

In areas remote from large urban centres, mobility is also a factor – but not just for work. Public transport provision in such areas tends to be much more limited than in urban areas and has resulted in car ownership increasing in rural areas. The car is thus important for access to work, shopping, services and communication in these areas.

The advent of 'teleworking', and its active promotion, may act as a countervailing trend to increased commuting but is unlikely to lead to significant reductions in car use or the need to travel (see Chapter 3.12).

2.2.2. Tourism and recreation

Rural areas are increasingly the playground for a growing urbanised population, providing a stress-relieving setting for tourism, recreation and leisure pursuits.

Rural tourism in the 1990s is very different from its romantic 19th-century past when writers such as Wordsworth and Schiller captured the rural scene. Far larger numbers of people are involved, and their penetration into the countryside is far greater. The spread of car ownership, and the improvement of road networks, have been important (OECD, 1994b).

Rural areas can benefit from tourism as an alternative income source and a means of maintaining population and labour. However tourism and recreation also require provision of infrastructure (such as roads and water supplies) which comes at a high cost due to excess capacity for the large part of the year outside the holiday season. Furthermore, as the trend towards activity holidays increases, environmental impacts are unavoidable in some rural areas as tourists tend to scatter over larger and often sensitive areas. These are particular concerns in mountain and coastal areas (see Chapters 3.14 and 3.15) where tourist and recreation activities tend to be more concentrated.

2.2.3. Energy and rural areas

The European Commission's policy objectives include an increase in the share of energy from renewable sources, which should account for 12% of EU energy supply by the year 2010 (European Commission, 1996a). Agriculture and forestry will make an increasing contribution, especially through the use of energy crops for biofuels such as oil-seed rape. The estimated requirement of such biofuels would be 18 Mtoe, to be grown on some 11.5 million hectares of land. This could present a promising opportunity for rural areas in terms of agricultural activity and other economic activities related to energy production, although a substantial increase in energy prices would be needed if bio-energy is to be seriously competitive with fossil fuel energy.

At present, an estimated 60% of energy crops are being grown on set-aside land as non-food crops. These crops include oil-seed rape, sugar/starch crops and woody stemmed crops such as willow and poplar. With the Council conclusion (March 1999) to place the set-aside rate at zero from 2002/2003 onwards and given the present uncompetitiveness of bio-energy, developing the non-food sector would need to be combined with appropriate fiscal measures. The value added for rural areas is not simply in terms of the production of raw material but also in terms of processing and energy production either as electricity or as steam/heat for local or district heating. This will also have a positive employment benefit for rural areas.

Energy is also produced from the digestion of farm slurries (26 Ktoe in 1996) and from agri-food industry effluents (103.2 Ktoe in 1996). In rural areas where intensive livestock rearing is practised and where available land for disposal of animal manure is limited, this alternative form of disposal and production of energy has potential to generate revenues and reduce environmental impacts.

Fuelwood production within the EU is increasing steadily (16% between 1991 and 1995), and forests have potential as a source of energy, either by short rotation plantations or by the use of forest residues and available low-quality wood (European Commission, 1995). Higher prices of energy from fossil sources and technological advances may make it more possible for rural communities to set up and run their own power generation companies based on renewable energies or waste to energy (this has been the subject of pilot projects supported by the LEADER II programme – see section 3 below).

Any increased use of biomass and fuelwood will tend to reduce carbon dioxide emissions. However, it will be important to avoid any negative environmental impacts that could result from restructuring of rural land holdings or conversion from agricultural land that may be required to facilitate increased biomass or fuelwood production.

Localised generation from renewable sources may reduce requirements for energy transmission infrastructure, thereby benefiting the rural environment. High-tension power lines and their support pylons often detract from the landscape value of sensitive areas, and are also a hazard for bird life especially where they cross migratory routes. It has been estimated that up to 15 birds per pylon per year are killed by power lines (IFEN, 1994).

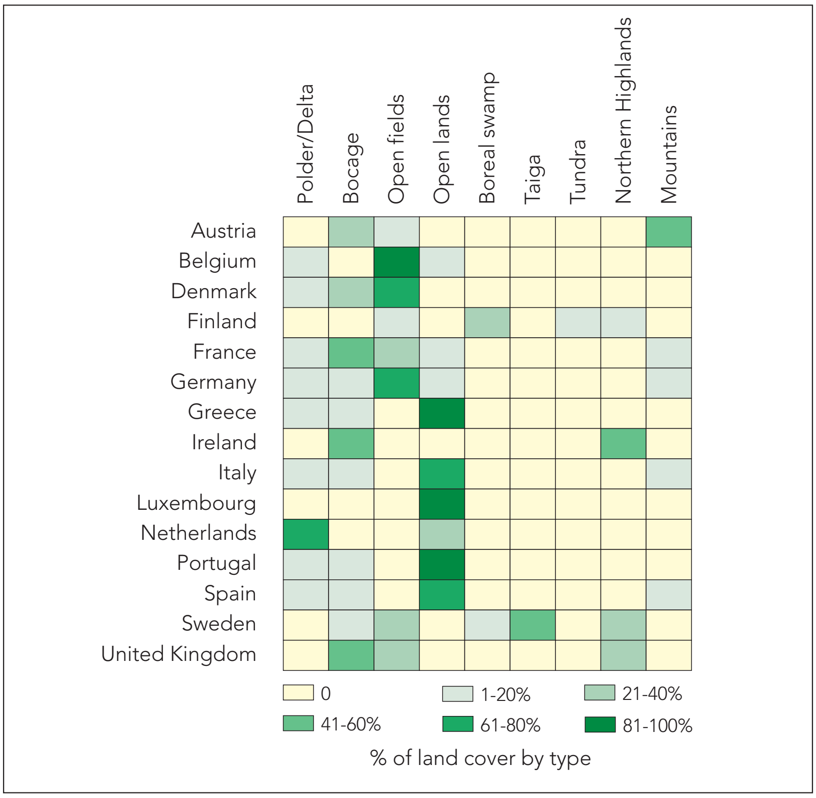
2.3. What is the environmental situation in rural areas?

The environmental characteristics of rural areas vary across Europe, although regions do share broad biogeographical characteristics which determine the nature of their response to environmental pressures and impacts (the subject of environmental and sustainable development indicators for rural areas being developed at EU and OECD level).

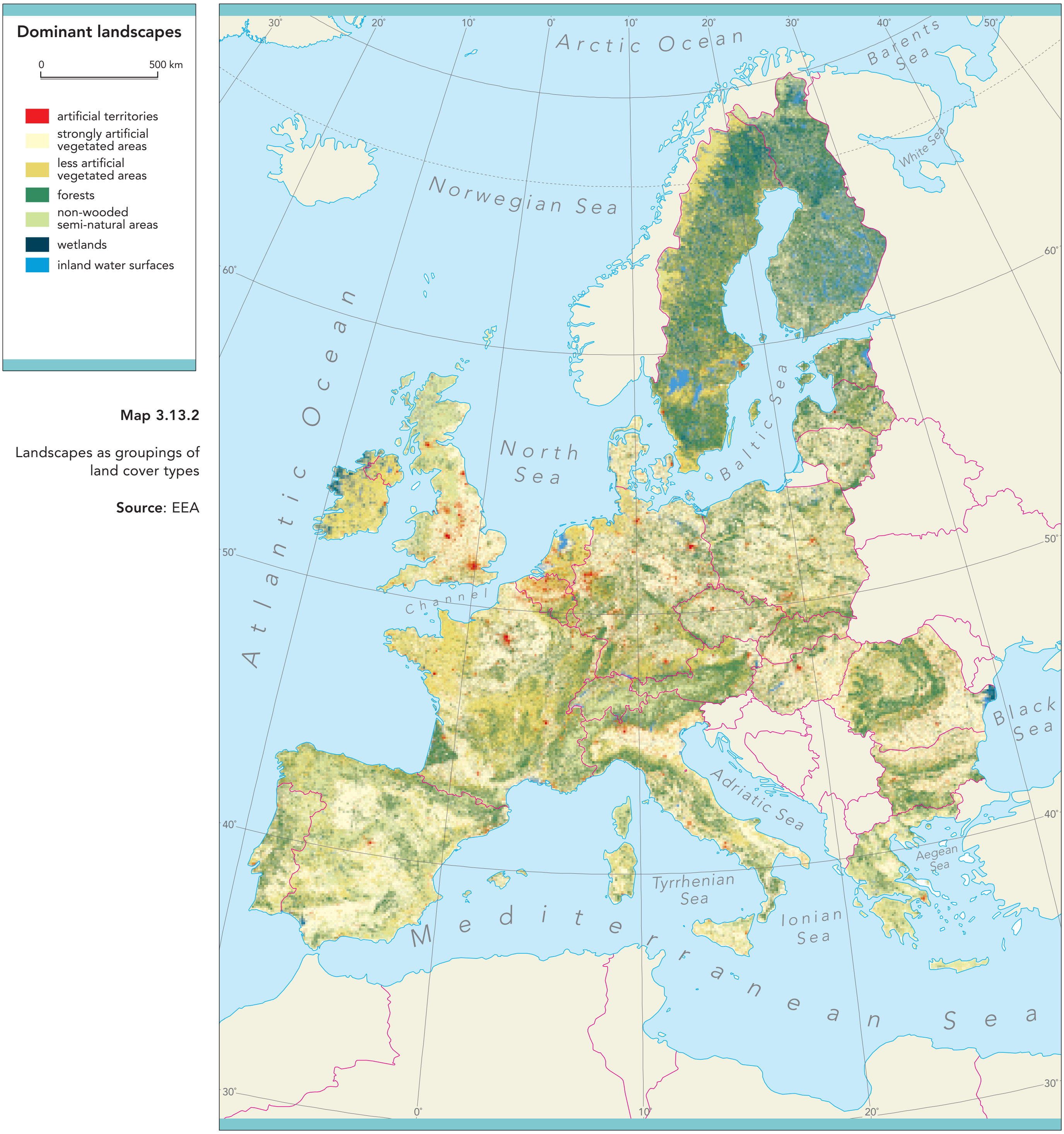
2.3.1. Landscapes

Rural areas in Europe provide a rich diversity of landscapes whose primary characteristics have been shaped over time by geomorphological, climatic and biological processes, and influenced by human activities since the Neolothich Period, when the first farmers started cultivating and opened the first clearings in the great forests. Beginning early in southern Europe and spreading over several thousand years towards the north and north west, this resulted over time in the wide range of landscape types (Figure 3.13.2) which we live in today, from the distinct open-field landscapes of France, Spain, Ireland, UK and northwest Europe to the Taiga and Boreal Swamp landscapes of Finland and the highly composite dry Mediterranean or forest-dominated central European landscapes (Map 3.13.2). Only very few of these landscape – the most remote – are still in a near-natural state. For the vast majority, cultivation, urbanisation and big infrastructure have moulded today's landscapes over the geomorphological forms, based on the possibilities set by soil, climate and natural biodiversity. In rural areas the cultivation pattern developed over centuries, with extensive cultivation as the basis for the present variety of biodiversity and scenic features, which in many ways grow to be richer and more varied than their totally natural state (ECNC, 1998). But the relatively high nature value of many cultivated landscapes has been under severe pressure for several decades, developing in general towards more uniform, less complex and composite landscapes (Box 3.13.3 & 3.13.4). Present pressures are even more dynamic, but now the intensification of landscapes in many

Dominant landscape types within EU rural areas Figure 3.13.2



Source: EEA



Map 3.13.2

Landscapes as groupings of land cover types

Source: EEA

areas is accompanied or substituted by land abandonment and afforestation (see also Chapters 2.3 and 3.11).

Traditional agricultural systems call for a considerable input of skilled work, to manage grazing systems and maintain features such as stone walls and hedgerows. With the decline in traditional farmland management, the shift towards mechanisation and more intensive production systems, coupled with a decline in the numbers of those working the land, many of these 'cultural' landscape features are being lost.

Agriculture and forestry are the main caretakers of rural landscapes. Its continued usage in a well-adjusted way is a pre-requisite for maintaining its environmental worth (European Commission, 1997b).

2.3.2. Forests in the rural landscape
Forests are an important part of the European landscape of rural areas in their own right as they fulfil multiple roles in terms of timber production, recreation, hunting and as an important reservoir for wildlife (Box 3.13.5). Forest cover varies considerably between EU Member States, ranging from

9% in Ireland to 71.3% in Finland (Map 3.13.3). Those Member States with a large percentage of forest cover (Finland, Sweden, Germany and France) have tended to develop multiple-use approaches to the forest resource and to see forests in the wider context of landscape and biodiversity. Other Member States (Ireland and Spain), in seeking to extend their forest cover rapidly for either commercial or watershed-management purposes, have often run into conflicts over the landscape impact largely related to the loss of open field or moorland landscapes and the planting of monocultures of coniferous trees. Denmark is looking towards doubling its present 12% forest area to around 25% by mid-2000.

Box 3.13.3 Main threats to European landscapes (see also Chapter 3.6)

According to Luginbuhl (1998), landscapes are undergoing radical transformation as a result of six main trends:

- the intensification of agricultural landscapes in which the quest for greater agricultural productivity continues with ever larger property structures and increasing mechanisation;
- the reforestation or fallowing of rural land gradually abandoned by agriculture, the continuation of a centuries-old transformation;
- the increasing fragmentation habitats, in particular in large alluvial valleys or on coastlines;
- the extension of the urban peripheries of big cities until they form metropoles;
- the spread of public-transport infrastructure, motorways, high-speed rail tracks and power lines;
- the expansion of tourist facilities in mountain regions or on coastlines with an increasingly marked propensity to engage in large cultural marketing campaigns at important historic or natural sites.

Box 3.13.4 Why landscapes matter to people

Landscapes provide the setting for our lives, today and into the distant future. The quality of that setting affects the quality of our lives, whether we live in a city, a town or in the countryside. Every landscape has importance for the people who live in it.

Our concern, therefore, is with all landscapes, the whole territory of Europe, including cultivated or natural areas, and the urban and peri-urban landscape. This dual view is necessary because most Europeans live in towns and cities and because rural landscapes occupy an important place in European consciousness.

Within this broad view, it must be recognised that landscapes vary in their character and quality. Some landscapes are so rich in natural and man-made beauty or cultural interest to justify concern at more than local level. Many landscapes are recognised as regional or national parks or by other designations. Some landscapes have such outstanding and universal qualities that they may merit recognition at the European or global scale.

Examples of such landscapes might include the *puszta* of the Hungarian plains, the hills of Umbria and Tuscany, the valleys of the Tarn and Dordogne, or the Lake District of Northern England. Such areas have inspired artists, drawn travellers and achieved fame beyond the immediate locality.

If the conservation of Venice, Granada or Prague is of European concern, so too should be that of Europe's important landscapes. To this end, the Council of Europe is working on the drafting of a pan-European Landscape Convention in association with the Congress of Local and Regional Authorities of Europe (CLRAE). It is expected that this convention will strengthen existing efforts to protect Europe's landscapes under the 1995 Pan-European Biological and Landscape Diversity Strategy.

After Dower, M. *Towards Landscape Policies.* Naturopa, Vol. 86. 1998.

Figure 3.13.3
A rural landscape over 1910-1994;
Top: Loèche Plan (Switzerland) 1910
Bottom: 1994
Source: N. Crispini

Box 3.13.5 The role of forests in rural areas

In 1998, the European Commission produced *'a Forestry Strategy for the European Union'* (COM (98) 649 final). The strategy recognises the diversity of Europe's forests, their multi-finctional role and the need for ecological, economic and social sustainability. Forests in Rural Areas fulfil a number of functions including:

- viable timber production
- wood-based industries
- rural employment
- landscape and biodiversity
- watershed management and water filtration
- soil conservation
- recreation
- carbon sequestration.

Forests within the EU are under threat from a number of factors, in particular air pollution, forest fires (destroying around 350 000 to 500 000 ha of forests annually), pests, diseases, reduced species diversity and in some cases an over-emphasis on timber production. The multiplicity of uses and abuses of forest resources highlights the need for observance of Sustainable Forest Management (SFM) principles. These have been defined as the 'stewardship and use of forests in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economical and social functions, at local, national and global levels, and that does not cause damage to other ecosystems' (Resolution H1, Ministerial Conference on the protection of Forests in Europe, Helsinki, 1993). These principles were formally adopted in Lisbon in 1998 by the Ministers responsible for Forests within the UNECE Region (UNECE, 1998).

2.3.3. Water stress in rural areas: a spatial challenge

The rural areas of Europe generally have access to water resources which they avail of for a variety of purposes including domestic, agricultural and industrial use. Generally, northern European Member States and Accession Countries have a surplus of water supply, while their southern counterparts have areas of water stress due to low rainfall, but also an excess of abstraction (see Chapter 3.5 for a more detailed discussion of this problem) raising the issue of an integrated land planning of catchments areas.

Rural areas probably have poorer water quality per capita than urban areas. Water-quality reports for some pre-dominantly rural areas in Ireland reveal deficient water quality mainly due to a combination of contamination of groundwater by agricultural and domestic waste – including pesticides – as well as poor water-supply infrastructure (EPA, 1996). This arises from the preponderance of small privately managed group supplies which do not receive the degree of treatment given to small public supplies in rural areas.

In terms of river quality, phosphorus and organic matter concentrations have decreased markedly over the past 20 years. Nitrate concentrations have been stable over the same period. Available data, however, does not allow differentiation of these trends for different catchment types including predominantly rural catchments (see Chapter 3. 5).

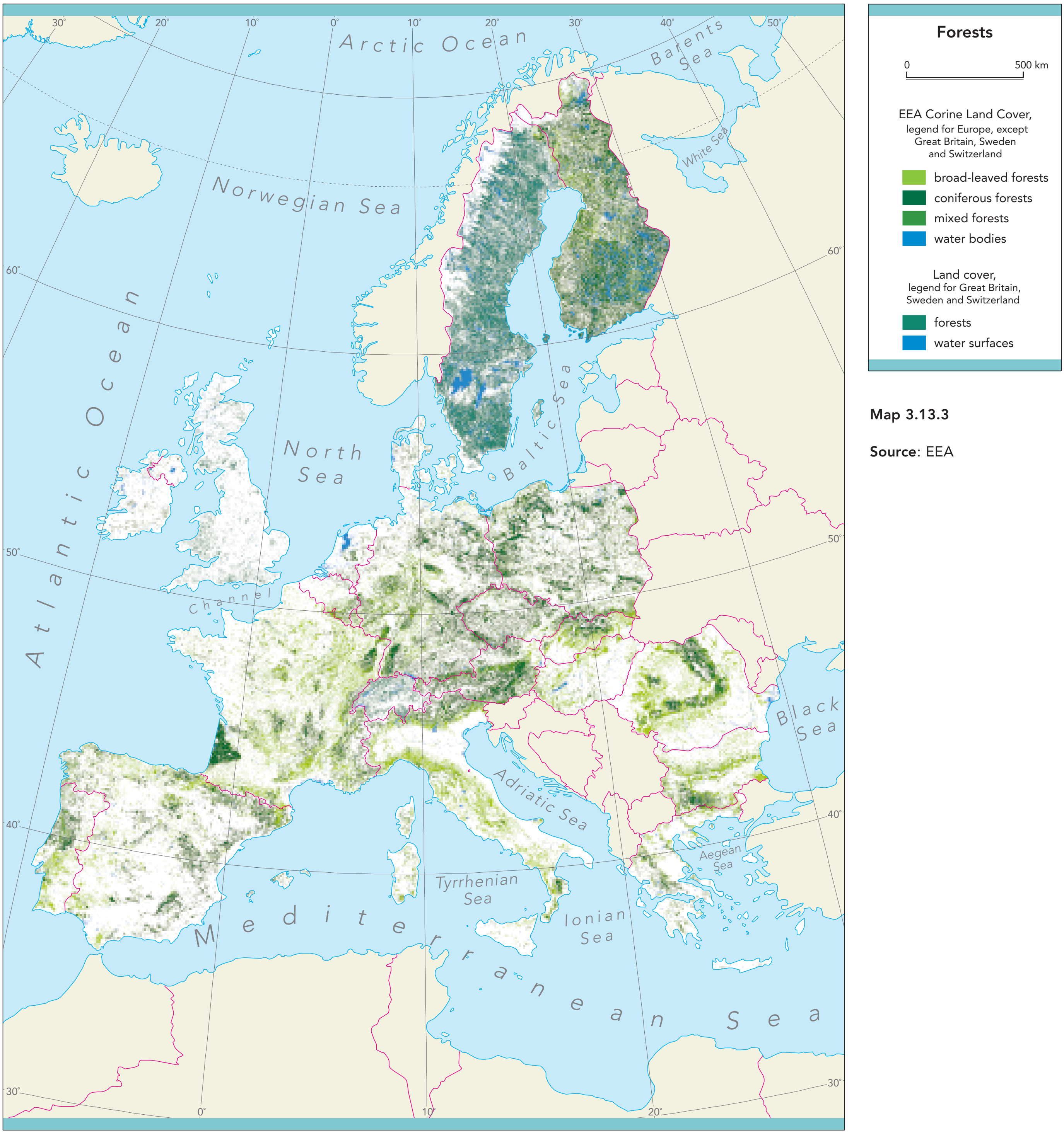
2.3.4. Soils in rural areas

Erosion is a major cause of degradation and the effects are increasing. All European countries are affected to some extent: about 12% of the land area of Europe, mainly rural, is affected by water erosion and 4% by wind erosion (see Chapter 3.6). The actual magnitude of erosion, and consequent nutrient loss, is determined by a variety of factors: climate, soil type, topography and human activities. As a result, soil and nutrient loss will vary greatly between different rural areas. Within the EU, agricultural intensification and marginalisation have contributed substantially to these problems, through, on the one hand, increased mechanisation, the cultivation of steep slopes, changes in crop rotation practices, overgrazing, land drainage, and the loss of hedges and field walls, and on the other, the abandonment of traditional forms of land use. Much of the eroded soil and nutrients end up in surface waters thereby contributing to solids and nutrient loadings.

Modern intensive agricultural practices of specialising in either arable or livestock farming has resulted in declining organic content of soils in some rural areas due to the rupture of traditional organic and nutrient cycling associated with mixed farming systems (IEEP, 1998). Although trends in artificial fertiliser use within the EU show a decline overall, there are still pockets of excessive use which are spatially defined (see Chapter 3.6).

2.3.5. Rural areas – Europe's biodiversity reservoir

Rural areas within the EU contain the vast bulk of its conservation and biodiversity assets. They also show great spatial variation across the EU. However they are increasingly under pressure from a variety of land uses and other pressures, as stated and assessed in Chapter 3.11.



Map 3.13.3

Source: EEA

It is generally reported that the threat to Europe's wild species is severe and growing. In many countries up to half of the known vertebrate species is under threat, and over a third of bird species are declining, rare or vulnerable. Birds are excellent indicators of broader environmental quality. The main causes are the abandonment of traditional forms of agricultural land use which alone accounts for over 40% of Europe's declining bird species (Chandler & Faulks, 1997), inappropriate forestry, infrastructure development (transport networks can fragment wildlife habitats), water abstraction (drying up of wetlands) and pollution. Detailed information on variation in biodiversity assets within different rural regions in the EU is not available, but generally the highest biological diversity is to be found in predominantly rural areas, mountain areas and in areas where extensive or traditional agricultural practices are to be found. Indeed, there appears to be a high correlation between the EU's biodiversity resources and rural areas designated as Less Favoured Areas (European Commission, 1997a).

3. What future for rural areas?

Responses to environmental pressures in rural areas can be seen in current EU policies concerning agriculture, environment and regional policy (Box 3.13.6). Generally, the measures being implemented can and are achieving some measure of success. The responses to environmental problems in rural areas have traditionally tended to be of a prescriptive nature often in the form of horizontal regulatory instruments which did not or do not have regard to the differing spatial contexts of rural areas within the EU. However, targeted agri-environmental measures implemented by zonal programmes have been introduced following the 1992 reform of the Common Agricultural Policy.

Responsibility for implementation of many of the regulatory instruments designed to respond to rural issues (including environment) is in the hands of individual Member States on the basis of the Principle of Subsidiarity. This can lead to wide differences in approaches to dealing with environmental problems.

3.1. Protecting important assets in rural areas

EU environmental policies and instruments responding to specific issues within rural areas centre mainly around the protection of important bird and habitat areas as well as the protection of vulnerable water resources from nitrates pollution. Three Directives are important in this regard, the Birds Directive (79/409/EEC), the Habitats Directive (92/43/EEC) and the Nitrate Directive (91/676/EEC). Effectively, they all require the identification and designation of nature conservation areas or vulnerable zones within which development or land-use practices have to or will have to be adapted, in compliance with good agricultural practices or action programmes as defined by the national or regional authorities.

For instance, the Nitrate Directive will restrict, in vulnerable zones, the application to the soil of livestock manure to 170 kg N/hectare by the year 2003. On a regional basis, the quantity of livestock manure produced by current livestock numbers already exceeds the absorption capacity of the agricultural areas in large parts of predominantly urban Netherlands, Belgian Flanders and significantly rural areas of Brittany and Lombardia. To comply with the Directive could therefore mean, in some situations, an effective reduction in the numbers of livestock (European Commission, 1997a).

3.2. Integrating the environmental dimension into public policy in rural areas

3.2.1. Regional and rural policies

The European Agricultural Guarantee and Guidance Fund (EAGGF), the European Regional Development Fund (ERDF) and the European Social Fund (ESF) provide assistance for a range of eligible investment measures within Objectives 1, 5a, 5b and 6 according to specific regulatory provisions and on the basis of multi-annual regional development programmes. Besides a requirement to undertake an environmental

Box 3.13.6 Current policy responses to environmental issues in rural areas

Policy	Measures
Environmental policy	**Sustainable development:**
	Integration of environment within agricultural practices Habitats Directive Birds Directive Nitrate Directive
Regional policy	**Objectives 1, 5b & 6:**
	Diversification of rural economies Reform of farm structures Environmental protection linked to economic development (eco-tourism)
Agricultural policy	**Promotion of environmentally friendly forms of agriculture or changes in practices/land use:**
	Agri-Environment Measures (Regulation 2078/92) and Forestry Measures (Regulation 2080/92)

appraisal of the development priorities concerned with respect to their likely environmental impact, the programmes often include specific environmental investment priorities which are geared to providing basic environmental infrastructure (e.g. water supply, waste recycling) as well as measures linked to nature conservation or landscape management. The Community initiative LEADER II is assisting many rural communities using a 'bottom-up approach' which not only empowers rural communities, but also contributes to environmental integration at the local level.

On a broader scale, agri-environmental measures provide an important contribution to the integration of the environment in a land use context. It is still too early to assess the actual impact of both Structural Funds programmes and Community initiatives in rural areas in either positive or negative terms. Most of the current programmes are running until the end of 1999 and even at that point, it would be some time after before it would be possible to gauge their effectiveness (IEEP, 1998).

Despite improved integration in the definition and implementation of regional development programmes, there is still a need to more closely integrate these measures and other public policy measures such as transport within national or regional planning frameworks in order to avoid potential resource or land-use conflicts.

3.2.2. LEADER II – a means to facilitate environmental integration

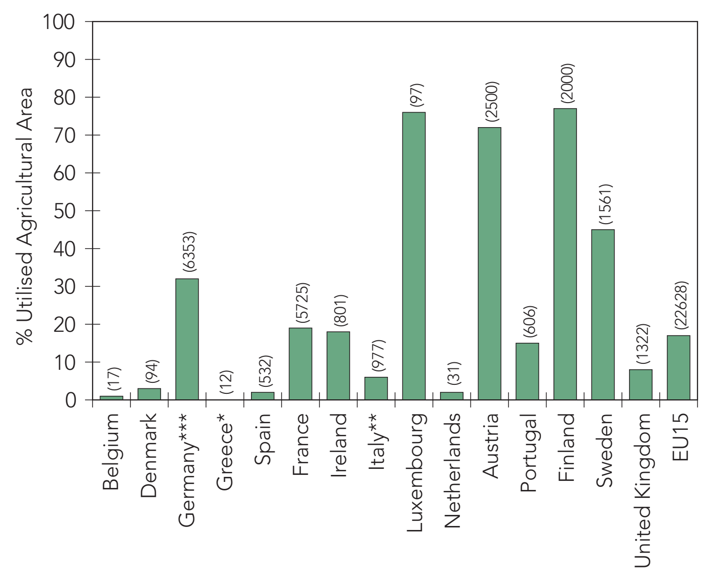
Besides the mainstream Structural Funds programmes mentioned above, the European Union co-finances a number of initiatives of Community interest. The most important of these for rural areas in the LEADER initiative. The current LEADER II initiative has a budget of approximately 1.8 billion euros (1996 prices) and supports rural development investments that have been designed and are managed by local partnerships (the so-called 'bottom-up approach'). The focus of LEADER programmes is on innovative approaches to rural development which add value and are transferable. All individual projects co-financed through LEADER programmes should be consistent with local development strategies and plans. The LEADER initiative applies to rural areas covered by Objectives 1, 5b and 6 with over 1 billion euros earmarked for Objective 1 and 6 regions. The projects receiving assistance are varied and include environmental actions such as development of renewable energy sources and waste recycling.

3.2.3. Agri-environment measures

Member States put forward programmes based on Council Regulation (EEC) No. 2078/92 to the Commission based on the priorities and conditions in the regions concerned (see Box 3.13.7). Agreements covering 22.3 million hectares (Figure 3.13.4), or 20% of the utilised agricultural area of the EU are now in place (European Commission, 1997b). While some countries have made very substantial use of the opportunities (over 70% of utilised agricultural area in Austria, Luxembourg and Finland), others have not (eg 1% in Belgium.): there is also variation within Member States in the degree of uptake (Figure Map 3.13.4).

The single objective of these schemes during the first implementation period is the continuation of relatively low input farming systems associated with sensitive areas followed by reduction of water pollution from nutrients. The former systems are generally characteristic of predominantly rural areas and extensive landscapes such as the *dehesas* in Spain. The latter tends to be in more specialised and intensive rural areas.

Current take-up of agri-environment measures in EU countries Figure 3.13.4



* 1995 data ** 1996 data *** 1997 data

Source: European Commission, 1997

Box 3.13.7 Protecting areas of special biodiversity/nature interest in rural areas under Regulation 2078/92

- **Agri-environmental programmes in France**

Many of the targeted measures of the local operations within the French agri-environmental programmes implemented under Regulation 2078/92 have a strong ecological dimension. A large proportion of the 270 local operations implemented so far are in designated environmentally sensitive zones (including SPAs; SACs; *Zones nationales d'interêt écologique, floristique et faunistique* and natural parks). For this reason, nature protection relative to the NATURA 2000 exercise forms a substantial part of implementating the agri-environmental programme.

Significant examples of measures that target sensitive biotopes are the 'coastal marshes' comprising 20 local operations mainly in Pays de la Loire and Charentes, but also in Province Alpes Cotes d'Azur and Languedoc-Roussillon. The coastal marsh measures have been developed following a significant amount of preparatory work, based on analysis of the state of the environment, a high level of technical expertise, and awareness-raising and promotion amongst farmers. This resulted in a high uptake and significant reduction in environmental impacts of agricultural activities (including prevention of degradation, recovery of pastures, reconstitution of the hydraulic infrastructure, reduced fertilisation and stocking rates and changes to mowing and grazing regimes). In one particular situation in the *Marais salants de Guérande et du Mes* in Pays de la Loire, farmers rediscovered extensive grazing systems which had formally disappeared.

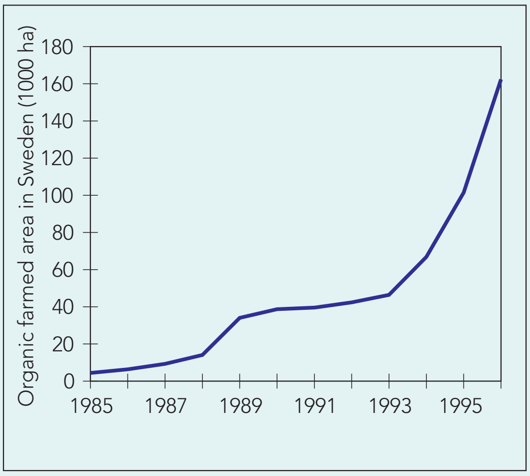
Despite some continuing problems in relation to water management, the overall impact of the programmes in the areas concerned has been successful with improvement in the management of natural pastures (which were previously threatened) to the benefit of marshland biodiversity, in particular the general habitat type.

The French example highlights the benefit of good planning and targeting in the use of the agri-environment Regulation and the need to prepare the ground well with those whom one wants to influence – namely the farmers.

- **Organic farming continues to grow**

In 1996, organic farming accounted for some 1.3% of the total utilised agricultural area (UAA) and 1% of the agricultural holdings within the EU. Despite this apparent marginal slice of the total UAA, between 1985 and 1986, the organic UAA has increased tenfold and the number of farm holdings fivefold. Moreover, for Sweden (see Figure 3.13.5), Finland and Austria, growth in organic UAA has surged from 13 000 to 660 000 ha over the same period.

Fig. 3.13.5
Organic farmed areas in Sweden 1985-96



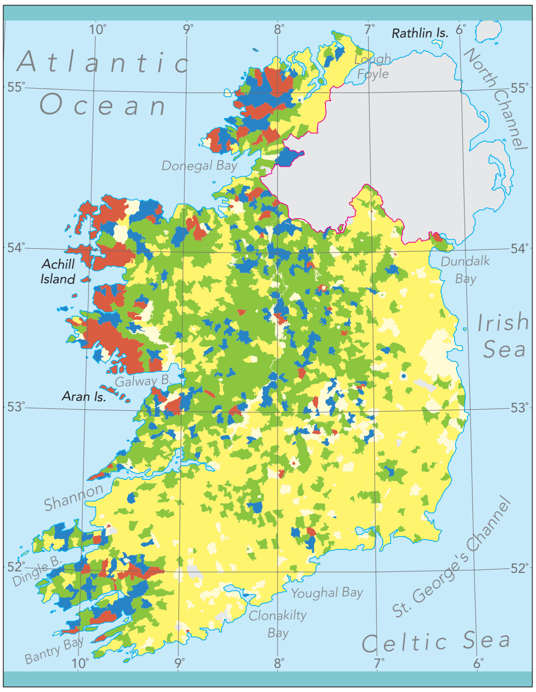
Source: Eurostat, 1998

Uptake of agri-environmental support in Ireland, 1998

0 10 km

area in Rural Environment Protection Scheme (%)

- more than 75
- 50 – 75
- 25 – 50
- 1 – 25
- no data



Map 3.13.4

Source: Department of Agriculture and Food, Ireland (1998)

The measures adopted by farmers within the programmes can be categorised into four different types:

- environmentally beneficial productive farming, encompassing organic farming, non-organic farming with environmental improvements and maintenance of existing low-intensity systems;
- non-productive land management, comprising the maintenance of abandoned land, environmental set-aside, protection of landscape features and public-access measures;
- training and demonstration projects;
- integrated and whole-farm plans.

A recent report to the Council and the European Parliament (European Commission, 1997b) stated that in general the first of these types of measures show positive impacts on soil and water quality and on biodiversity and landscape protection, although in some cases monitoring the impact on water quality is problematical. Non-productive land management measures also show positive impacts, for example in soil-erosion control and landscape conservation, however the take-up of the schemes has been mixed, particularly regarding set-aside of land, and consequently the benefits are viewed as being fewer than is possible.

Despite the high take-up rate in those countries making substantial use of this measure, it is still too early in the implementation of the scheme to undertake a detailed appraisal of its environmental impacts. The shortage of empirical studies and difficulties in obtaining reliable data on implementation are problematic in this regard (IEEP, 1998). A formal requirement for Member States to undertake monitoring of the impact of these schemes is now in place. This will assist in the impact assessment of the schemes provided a proper baseline assessment of environmental conditions prior to their introduction was undertaken. First results have already been submitted to the European Commission which presented a synthesis report to the Member States in 1998 (European Commission, 1998a).

3.2.4. Forestry measures (Regulation 2080/92)
Another of the flanking measures adopted to accompany CAP reform was Council Regulation (EEC) No 2080/92 instituting a Community aid scheme for forestry measures in agriculture. The aim of this instrument is to promote afforestation as an alternative use of agricultural land and the development of forestry activities on farms.

A 1997 report (European Commission, 1997c) showed that just over 500 000 hectares of land was afforested under Regulation 2080/92; almost half of this was in Spain, with the United Kingdom, Ireland and Portugal accounting for most of the remainder.

About 40% of the afforested areas in the EU consist of coniferous species, and 60% are broadleaves or mixed plantations, however this varies widely (Table 3.13.2), with the proportion of conifer afforestation from below 10% in the Netherlands, Greece and Germany to about 80% in Ireland.

Most of the land (61%) which has been afforested under the Regulation was previously permanent grassland and pasture, while another third (36%) was arable land. A small proportion was converted from permanent crops, such as vines and fruit trees. Afforestation rates are fairly low on land where the farm value added is high, for example in arable crop areas and intensive livestock farming areas; woodlands are established preferably on permanent grassland in less profitable livestock areas, or on unproductive arable land (Table 3.13.3).

It would appear, though, that afforestation of agricultural land has had only a small impact on reducing surplus agricultural production, with marginal decreases in the utilised agricultural area in most Member States (the largest reported decreases are in Ireland, Portugal and Spain, at 1.35%, 1.25% and 0.95% respectively), although it nevertheless plays a part in diversification and rural development (European Commission, 1997c).

This finding tends to suggest that afforestation measures generally have no effect on agricultural practices in rural areas where they are more specialised and intensive in character. Afforestation may play an important part in environmental protection and may generate a number of positive external effects, for example curbing erosion, preventing desertification, encouraging biodiversity and regulating the hydrological regime. However, where the aim is principally to create economically viable wood-based industries, tensions can exist between the need to maximise the economic return

Percentage of conifers and broadleaves in woodland afforested under Regulation 2080/92 — Table 3.13.2

Country	Conifers	Broadleaves and Mixed Plantations
Denmark	27	73
Germany	9	91
Greece	6	94
Spain	44	56
France	48	52
Ireland	79	21
Italy	6	94
Netherlands	5	95
Austria	11	89
Portugal	21	79
Finland	32	68
UK	33	67
Total	40	60

Source: European Commission, 1997c

Table 3.13.3 **Area of land afforested in the EU, by land type**

Country	Area afforested (ha)	% from grassland or pasture	% from arable land	% from permanent crops
Denmark	3703	1	99	0
Germany	18611	36	63	0
Greece	6234	12	84	4
Spain	238112	64	32	4
France	28900	80	20	0
Ireland	60477	95	5	0
Italy	32301	17	82	0
Netherlands	6499	0	100	0
Austria	331	100	0	0
Portugal	50035	17	76	7
Finland	177	47	53	0
UK	61597	88	12	0
Total	506978	61	36	3

Source: European Commission, 1997c

and the protection of important environmental assets in different rural areas – in particular landscape, biodiversity and water resources (ERM, 1997).

3.3. Towards integrated rural development

There is evidence of a gradual evolution of rural policies from policies based largely on agricultural production to policies based on broader sustainable rural development incorporating environmental issues. However, responses to environmental issues and problems have been fragmented and insufficient. Rural policies, and notably agri-environmental policies, have a great potential for environmental integration in a spatial context or framework within which it is possible to discern the actual impact of the shifts in policy response.

A significant step in this direction is Agenda 2000 which introduces rural policies, including agri-environmental policies, and investment in environmentally sound techniques, as a second pillar of the CAP. As a general rule, the application of rural development measures would have to respect minimum environmental standards. Additionally, Member States would be obliged to undertake appropriate environmental measures, by means of agri-environmental measures, environmental legislation, or specific conditions for direct payments. For the latter two options, Member States would be able to reduce direct payments to farmers in the event of non-compliance.

Despite the fact that land-use planning is not a European Community competence, the recognition of the need for a spatial development dimension to European Union policies in recent years has led to the development of the European Spatial Development Perspective (ESDP) – a set of guidelines or orientations designed to ensure greater coherence of Community policies in their interaction with the EU's diverse territorial characteristics (European Commission, 1997d).

From a rural areas perspective, the ESDP is highly significant. It notes the shifting economic structures of rural areas and recognises that as agricultural employment and activity continue to decline in some rural areas or become more specialised in others, rural areas will continue to become even more diverse than before. It acknowledges that the way to address this challenge is through spatially differentiated rural development within which coherence of Community and Member State sectoral policies (including environmental policies) can be better integrated.

The value-added dimension of a spatial development approach to rural areas can also be seen in terms of the potential to co-ordinate sustainable development actions within rural areas by means of integrated, multi-sectoral development strategies that promote co-operation amongst a spectrum of local actors (Sallard, 1998).

The European Commission's Agenda 2000 proposals for the future of rural development policy within the EU respond to the need for a spatial dimension to rural development and the need to make rural development measures applicable in all areas. They imply a broader context than a purely sectoral approach dominated by CAP measures (market supports, income supports, accompanying measures, etc.) towards to one which makes rural development measures (rural tourism, on-farm diversification, rural SMEs, etc.) an integral part of the CAP. This 'marrying' of existing policy instruments is to be achieved by adopting a targeted approach to rural development in the future. The key to implementing this will be through the development of *integrated rural development plans* by Member States at an appropriate geographical level.

From an environmental and sustainable development viewpoint, this approach will also be useful in helping to balance competing land-uses that can and will arise in different rural areas, enabling the best economic, social and environmental use of land resources. This is consistent with Community environmental policy (European Commission, 1996b) and will also be vital in order to maintain a critical level of occupation and functioning of rural areas (Bauer & Mickan, 1998). However the success of the proposals may depend on policies for environmentally sustainable agriculture and development initiatives being implemented across the whole countryside, not simply in selected or marginal areas.

It will also be important to ensure that adequate mechanisms are in place for monitoring the impact of rural development and agri-environmental measures given the paucity of data relating to the impact of current measures (IEEP, 1998). The development of a set of regionally orientated rural development indicators would be most helpful in this regard. This set of indicators should include environmental and sustainable development indicators as advocated by the OECD (1996), and more recently by the European Council at Cardiff, June 1998.

3.4. Perspectives on rural areas in Accession Countries

Rural areas within the Accession Countries show considerable variation in land use (Table 3.13.4). Forested land varies from 50% of the surface area in Slovenia to 30% in Romania. Generally, though, forest cover is

Overview of rural areas in Accession Countries Table 3.13.4

Country	Population (millions)	% Rural Population	% Employed in Agriculture	Agricultural Production (% GDP)	Agro-Food Trade (% of total exports)	% Agricultural Land	% Forested Land
Estonia	1.5	30.6	8.1	8.0	15.7	25.0	45.0
Slovenia	1.99	75.0	6.0	4.4	6.3	38.0	50.0
Lithuania	3.77	32.0	24.0	10.2	13.1	50.0	30.0
Latvia	2.46	30.0	17.0	7.6	16.8	39.0	44.0
Czech Rep.	7.9	25.0	5.0	2.9	5.7	55.0	30.0
Romania	22.6	45.0	37.3	19.0	8.8	60.0	28.0
Poland	38.6	38.0	26.7	5.5	11.3	59.1	28.2
Slovakia	5.34	48.0	5.8	4.6	5.4	50.0	41.0
Bulgaria	8.28	32.0	24.3	12.8	18.8	55.0	28.2
Hungary	10.1	37.1	8.2	5.8	17.5	66.5	19.0
AC10	102.4	40.0	22.5	6.8	11.9	55.9	34.3
EU15	372.1	25.0	5.0	1.7	7.4	40.0	36.0

Source: Agricultural Situation and Prospects in the Central and Eastern European Countries, Summary report, DG VI Working Document, 1998.

somewhat higher than the EU average. Agricultural land accounts for around 60% of land area in Romania while it is only 30% in the Czech Republic. The percentage of population employed in agriculture is generally much higher than within the EU. It ranges from 37.3% in Romania to around 5% in the Czech Republic. In Romania, the percentage of agricultural employment actually rose in the past five years and is partly helping to maintain overall employment in the face of declines in other industrial sectors (European Commission, 1998b). The global picture of the agricultural situation in the Accession Countries highlights the relatively higher importance of agriculture to the economies of the Accession Countries compared with the EU Member States.

Agricultural production in the Accession Countries has been through periods of intensification of agriculture similar to that experienced in the EU. Hungary, for instance became one of the most efficient co-operative and state farming systems in Eastern Europe. About 500 000 people moved off the land in the 1960s to make way for the establishment of large-scale farming systems and the introduction of intensive production techniques (Fesus & Lanszki, 1994) leading to the same environmental impacts and problems as in the EU. Intensive pig and poultry rearing was a feature of the Estonian rural economy up to the collapse of the Soviet state. This did have some environmental impacts. For instance, in the 1980s, 76% of the nitrate load and 20% of the phosphorous load to water bodies originated from agriculture. However, pig production has contracted by around 60% since independence (European Commission, 1998b) and this may help reduce further emissions to the aquatic environment.

Another environmental problem common to rural areas of a number of the Accession Countries is erosion of soil. It is estimated that this affects 20% of agricultural land in Lithuania, and 30% in the Czech Republic (European Commission, 1998b). In addition, there are hot spots of eutrophication or acidification which have been detected by 'critical loads mapping' in rural regions of Romania, Bulgaria and Hungary (Posch, *et al.*, 1997).

However, large areas of traditionally farmed, extensive land still survives. For example, looking at the Wielpolska region of Poland there is evidence of a long tradition of landscape management going back to the 1820s which has helped to reduce soil erosion and nutrient emissions to water courses while at the same time enriching the biodiversity of the area (see Box: 3.13.8). This multiple use of the land provides employment for rural people and contributes in a significant way to the national economy. It contrasts with much of the EU where biological and landscape diversity has declined and agricultural employment has fallen significantly.

The recent Aarhus Declaration by Ministers of Environment within the UNECE region in June, 1998, noted the importance of the biological and landscape diversity of the Central and East European Countries as an asset in their own right. They concluded that the best way to ensure that these assets could be protected and enhanced was through an integrated rural development approach. In general, the formulation of rural development policies is in an early stage within the Accession Countries focusing on agriculture and basic infrastructure. However, a number of Accession Countries (e.g. Lithuania, the Czech Republic, Slovenia and Hungary) have also adopted agri-environmental measures (OECD, 1997).

As part of the Agenda 2000 package for the Accession Countries a specific rural development regulation has been proposed by the European Commission (1998c). It will promote the development of integrated rural development plans in these countries along similar lines to that proposed for the existing Member States. The Accession Countries will have to ensure that the environmental and sustainable development dimension is incorporated into the development and implementation of these plans.

However, the success of this approach is not automatically assured given the dynamic nature of the economic, political, institutional and cultural changes that are underway. In addition, the task of 'setting the baseline' or environmental benchmark for many development initiatives and plans within rural areas of the Accession Countries relies on the availability of adequate and reliable regional environmental statistics and indicators. Given that such statistics and indicators are still in the developmental stages within the EU, it would seem logical that the Accession Countries should also be included in the development of rural environmental indicators as a matter or priority.

Box 3.13.8 Landscape-friendly farming – shelter-belts in Poland

The tradition of landscape management aimed at the integration of agriculture with landscape and nature protection has a long history in Wielkopolska, the bread-basket of Poland. In the 1820s, General Dezydery Chlapowski, promoting advanced agriculture, introduced in his Turew estate the practice of planting mid-field shelter-belts on an area of 10 000 ha in order to modify micro-meteorological conditions, as well as to provide refuges for wildlife survival. Shelter-belts thus became elements of everyday life for farmers in the region.

During the past 40 years, the Polish research Centre for Agriculture and Forest Environment has been studying these systems and has published the results of its work. The work reveals the importance of so-called biogeochemical barriers composed of shelter-belts, meadow strips, mid-field water ponds or patches of swampy vegetation for the control of ground water pollution.

For example, very high concentrations of nitrates in the groundwater in some cultivated fields of up to 50 mg $N\text{-}NO_3$ per litre could be detected, while in the stream draining the Turew watershed, the average concentration of $N\text{-}NO_3$ over a period of many years was only 1.5 mg $N\text{-}NO_3$ per litre.

Shelter-belts are also extremely important for biodiversity. In the Turew landscape more than 80 species of birds were found during the breeding season and their nesting density was up to 140 pairs per sq. km. The shelter-belts are also home to mammals including wild boar, deer, badgers and foxes, and act as corridors facilitating movement of animals between different wooded areas.

The diversity of insect fauna is also 20 – 50% higher in the Turew mosaic landscape than in more uniform cultivated fields. Plant species diversity is also high with more than 800 vascular plants including 21 rare or protected species.

In 1992, the Research Centre, a number of local administrations and farmers in the region came together and set up an Agro-Ecological Landscape Park. The purpose of the park is to demonstrate the benefits of agricultural landscape management techniques and practices. In the past four years, a total of 26 km of new shelter-belts were planted traversing both large and small farm holdings. Around 8 km of these shelter-belts were composed of 7-11 rows of trees designed to act as links between larger wooded areas.

The Turew Landscape Park is playing an important role as a regional model for maintaining agricultural and landscape management practices which benefit rural areas and provide a working model of sustainable agricultural practices.

Adapted from Ryszkowski, R (1998). Nature-Friendly Farming – Shelter-Belts in Poland. Naturopa, Vol. 86, 1998.

Key References:

Baldock D., Beaufoy G., Brouwer F. and Godschalk F., 1996. *Farming at the margins: abandonment or re-deployment of agricultural land in Europe.* Institute for European Environmental Policy & the Agricultural Economics Research Institute. London and the Hague.

Bauer S. & Mickan S., 1998. 'Necessity for Integration of Agricultural, Regional and Environmental policy for disadvantaged rural areas.' Paper presented at the LSIRD NAPLIO Conference, 1998.

Bryden J., 1996. 'A new vision for rural communities.' Paper presented at a workshop organised by the New Celtic Environment Exchange, Avondale, Ireland.

Chandler and Faulks, 1997. Investing Wisely for Europe's Biodiversity. In: *Environment Strategy Europe.*

Dower, M., 1998. Towards landscape policies. Naturopa: 86. 1998.

ECNC, 1998. *Monograph on European Landscapes – Classification, Evaluation and Conservation. European Topic Centre for Nature Conservation*, Tilburg, the Netherlands (in prep.).

ECNC, 1998. 'Monograph on European Landscapes – classification, evaluation and conservation'. ECNC for the EEA (in prep.).

EEA, 1998. *Europe's Environment: The Second Assessment*, European Environment Agency, Copenhagen. Offoce for Official Publications of the European Communities, Luxembourg.

EPA, 1996. *The quality of drinking water in Ireland – a summary for 1996 with a review for the period 1993-95.* Environmental Protection Agency, Ireland.

ERM, 1997. 'Effects of CAP accompanying measures on biodiversity and landscape in Northern Member States'. Report for Directorate General XI, European Commission (unpubl.).

European Commission, 1994. *Europe 2000+, a perspective on the territorial development of the European Union.*

European Commission, 1995. *An energy policy for the European Union.* COM (95) 682 final.
European Commission, 1996a. *A green paper on renewable energy sources*. COM (96) 576 final.

European Commission, 1996b. *Progress Report on the implementation of the European Community Programme of policy and action in relation to sustainable development.* COM (95) 642 final.

European Commission, 1997a. *CAP 2000 – Situation and Outlook Rural Developments*, CAP 2000 Working Document, Directorate-General VI Agriculture, European Commission.

European Commission, 1997b. *Report from the Commission to the Council and the European Parliament on the application of Council Regulation (EEC) No. 2078/92 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside.* COM (97) 620. final.

European Commission, 1997c. *Report from the Commission to the Council and the European Parliament on the application of Regulation (EEC) No 2080/92 instituting a Community aid scheme for forestry measures in agriculture.* COM (97) 630 final.

European Commission, 1997d. 'The European Spatial Development Perspective', First Official Draft, Noordwijk 9-10 June.

European Commission, 1998a. 'STAR working document – state of application of Regulation (EEC) No. 2078/92. Evaluation of agri-environment programmes.' Directorate General for Agricultural Policy, European Commission.

European Commission, 1998b. 'Agricultural situation and prospects in the Central and Eastern European Countries – working documents for the Czech Republic, Romania, Slovenia, Latvia, Estonia and Lithuania'. Directorate-General for Agricultural Policy, DG VI, European Commission.

European Commission, 1998c. *Proposal for a Council Regulation on Community Suport for Pre-Accession measures for Agriculture and Rural Development in the Applicant countries of Central and Eastern Europe for the pre-Accession period.* COM (98) 153 final.

EUROSTAT, 1997. *A European agriculture taking the environment into account.* EUROSTAT, Luxembourg.

EUROSTAT, 1998. *Labour force survey – results 1997.* EUROSTAT, Luxembourg.

Fesus, I & Lanszki, I., 1994. Prospects for agricultural and environmental policy integration in Hungary. In: *Agriculture and the Environment in the Transition to a Market Economy.* OECD, 1994.

IEEP, 1998. 'Assessment of the Environmental Impact of certain Agricultural Measures'. Report for the European Commission, Directorate-General XI (Environment, Nuclear Safety and Civil Protection). Institute for European Environmental Policy, London. Unpubl.

IFEN, 1994. *Transport d'energie: quelle repurcussions sur l'environnment.* IFEN, Orleans.

Luginbuhl, Y., 1998. Landscapes: Policies for a pluralist Europe. Naturopa: 86, 1998.

OECD, 1994a. *Creating rural development indicators for shaping territorial policy.* OECD, Paris.

OECD, 1994b. *Tourism strategies and rural development.* OECD, Paris.

OECD, 1996. *Territorial Indicators of Employment – Focusing on Rural Development.* OECD, Paris.

OECD, 1997. *Agriculture and the environment in transition economies – monitoring and evaluation.* OECD, Paris.

Posch, M, J-P Hettelingh, P.A.M de Smet, R.J Downing, 1997. *Calculating and mapping of critical thresholds in Europe: Status Report, 1997.* Co-ordination Centre for Effects, RIVM, Bilthoven, Netherlands.

Ryskowski, L., 1998. Landscape Management for nature-friendly farming – shelter belts in Poland. *Naturopa: 86.*1998.

Sallard, O, 1998. Preparing the Future – The European Spatial Development Perspective. Introduction to Seminar 'for a new Rural-Urban Partnership', Salamanca, Spain.

Sharpley, R & Sharpley, J., 1996. *Rural Tourism – An introduction. Tourism and Hospitality Management Series.* Thompson Business Press, UK.

UNECE, 1998. Third Ministerial Conference on the Protection of Forests in Europe. Resolution adopting a set of Sustainable Forest Management principles, Criteria and Indicators. Lisbon.

3.14. Coastal and marine zones

Table 3.14.1 GDP statistics per region showing economic disparities between the North West and the other riparian areas in Europe (EU GNP=100)

Area/Region	Index
'Blue Banana' area (Milan to London)	120
North Sea riparian areas	100
Baltic riparian areas	88
Mediterranean riparian areas	82
Atlantic riparian areas	78
Isolated regions	67

Source: Conference of Peripherals Maritime Regions of Europe (CRPM), based on EUROSTAT data

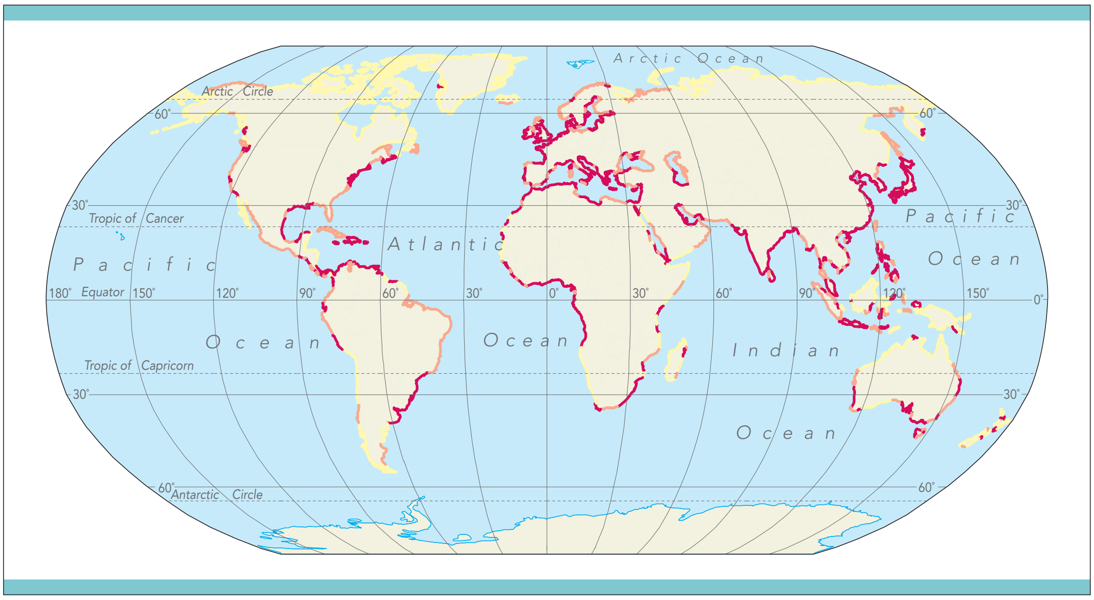
1. The issue

Coastal zones are considered to be areas where land and sea influence, meet and interact. The coastal band varies depending on the nature of the environment, the interactions of the marine and terrestrial coastal processes and the management needs. Coastal zones occupy less than 15% of the Earth's land surface, yet they accommodate more than 60% of the world's population. If this trend continues, by 2025 there could be up to 75% of humanity residing in coastal areas (UNCED, 1992). Most of the world coastal ecosystems potentially threatened by unsustainable development are located within northern temperate and northern equatorial zones with Europe having 86% of its coasts at either high or moderate risk (Bryant *et al.*, 1995) (Figure 3.14.1).

Coasts are not static. They can change shape rapidly, and coastal erosion, due to human activities or natural causes, is a common phenomenon: in the EU 25% of the coast is subject to erosion, while 50% is stable and 15% aggrading: for the remaining 10%, the evolution is unknown (Corine, 1998). Erosion also varies: 32% of the Portuguese coasts is affected, but 75% of the Spanish Atlantic coasts are considered stable.

Improvements in economic conditions are a priority for coastal regions of Europe. They are among the least economically developed regions of the EU (Table 3.14.1), and in 1996 accounted for 19 of the EU's 25 less favoured areas (compared with 23 in 1983). Coastal regions have received substantial assistance – mainly for infrastructure investment – from the EU Structural and Cohesion funds: nearly 70% of the EU Structural Funds for the period 1994-1999 were allocated to the EU's coastal area (including nearly all EU Mediterranean areas; all areas on the Atlantic coast of Portugal, Spain and France, half of the UK coast, etc.).

For the purpose of this report a strip of 10 km wide is generally considered, in connection with impact of human activities. The EU coastal zones contain irreplaceable ecological, cultural and economic resources; mainte-



World coastal ecosystems threatened by development

1: 250 000 000

Potential threat

- high
- moderate
- low

Figure 3.14.1

About 34% of the world's coasts are at high potential risk of all kinds of degradation, and another 17% are at moderate risk.

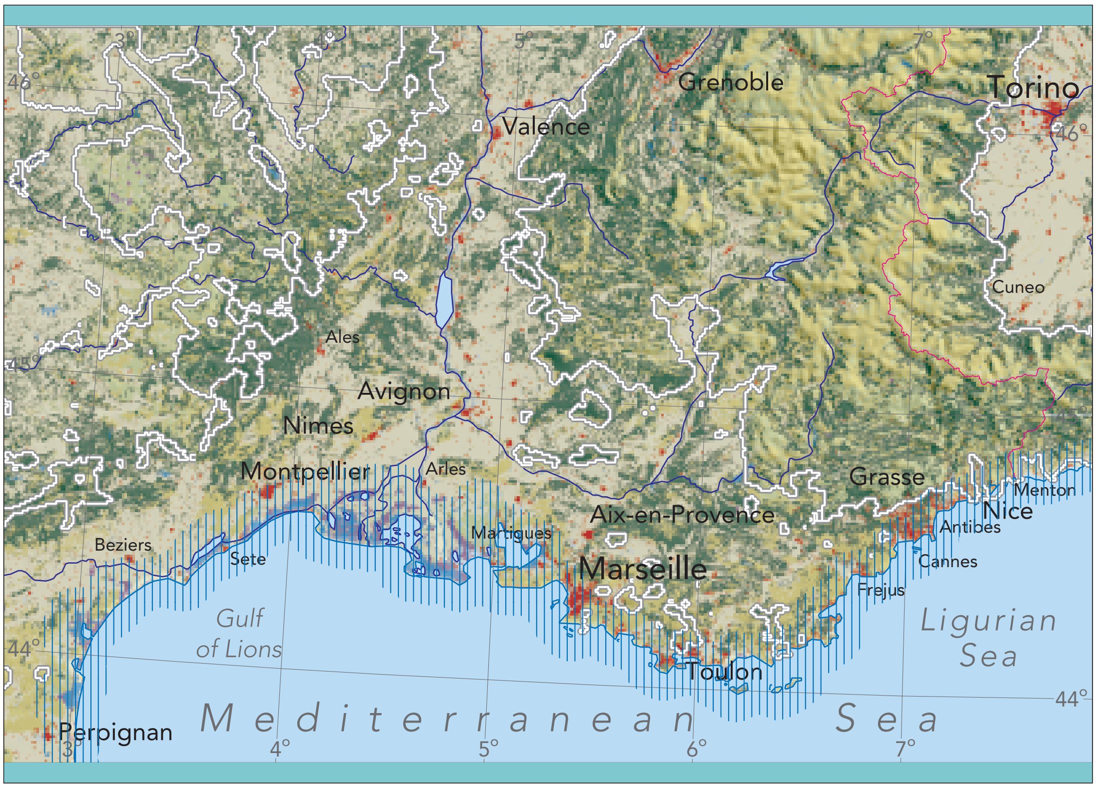
Source: World Resources Institute

Zoom in on mountain and coastal areas

0 80 km

mountain zones

coastal zones



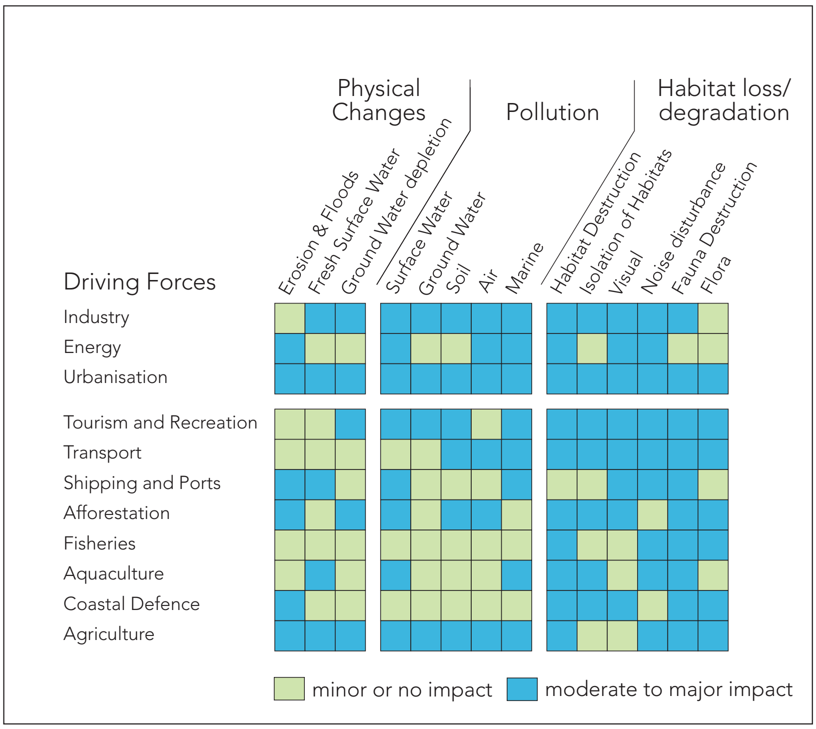
Map 3.14.1

What happens in the coastal zone is important to all Europeans. Much of the influences and pressures on the coastal and marine environments are concentrated in this sensitive area.

Source: EEA

nance of these resources depends on protection of the fragile equilibrium among the dynamic systems (human and natural) of the coastal zones (Map 3.14.1). More importantly, the whole of the EU marine resources depend on the quality of the coastal zones, a relationship recognised in the 5th Environmental Action Programme. Coastal zones also face pressure from development, since they are areas where people want to live and work and where recreational activities also feature in a major way. The EU has recognised the importance of environmental resources in coastal areas and the need for protective measures to ensure that they are not threatened by human activities, in particular urbanisation, transport, tourism, agriculture, industry, energy and fisheries. In 1992, the Council of Ministers called on the Commission to develop an integrated strategy for coastal zone management with a view to providing a coherent environmental framework for sustainable forms of development. The impacts of different human activities on coastal areas are summarised in Figure 3.14.2.

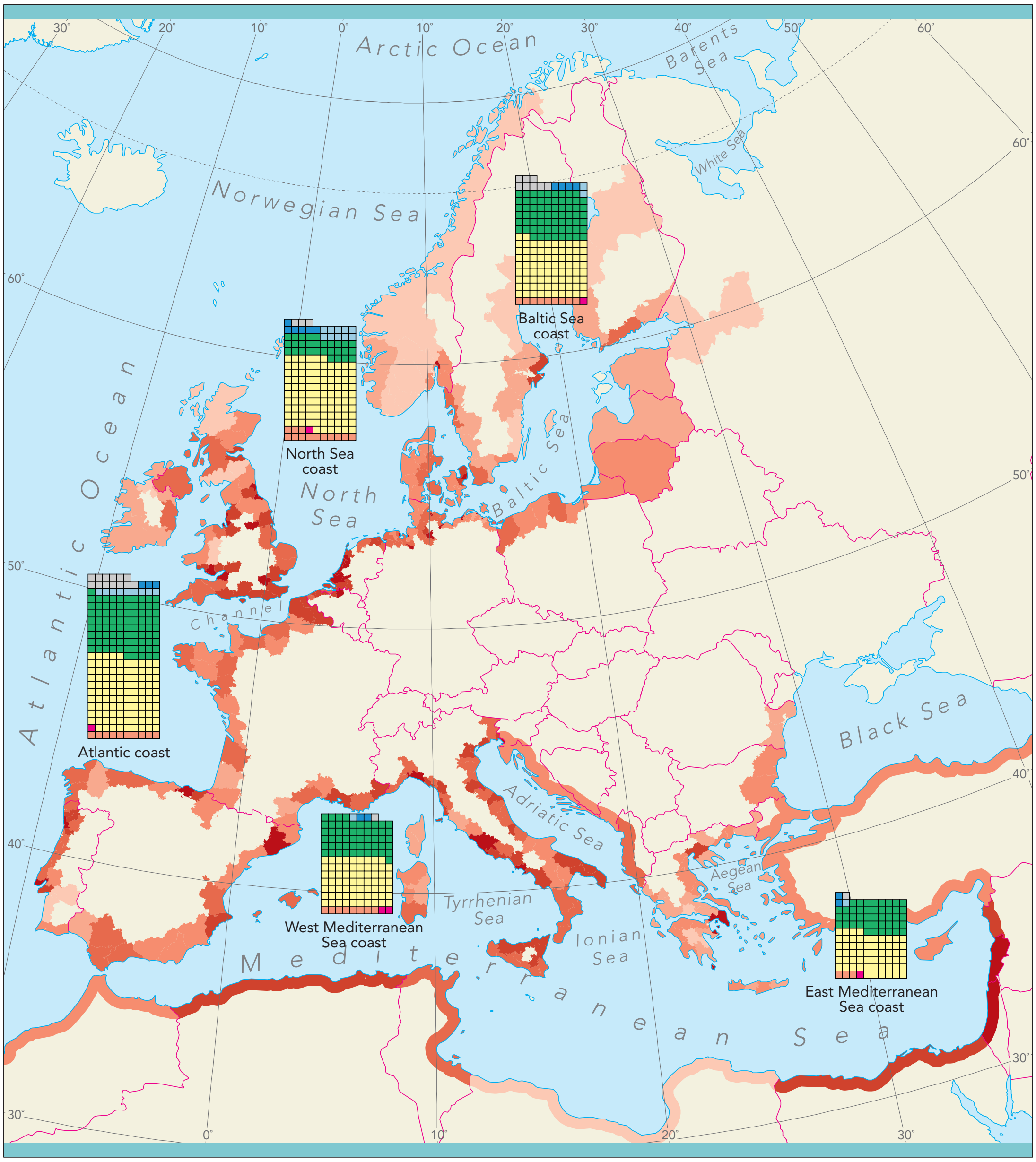
Figure 3.14.2 **General situation of Impacts of the different Driving Forces in coastal areas**

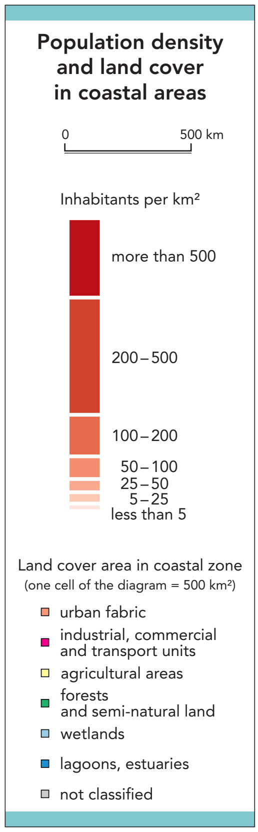


Source: After Rigg *et al.*, 1997; modified

Key areas of action for Integrated Coastal Zone Management (ICZM) are environmental impact assessment, coastal land planning, habitat management and pollution control. The results of the EU 'ICZM Demonstration Programme' and the Water Framework Directive should provide concrete examples of how to tackle coastal zone management issues as they occur. However, although the EU could lead and co-ordinate the approaches to ICZM, decisions on management and implementation should be made at appropriate levels within Member States.

The challenge, then, is to ensure that economic development is sustainable in environ-





Map 3.14.2

Source: Land Use: CORINE Land Cover; Population data: EEA, 1996 (modified from GISCO 1996); CORINAIR Emissions Inventory, 1990;– Blue Plan

mental terms, and does not compromise the quality and viability of the marine environment and its ecosystems. The challenges are being addressed through the development of integrated management strategies in the main coastal areas of the EU: around the Baltic Sea, the North Sea, the Atlantic Ocean and the Mediterranean Sea.

2. The main drivers affecting coastal and marine areas

2.1. Population and urban development

About one-third of the EU population is concentrated near the coasts. Heavy populated areas in the south are usually connected with regions with large cities (e.g. Athens, Rome, Genoa, Marseilles, Barcelona, Lisbon) while a more even, but denser, distribution can be found in the north west of Europe; in the north the population decreases but again the majority of the population is concentrated in the coastal areas (Map 3.14.2). Human activities are often in competition for the use and control of the coastal resources (for example, agriculture and urban areas in the North Sea, agriculture and forests in the Mediterranean and the Baltic Sea; coastal wetlands threatened by other land uses in the Mediterranean, the North Sea and Atlantic).

Urbanisation claims large expanses of coastline, and while stabilising in northern Europe it continues to increase in the southern countries (EEA, 1998) (Figure 3.14.3 and Box 3.14.1). It has major impacts on land, air and water quality (including the surrounding seas) (see Figure 3.14.2), and urban sprawl is

Box 3.14.1 Urbanisation around the Mediterranean Sea

Over the past four decades, urban population rate in the Mediterranean countries grew on average by 44% to 62%. Very fast-growing trends characterise southern Mediterranean countries which show significant annual growth rates, about a doubling of urban population every 30 years.

The number of cities with more than 1 million inhabitants tripled over the same period, from 10 to 29; the number rose from 2 to 17 for the southern Mediterranean countries where Cairo – now the largest city in this area – experiences a density of about 21 000 hab/km2. This striking growth hides the fact that there is also, relatively speaking, a higher growth rate for smaller cities (with over 10 000 inhabitants) which numbered more than 4 000 in 1995, most of them in coastal areas. This urban 'booming' is not comparable to European countries: indeed, while it took one century in Europe to absorb urbanisation, similar phenomena occur only over 20 years in southern Mediterranean countries.

The Mediterranean region in any case faces severe environmental pressures associated with a rapid increase in population, projected to grow from under 400 million in 1990 to around 600 million in 2025, with urban concentrations reaching 75-80% (over 400 million in 2025, up from 220 million in 1985), and the coastal population rising from 140 million in 1990 to over 200 million in 2025. The development pressures are illustrated by projections for an increase in the number of motor vehicles (rising from 60 million in 1980 to 175 million in 2025) while the area of coastal land covered by roads increases to 10 000 sq. kms

Control and management of the social, economic, spatial and environmental consequences of such developments raises serious concerns for the urban quality of life which for hundreds of years has been characteristic of the Mediterranean region, as well as the for the maintenance of high environmental, cultural and economic values of the coastal areas.

Source: Geopolis data base, 1998, quoted and analysed by Blue Plan, 1998; UN population forecast.

a problem in all coastal regions (see Chapter 3.12). In the Mediterranean, MAP/Blue Plan already reported 10 years ago that in 1985 almost 90% of urbanised land in the Mediterranean was located in the coastal zones of Spain, France, Greece, Italy and former Yugoslavia (Grenon & Batisse, 1989). In Southern Mediterranean countries, from Morocco to Syria, 55% of the total population (82% of the urban population in Tunesia) is located in coastal areas which account for 6% of these countries' area.

2.2. Tourism

Coastal-based tourism has been an important part of the economic development of many of the poorer areas of Europe, especially in the South. Over-all, the annual growth rate for tourism in Europe is 3.7% per year, projected to continue through 2000. Nevertheless, tourism in Europe has been losing market share to Eastern Asia and the Pacific, and an additional 10% loss in market share is forecast for 2000, which could lead to a fall in the average growth rate (EUCC, 1997).

In the Baltic sea region tourism may be potentially important to the economies of the Baltic Sea states, especially in places with tourist attractions (such as fishing village, architectural heritage and nature parks) (VASAB, 1994).

The Mediterranean region is the world's leading leisure tourism destination, accounting for 30% of international tourist arrivals and for one fourth of the receipts from international tourism. The French, Spanish and Italian coasts account for 90% of the tourists travelling to the Mediterranean, although the non-EU countries to the south and east are expecting to increase their share in the next decade. The coastal region received some 135 million tourists a year in 1990, and an increase to 200-250 million is projected for 2010 (Blue Plan, 1998). Tourism in coastal regions is estimated at around half of the total tourism to the countries concerned but by far the highest concentrations are found in coastal resorts.

International visits from within Europe (measured as nights) are widely perceived as the dominant form of tourism in Mediterranean coastal regions and the major source of environmental impact. On current estimates (Blue Plan, 1998), however, domestic tourism was already as large in volume in 1990 and this is typically for overnight visits only. The environmental impact of residents' day visits for all purposes is undoubtedly massive in the Region: although there is no adequate data, it is likely that domestic tourism (as defined by the World Tourism Organisation) is at least twice the volume of international tourism, certainly in the more economically developed countries that look South on the Mediterranean.

For international holiday tourism in the Region, package tours are the dominant form in 1999 covering around 84% of visitors to Malta, 78% to Cyprus, 67% for Greece and 48% for Spain (the coastal figures are likely to be even higher). Following a spate of national and international amalgamations among tour operators in Northern Europe in the last three years, fewer than 10 very large operators now dominate the industry, perhaps accounting for over two-thirds of the market.

Environmental and economic impacts include poor water quality – both salt and freshwater – conversion of nature and agricultural land into tourism facilities, overconsumption of groundwater resources and discharges of untreated wastewater to the sea/catchment area. Analysis of the impacts of tourism on the coastal and marine environments would be assisted by better information to support the framing, monitoring and implementation of sustainable development policies in coastal areas.

2.3. Agriculture

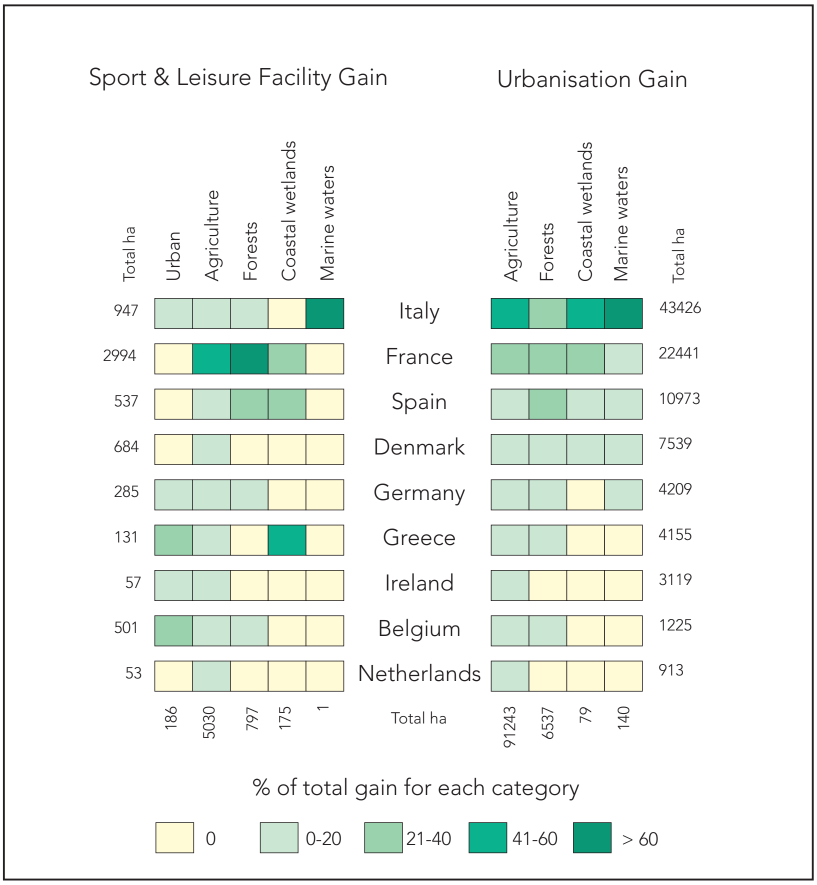
Agriculture is a significant, albeit declining, source of employment in EU coastal zones (the proportion of the workforce in agriculture (9%) is almost twice the EU average of 5.5%).

Along the coasts of the North Sea, a general decline of the area of arable land under cultivation by at least 10-11% as a result of set-aside is expected in agriculture by the end of the century, while a further 4 to 5% of arable land will be farmed less intensively, chiefly because of stricter environmental controls (European Commission, 1994). In the Mediterranean basin, intensive agriculture and farming is limited by the topography of the terrain, being concentrated in the few alluvial plains (Ebro, Rhone, Po and Nile); countries on the northern and western Euro-Mediterranean coasts are specialised in monocultures and achieve good yields while in the south and east, demographic pressure constantly increases and cultivated surfaces continue to expand at the expense of forests and grazing land (EEA/UNEP-MAP, in press).

It is interesting to note that in northern EU countries the loss of agricultural land is connected with the increase of urbanisation, while in the south EU countries agriculture and urbanisation grow simultaneously at the expense of semi-natural and natural areas.

Agri-environment schemes (see Chapter 3.13) can help maintain farm employment and income, while promoting farm diversification and sustainable land management. In coastal regions these schemes can make use of land taken out of production for development of wildife habitats, such as coastal grazing marsh and reed beds behind low lying seawalls, or create new saltmarsh as part of managed realignment of sea walls for conservation and flood defence objectives.

Urbanisation and sport and leisure facilities gains in EU coastal zones (1970s-1990s) Figure 3.14.3



Urbanisation, connected mainly with agricultural and forest loses, continues to grow in the southern European countries but this process is slowing down in the North.

Source: LACOAST Project, JRC, European Commission

2.4. Fisheries and aquaculture, both in transition

2.4.1. Fisheries

A decline of fisheries has been reported in almost all regional seas (EEA, 1998). In April 1997, following an expert group recommendation for a 40% reduction in fleet capacity to match the available fish resources, the EU decided on a reduction of 30% for those vessels targeting those stocks at risk of depletion and 20% for those pursuing stocks which are over fished. Fleet technology in the industrialised EU countries is very high and there has been a shift from labour-intensive to more capital-intensive vessels. In recent years pelagic fishing and processing has increased (EEA, 1998).

Gear such as bottom trawls, pelagic trawls and drift nets, although highly productive, is indiscriminate, and EU drift net fisheries for tuna and a number of other species will be prohibited from 1 January 2002.

The main objective of the EU's Common Fisheries Policy (CFP) is to control fishing pressure so that the fish stocks are exploited sustainably and are able to replenish themselves in the medium and long term.

A 1994 Council Regulation (No 1626/94) (amended in 1996 – No 1075/96 – and 1998) for conservation of Mediterranean fishery resources enhanced the protection of resources and the environment by harmonising different national rules of the four involved EU countries, in accordance with available scientific studies. Mediterranean fisheries are operated by both EU and non-EU countries, and cooperation is essential to ensure conservation and management of shared resources, since management of fisheries focuses mainly on control of licences and subsidies to the sector, rather than quota control. In 1997 the European Community became a member of the General Fisheries Council for the Mediterranean (GFCM).

2.4.2. Aquaculture

Intensive aquaculture results in the production of waste which can stimulate and distort productivity and alter the abiotic and biotic characteristics of the water body (see Chapter 3.5). Aquaculture can result in genetic disturbance of the natural ecosystem, the transfer of diseases and parasites and contamination by chemicals. The effects vary according to a closed, or semi-closed, or open area (see Figure 3.14.2).

In the Baltic region fish produced in hatcheries account for more than 90% of the salmon population. In the North Sea aquaculture is expected, generally, to stabilise rather than grow, primarily due to environmental restrictions and increased production costs. Cultivation of mussels and oysters in the Channel and Wadden Sea, salmon in Norway and Scotland, along with oysters, scallops and mussels are the aquaculture products of the North Sea region. Aquaculture is significant on some Atlantic coasts particularly for local communities in Ireland, Spain and France. The regional aquaculture production in the Mediterranean show a sharp increased by about 185% in a decade (39 575 tonnes in 1984 to 113 103 tonnes in 1994) (EEA/UNEP-MAP, in press).

2.5. Industry and energy, very present in coastal zones

The dominant fuel used in EU countries is oil, almost all of which is transported across the sea to be processed within the coastal zones. The North Sea area is still the primary source of energy in the EU, but the extraction of oil most probably will decline in the years to come (European Commission, 1994). The Mediterranean basin endowment of oil and natural gas is leading to the establishment of many refineries in the region. The environmental consequences of oil (extraction, transport, refinement, and use) are well documented.

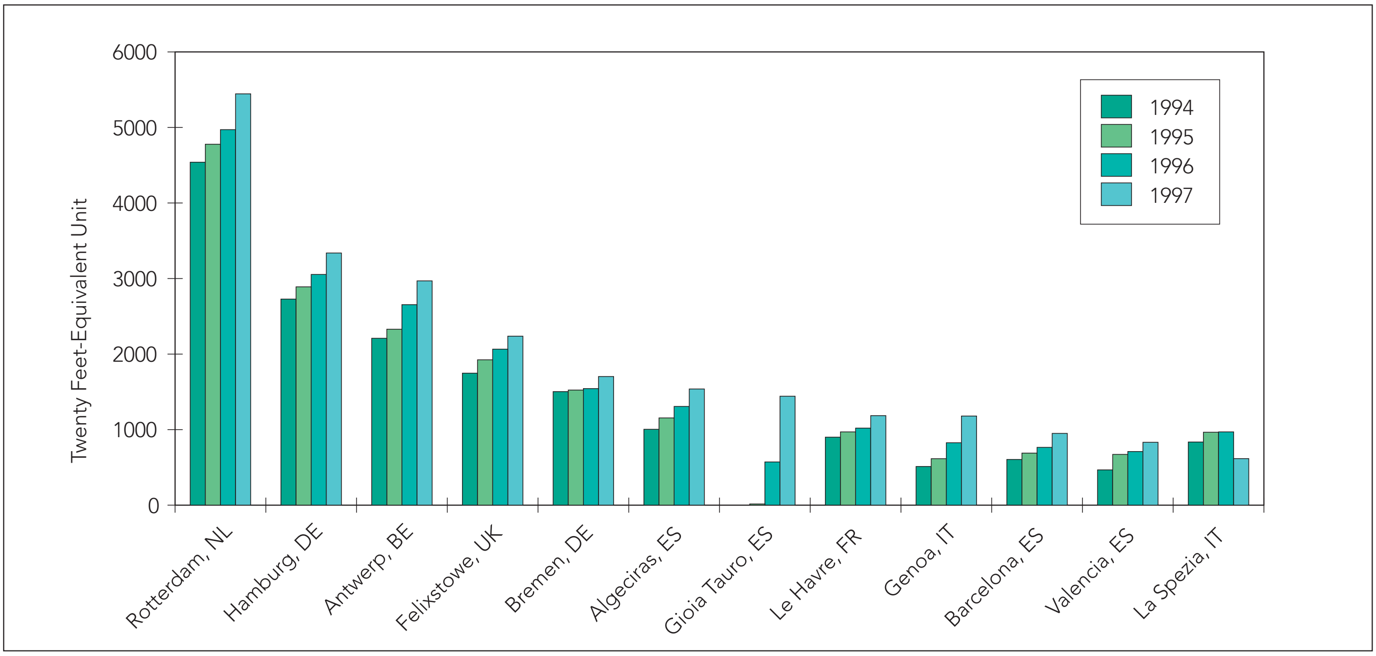
There are around 200 nuclear power plants operating throughout Europe, many of which are located in coastal regions or along important rivers due to the large volume of cooling water needed. The nuclear industry poses a special set of threats to coastal and marine ecosystems mainly due to the sheer scale of damage that could result from a major nuclear accident, however unlikely that may be. In the absence of major accidents, coastal and marine ecosystems are still subject to operational discharges of radioactive waste.

Industrial inputs to the Baltic Sea mainly come from pulp and paper processing (this area is responsible for 25% of the world's pulp production), iron and steel industry, mining and fertiliser production (HELCOM, 1998). In the Atlantic coast many manufacturing industries are in decline but a number of traditional industries maintain their importance (European Commission, 1994). The development of renewable energy sources (especially wind and, solar sources) is preferable to continued investment in conventional energy supplies since there is a lower contribution to global warming and air pollution. The use of renewable energy sources in the North Sea area is expected to increase especially in coastal areas (European Commission, 1995). Renewable energy sources have impacts on the landscape, particularly at the local level, although fields of modern wind turbines or solar panels may be less undesirable than large power plants with cooling towers and huge steam clouds.

2.6. Transport growth

Maritime transport of goods increased in the EU by 35% between 1975 and 1985, but has since levelled off (EUCC, 1997). It is considered to be one of the most environmentally friendly modes of transport, if all measures and legislation are enforced. However, it has environmental impacts in the European coastal and marine environ-

Maritime freight in container traffic for main EU ports 1994-97 | Figure 3.14.4



Source: Port of Rotterdam – web site

ment from spills of hazardous materials (oil spills being the best well known), and can cause significant environmental damage with implications for economy (e.g. tourism, fisheries, agriculture), ecology and health (see Figure 3.14.2). Ports have a key role as interconnection points between seaborne and land-based transport modes. Freight passing through European ports has increased in the past five years and this trend is probably going to continue as the enlargement of the EU generates new transport flows (Figure 3.14.4). Large ports such as Rotterdam – the world's largest – Hamburg, London, Le Havre connect to some of the busiest shipping routes in the world. In the Mediterranean basin the major transportation mode of commerce between countries is through the sea, mostly by ferries. It is estimated that about 220 000 vessels of more than 100 tonnes cross the Mediterranean each year, which is estimated as 30% of the total merchant shipping in the world and 20% of oil shipping mainly coming from the Middle-East (MAP/REMPEC, 1996).

In the Baltic Sea the transport of goods, including oil, via the Baltic ports has grown significantly since 1990. The threats to marine and coastal environment degradation are increasing but the political will of the countries in the Baltic region to fight oil pollution is strong; they have agreed to implement an integrated, no-special fee system, for oil and wastes in their harbours and making it mandatory to deliver oil at a reception facility before departure.
Ports, in conjunction with water-borne transport, can make an important contribution to environmentally sustainable transport, but this depends on measures to limit adverse environmental impacts, and in particular a full assessment of the environmental impacts of all port-related developments.

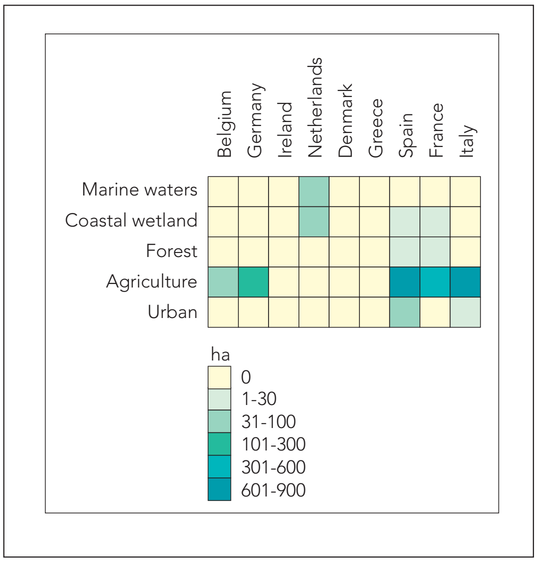
Railways, motorways and roads occupy long stretches of land and form barriers which lead to the fragmentation and/or isolation of habitats. If located near the coast, they can inhibit the natural processes of shore formation and development, they can have an impact through airborne pollutants on the surface water, and they can also cause significant coastal erosion; one of the feedback effects of erosion could be the destruction of the infrastructure itself (example can be found in the Black Sea coastline). In addition road runoff in the coastal zone and in catchment draining to estuaries cause chronic pollution from contaminants such as polyaromatic hydrocarbons. Road traffic in coastal zones is well developed but very dense, while railway use is in decline (EUCC, 1997). In some countries the geomorphology dictates the expansion of the road and rail network in the coastal zones (for example Italy has a long coastline with mountains in the middle; in the Netherlands creation of dams, are maintained for coastal protection) (Figure 3.14.5).

Figure 3.14.5

Changes in road and rail networks surface for some EU coastal zones (1970s - 1990s)

Note that geomorphology dictates the expansion of the road and rail network in the coastal zones (e.g. Italy, Netherlands)

Source: LACOAST Project, JRC, European Commission



3. Environmental conditions in regional seas

The environmental problems faced by maritime areas in the EU are summarized in Table 3.14.2. This summary has been formulated through an analysis of the INTERREG.II.C programmes of the EU. The information presented represents the 'perception' which, those in charge of the maritime areas, have of their environment, as discussed and agreed upon through the policy process.

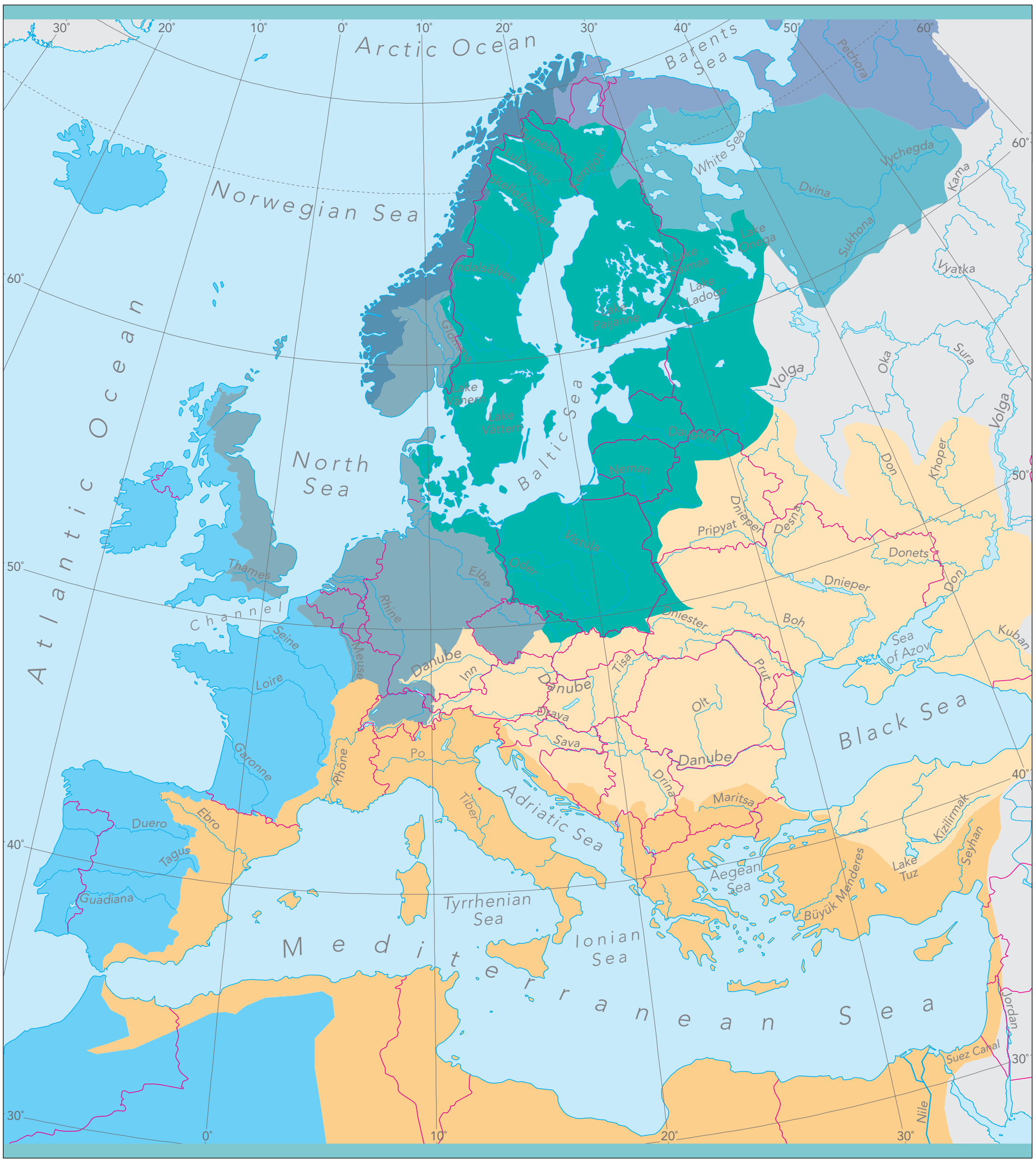
Important research has been made in all European regional seas through the MAST Programme from DGXII. During the MAST-III programme (1994-98) the regional seas were covered by the following projects:

- the Canary Islands Azores Gibraltar Observation (CANIGO) project with the

Drainage basins of regional seas

0 500 km

- White Sea
- Barents Sea
- Baltic Sea
- Norwegian Sea
- Mediterranean Sea
- Black Sea and Sea of Azov
- Atlantic Ocean
- North Sea
- not classified



Map 3.14.3

Source:Eurostat-GISCO

Challenges and problems in the different EU maritime regions — Table 3.14.2

Atlantic	North Sea	Baltic	Western Mediterranean
Dichotomy of under-exploitation of abandoned areas and over-exploitation and rising population of areas under development. Risks linked to natural conditions (insufficient amount of drinking water, erosion, fires, flooding). Maintain coastal ecosystems threatened by coastal erosion, regression of beaches and scarcity of water resources in humid sourthern zones. Seasonal pressure of tourism, especially in southern Brittany. Qualitative degradation of river and sea water (industrial dumping and abandoned mining sites). Apparition of extreme situations in agriculture: over-exploitation of certain zones, abandonment of other zones. Growing urban pressure, especially around 'capitals' and coastal cities, and diffuse and uncontrolled urbanisation in interior zones.	Strong consensus for integrated management of coastal areas. Improve quality and availability of operational information for spatial planning. Encourage renewable forms of energy. Coastal erosion. Reduce level of marine pollution. Concern to protect natural areas still untouched by economic development.	Increase in eutrophication leading to the proliferation of algae. Origin of major problems: nitrogen due to combustion of fossil fuels, agriculture and landfills; added phosphorus (agriculture and landfills). Numerous of hot-spots (direct industrial discharges). Global vulnerability of the Baltic Sea due to less saline water and its nature as a closed sea (narrow exchange corridors with the North Sea).	Conscious of rich natural heritage which is threatened and is at risk (natural risks, agriculture, tourism, transport, urbanisation in coastal areas). Prospects for fragile or low-density areas in all aspects. Control of tourism development. Manage and protect inland and marine waters; specific problems in semi-arid zones; regulating debit and quality of water, provision of water and risks linked to natural conditions (erosion, desertification, saline intrusions in groundwater).

Source: INTERREG-II

objective to understand the functioning of the marine system in that region of the Northeast Atlantic Ocean and its links with the Alboran Sea;
- the Ocean Margin EXchange (OMEX) project in the north east Atlantic, to gain a better understanding of the physical, chemical and biological processes occurring at the ocean margins in order to quantify fluxes of energy and matter across this boundary;
- the Baltic Sea System Study (BASYS) in the Baltic Sea with the aim to further the understanding of the susceptibility of the Baltic Sea to external forcing and to improve the quantification of past and present fluxes;
- the Mediterranean Targeted Project II-Mass Transfer and Ecosystem Response (MTP II -MATER) with the aim to study and to quantify the triggering and controlling mechanisms of mass and energy transfer in contrasting trophic environments (from eutrophic to oligotrophic) of the Mediterranean Sea and to investigate the ecosystem response to such a transfer.

3.1. North Sea

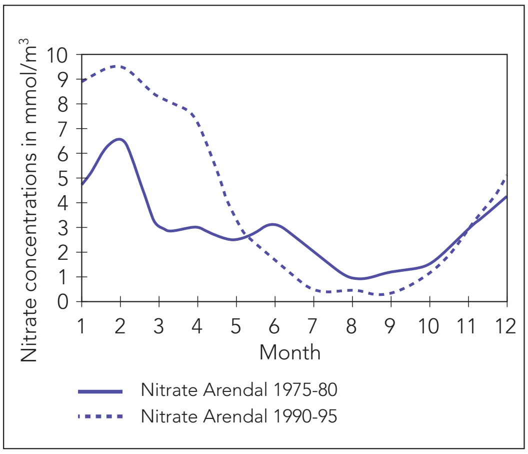
The North Sea catchment area (850 000 km^2) with about 165 million inhabitants has a high population density (194 persons per km^2, some 70% above the EU average). Around a quarter of the coastal areas of the North Sea are at risk from erosion (Corine, 1998). Nutrient levels seem to be high in some areas of the North Sea (Fig 3.14.6).

Large areas of the North Sea have contaminants (mainly coming from the rivers Elbe, Weser, Rhine, Meuse, Sheldt, Seine, Thames and Humber) in concentrations that are clearly above the North Atlantic background level (EEA, 1998). Synthetic organic compounds such as PCBs, DDT, PAHs, and TBT, are widespread, although higher concentrations are clearly identifiable in certain areas (EEA, 1998). Higher concentrations of PCBs are found in the southern part of the North Sea and close to harbour and city areas, and TBT concentrations are higher in some estuaries, harbours, and shipping lanes. Despite actions to restrict or, in some cases, ban the use of PCBs, unacceptably high concentrations are still found, which sug-

Figure 3.14.6

Nitrate concentrations in the coastal water mass at Arendal on the Norwegian Skagerrak coast (monthly mean values for the periods 1975-80 and 1990-95)

Source: ANON, 1997a

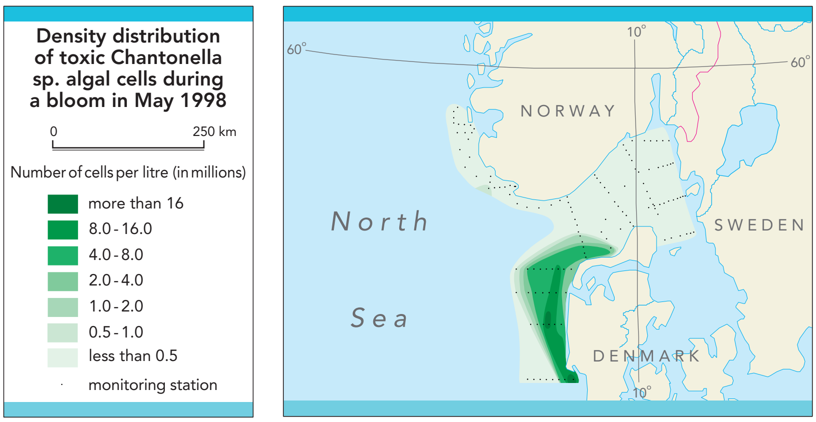


gests that existing measures are only partially effective. There is little evidence on the environmental effects of synthetic organic compounds.

In recent years, algal blooms (for example *Chrysochromulina polylepsis*, in 1988) have occurred in the North Sea (particularly in south eastern parts such as the Jutland coastal watermass) due to the elevated nutrient concentration. A new toxic species, *Chatonella sp.*, formed blooms the major of which occurred in May 1998 (Figure 3.14.7) and caused fish kills in Norwegian salmon farms. In such conditions oxygen depletion, caused by degration of algae, can damage marine life.

Figure 3.14.7

Distribution of the densities of algal cells during a bloom in May 1998 of the toxic species *Chatonella sp.*



Chatonella species were first seen in 1990 and probably introduced from ballast water.

Source: Data from Institute of Marine Research, Norway

3.2. European Arctic Seas: Norwegian, Iceland, Greenland Barents and White Seas

Areas surrounding the European Arctic seas are sparsely populated (about 2.2 million inhabitants) and not very industrialised: some mining and metal industry in Northern Norway and Russia, offshore petroleum industry in expansion in the Norwegian and Barents Seas, and fisheries of major importance for population in Iceland, Faroe Islands and Northern Norway.

The northern seas is the home area for some of the largest fish stocks in the world which in turn support large stokes of seals, cetaceans and birds. However, most of the major commercial fish stocks in the area are below safe biological limits. A further issue of concern is the damage by bottom trawling on cold-water reef colonies in shelf and slope waters in the Norwegian Sea (ANON, 1997b).

The major source of pollutants and radionuclides in the Arctic is atmospheric long range transport, Russian rivers, ice-drift and ocean currents (AMAP, 1997). High levels of persistent organic contaminants, with possible effects on the reproduction and on the immune system, are detected in some top predators such as polar bears, glaucous gull and harbour porpoise probably coming from atmospheric deposition (AMAP, 1997). In spite of the presence of nuclear power plants in Russia and of the considerable amount of nuclear waste (ANON, 1997b; Layton *et al.*, 1997) the concentration of radionuclides in the marine environment in the Arctic is generally very low. The most immediate and potentially largest threats relate to nuclear wastes from past Russian military activities.

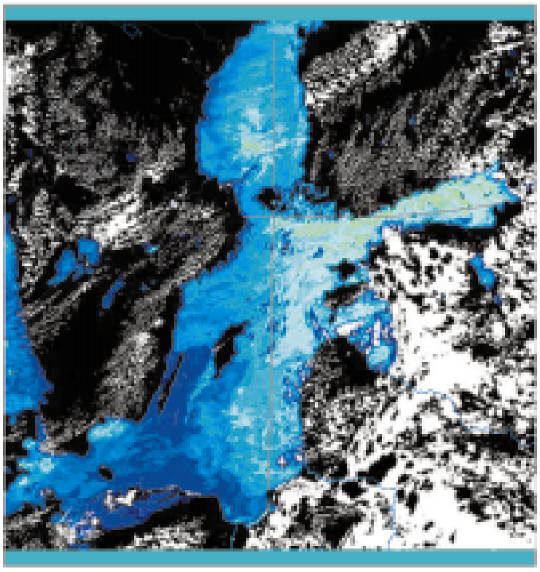
3.3. North-East Atlantic

The North-East Atlantic region includes some densely populated coastal areas such as South Wales, the Basque country, and major cities (Lisbon, Porto, Bilbao, Dublin, Glasgow, Nantes and Bordeaux). Many river catchments such as the Mersey and the Oria, are heavily industrialised, while others such as Loire and Shannon are largely rural and agricultural.

The NE Atlantic is not heavily affected by eutrophication, although sporadic toxic seaweed blooms can be observed (EEA, 1998). Contaminants of both heavy metals and organo-chlorines are not found in concentrations dangerous either for the environment or for human health (EEA, 1998).

The NE Atlantic (and particularly the North Sea) is also contaminated to varying degrees by radionuclides discharged in particular from nuclear fuel reprocessing plants in the UK (Sellafield) and France (The Hague) (Brown, *et al.,* 1998). However, even in the periods of peak discharges, doses of the most exposed members of the public have remained well within the statutory limits and there has never been any evidence of ecological damage. Moreover, taken collectively, annual discharges of the most significant nuclides from the point of view of public exposure have been substantially reduced by up to two orders of magnitude since the peaks of the mid-1970s in the case of Sellafield and by one order of magnitude since the mid-1980s for Cap de la Hague. Packages of nuclear waste have not been dumped on the bed of the North-East Atlantic since the early 1980s and various surveys carried out since then have not revealed any evidence of significant leakage from the packages (EEA, 1998, p.214).

Abundant bleu-green algae (cyano bacteria) in the Baltic Sea — Figure 3.14.8



Source: Finnish Institue of Maritime Research, 1997

3.4. Baltic Sea

The Baltic Sea is the second largest brackish water area in the world. The population in the catchment area is about 85 million, nearly 15 million of which living within 10 km from the coast (Sweitzer *et al.,* 1996). The 'Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and the Kattegat' presents the status of the marine and coastal biotopes with severe cause for concern, as 83% of all biotopes of the Baltic Sea Area are rated as heavily endangered (15%) or endangered (68%) (HELCOM Environment Committee, 1998). Agriculture is well developed, except in the northern parts, and is responsible together with natural leaching for most of the total nutrient load entering the Baltic Sea (Elofsson, 1997). Excessive nutrients, the physical and chemical nature of the Baltic Sea and its topography are responsible for the eutrophication observed in this catchment area. The Baltic Sea states decided in 1988 to reduce nutrients, heavy metals and POPs by 50% by 1995 compared with the mid 1980s, to decrease the pressure of eutrophication effects in the coastal zones. Eutrophication affects almost all areas of the Baltic Sea and represents one of the main issues of concern for the marine environment (Fig 3.14.8). The frequency and spatial coverage of phyto-plankton blooms, especially cyano-bacteria, has increased due to the increase in nutrient concentrations, but also to changes in the seasonal availability and relative proportions of nutrients (HELCOM, 1996).

The blooms of harmful algae have resulted in losses to the fish farming industry, death of fishes and sea birds from poisoning, and also some damage to human health. Periods of oxygen depletion have increased, especially in the south-western parts (HELCOM, 1996). Contradictory trends of heavy metals concentration in sea water and biota have been observed (HELCOM, 1998), possibly due to inadequacies in the load data.

Discharges of organo-halogen compounds from pulp industry are reported to have been reduced by nearly 90% since 1987. A clear long-term decrease in concentrations of PCBs, DDT's, HCH and HCB has been observed from the early 1970s to the early 1990s, nevertheless, they are still several times higher than in the open North Sea and the Atlantic Ocean (HELCOM, 1996 and 1998). Although organo-chlorine levels are still very high in Baltic seals, measures taken by the Baltic Sea States have arrested a decline in seal populations and the total number of grey seals has increased considerably in the northern parts of the Baltic Sea since the mid 1980s (HELCOM, 1998).

3.5. Mediterranean Sea

The population in the Mediterranean catchment area is currently 129 million inhabitants, with an increasing trend (UNEP-MAP/Blue Plan, 1998). The increasing pressure due to the resident population is exacerbated by the seasonal variation due to tourism (Map 3.14.4). These pressures

Box 3.14.2 The changing marine environment of the Mediterranean: The Mediterranean Targeted project (MTP).

During the past five years 70 Institutions and 250 scientists from 14 countries have cooperated to produce important scientific results illustrating the change in the functioning of the Mediterranean ecosystems:

- The temperature of deep waters in the Western Mediterranean had increased by 0.13°C over the past 40 years ($3.2 \cdot 10^{-3}$° C/y).
- Evidence for climatic changes were also detected in the deep-water masses of the eastern Mediterranean basin.
- Increases in nutrient discharges (phosphate and nitrate) were documented from deep water measurements.
- MTP results supports strongly the hypothesis of phosphorus limitation for phytoplankton growth in the northwestern Mediterranean.
- Lead concentrations in surface waters decreased in the early 1990s following the application of European regulations relating to leaded gasoline.
- The southern Aegean Sea is one of the most oligotrophic areas of the world. Important changes were also observed (nutrient enrichment connected water masses movement from the Cretan Sea), having a direct effect on the biology of the region.

Source:
Interdisciplinary Research in the Mediterranean Sea, 1997

give rise to deterioration in the geomorphological patterns of the coastal strip leading to changes in natural processes, such as movement of dunes. Consequently, around one-fifth of the Mediterranean coast is estimated to be subject to coastal erosion (Corine Coastal Erosion Atlas, 1998).

The overall environmental task and the need to address tourism specifically is huge. It is estimated that the tideless Mediterranean, the principal natural resource for leisure tourism, was being treated as a sink in the mid-1990s for some (Blue Plan, 1998):

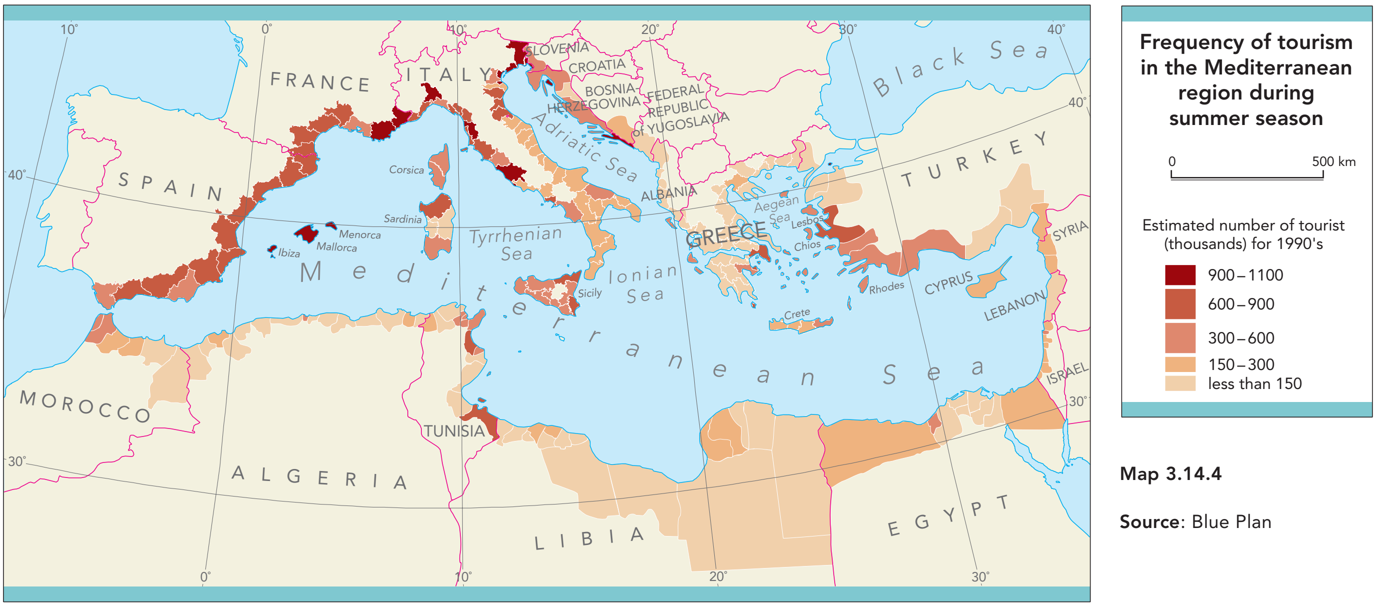
- 10 billion tonnes of industrial and urban waste (including sewage) dumped annually – of which only a very small proportion receives even primary treatment before discharge (90% of municipal wastes in the whole basin is still untreated).
- Over 70 rivers which drain into the Mediterranean and, at the end of this century, many are still virtually open pipelines for industrial, agricultural and human effluent.
- 1 million tonnes of crude oil dumped by all activities, and a major risk factor in the Sea of Marmara for tankers entering and leaving the Black Sea oil terminals.
- 60 000 tonnes of detergents, 100 tonnes of mercury.
- 3 600 tonnes of phosphates.
- Sewage and agricultural run off leading to eutrophication which routinely creates red tides and algal blooms that disrupt the ecosystems of the area.

Concentrations of hydrocarbons in water and on beaches have increased in recent years. Values of 0-5 µg/l of hydrocarbons have been measured in open waters and over 10 µg/l near the shore, the latter caused mainly by point sources in the shore line and illegal discharges.

The presence of heavy metals does not appear to be a major environmental problem for the Mediterranean Sea (EEA/UNEP-MAP, in press). The contribution from industry is small compared with other industrialised regions; other main sources of heavy metals are natural geo-chemical occurrences, agriculture, and urban pollution. The same conclusion is valid for PCBs – with the exception of 'hot spot' sediments – with the difference that most of these substances are no longer used in the Mediterranean industry and agriculture.

Eutrophication, resulting in phytoplankton blooms, mainly occurs locally and in places in the Adriatic, the Gulf of Lion and the northern Aegean (EEA, 1998, p. 214). Microbial contamination is mainly related to urban waste water and represents a potential risk for human health especially through the consumption of uncontrolled shellfish food. The situation has been mitigated by the installation of urban waste-water treatment plants along EU Mediterranean countries and the demand for good water quality from the tourism industry has pushed also other countries to pay an increasing attention to this problem; nevertheless, about 60% of municipal sewage is still untreated (EEA/UNEP-MAP, in press).

Energy comes mainly from conventional oil and gas and, as this area exhibits high seismic activity (EEA/UNEP-MAP, in press), construction of nuclear plants in the Mediterranean basin should be generally avoided.



Map 3.14.4

Source: Blue Plan

3.6. Black Sea

The catchment area of the Black Sea, which is over 2 million km² – that is five times the size of the actual sea – covers (wholly or in part) 22 countries in Europe and Asia Minor with 175 million inhabitants. The largest volume of river flow entering the Black Sea comes from the north-western part of the basin (important rivers being the Danube, Dneper, Dnester) and from the Caucasus, Turkey and the Bulgarian and Romanian coasts. In the last 30 years the Black Sea has increasingly attracted the attention of scientists, governments and the public at large as a region suffering ecological deterioration. As the result of past geological events, its morphometry and specific water balance, nearly 87% of the Black Sea water volume is anoxic and contains high levels of hydrogen sulphide (Fig 3.14.9). Between 1973 and 1990, as mineral and nutrient concentrations increased in flows from rivers including the Danube, Dneper, Dnester, 60 million tons of bottom living animals (including 5 000 tons of fish), were found dead in the Black Sea (GEF/BSEP, 1997). The recent eutrophication caused by a heavy anthropogenic nutrient load has resulted in severe stress, even in the oxygenated area (13% of the Black Sea's volume) which consists mostly of shallow surface water. Future projections indicate that the Black Sea will remain the worst affected area for eutrophication in Europe in 2010 (European Commission, 1999).

Little is known about heavy metals in the Black Sea (GEF/BSEP, 1997). Information on pesticides is also scarce, although levels up to 200-300ng/l total organo-chlorine pesticides have been reported in the river Don and 5ng/l in the open Black Sea. 'Hot spots' of phenol in the water have been reported in the Odessa area and in other northern coastal areas (GEF/BSEP, 1997).

Due to its connection with the Mediterranean, the Black Sea consists of two general categories of flora and fauna: Mediterranean immigrants and Caspian relics. Thirteen Mediterranean and other exotic species have penetrated either through ballast waters and as fouling organisms on ship hulls (Tiganus, 1997). Another 13 species have been intentionally introduced. The most urgent and

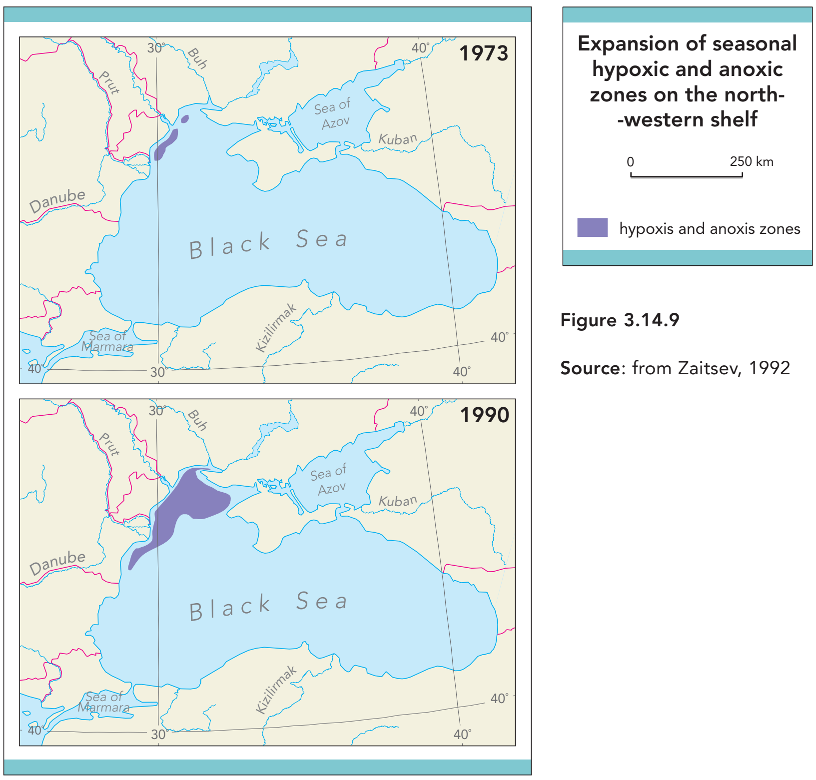


Figure 3.14.9

Source: from Zaitsev, 1992

most prominent example of the impact of exotic species in the Black Sea environment is that of *Mnemiopsis leidyi* (GESAMP, 1997).

4. What is the policy response for coastal and marine zones?

4.1. Marine – still a fragmented approach but with progress

Many of the policy developments in recent decades have been focused on the quality of the marine environment rather than on the factors influencing coastal zones. The transboundary characteristics of most of the environmental problems and the need for regional strategies and international cooperation have fostered the establishment of Regional Conventions, which now cover all the seas that are of direct concern to EU countries. The purpose of these Conventions is to assess the quality of the marine environment and its trend, and to define strategies for its protection, using appropriate scientific and management tools (Table 3.14.3).

At the EU level, environmental legislation related to the marine and coastal environment deals primarily with marine water quality and inputs of contaminants, and to a lesser degree with the protection of marine and coastal habitats. The objectives and results of implementation of EU Legislation are summarised in Table 3.14.4. The implementation of EU Directives varies between Member States.

The assessment approach for most of the EU Directives, based on monitoring the chemical determinants of water quality, requires the monitoring of a large and growing number of contaminants. This has placed an overwhelming and unnecessary (and expensive) burden on the regulatory authorities, who have to monitor a large and growing number of contaminants. At the same time effects of new contaminants are being missed, until they have a significant impact in the environment.

The Bathing Water Directive is arguably the most successfully implemented of all EU environmental legislation related to water

Table 3.14.3 **Regional Conventions for European waters**

	Signatories states	Area covered	Objective	Programmes	Main problems
OSPARCOM 1992 (Oslo ,1972 and Paris ,1974)	Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Norway, the Netherlands, Portugal, Spain, Sweden, UK, Luxembourg and Switzerland.	North-East Atlantic	Prevention and elimination of pollution of the marine environment in the North-East Atlantic, from land-based sources and by dumping from ships and aircraft.	JAMP (Joint Asessment and Monitoring Programme) Nutrient Monitoring Programme	No obligatory reporting
HELCOM Helsinki Convention 1974-1992	Czech Republic, Denmark, Estonia, the European Union, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia and Sweden.	Baltic Sea and Baltic catchment area	Protection of the marine Environment	COMBINE (Joint Comprehensive Environmental Action Programme of the Baltic Sea)	No obligatory reporting
Barcelona, 1975-1995	Albania, Algeria, Bosnia and Hergegovina, Croatia, Cyprus, Egypt, the European Union, France, Greece, Italy, Israel, Lebanon, Libya, Malta Morocco, Slovenia, Spain, Syria, Tunisia, Turkey	Mediterranean Sea	Protection of the Marine Environment and the Coastal Region	MAP, (Mediterranean Action Plan)	Different pace of the EU and non-EU countries
Bucharest Convention 1992	Bulgaria, Georgia, Romania, Russia, Turkey, Ukraine	Black Sea	Protection of Black Sea against pollution	BSEP (Black Sea Environment Programme)	Lack of resources

EU Environmental Directives related to coastal zones and marine waters, and their objective — Table 3.14.4

Directive	Objective	Main results of implementation
76/160/EEC, Bathing Water	Achieving/maintaining good bathing water quality as defined by a set of parametric values. Monitoring bathing water quality. Publication of monitoring results.	Due to increasing number of urban waste-water treatment plants, encouraging results. Certain problems still remain with inland waters.
*76/464/EEC, Dangerous Substances	Dangerous substances to be eliminated and the groups of dangerous substances to be reduced from community waters.	
* 78/659/EEC Fish water, amended by 90/656/ECC and 91/692/EEC	Water Quality for fish.	Proper implementation; however, scope of waters covered is rather limited.
* 79/923/EEC, Shellfish Waters	Quality of shellfish waters.	Proper implementation; however, scope of waters covered is rather limited.
* 80/68/EEC – Groundwater amended by 90/656/ECC and 91/692/EEC	Prevention of groundwater pollution caused by certain dangerous substances.	Proper implementation; however, scope of waters covered is rather limited.
82/176/EEC, The Mercury Discharges		Based on values Europe-wide.

* will be incorporated in the proposed Water Quality Framework Directive (COM (97)49)

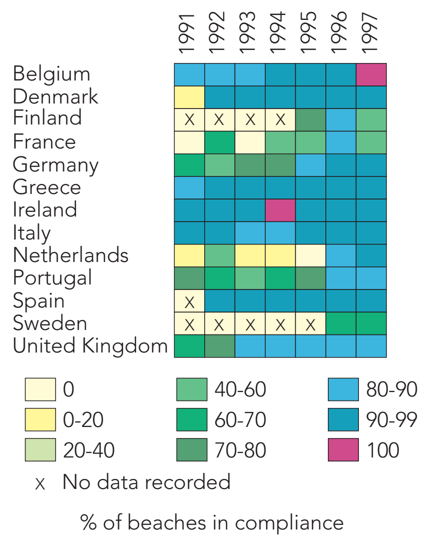
(see Figure 3.14.10). In 1997, more than 90% of EU bathing waters complied with the Directive's minimum quality requirements, leading to substantial environmental improvements for bathers and other recreational users in coastal areas. Measures to improve the bathing water quality have included increasing and improving advanced sewage treatment and the application of cleaner technology in industry, as well as a major control of deliberate and accidental disposal of waste and discharge of pollutants.

The proposed Water Framework Directive (see Chapter 3.5) is in line with the concept of integrated coastal zone management (ICZM) as it considers the entire river basin as the unit for the management of water and is designed to protect and enhance the quality of aquatic ecosystems. More EU Directives should follow this line of integration in the future.

4.2. Coastal zone management – sustainability still some way off

The lack of an effective integrated catchment and coastal zone management (CZM) has been recognised to be responsible of the degradation of coastal and marine environment. This lack of co-ordination not only concerns the horizontal relations between sectors of activity, but also the intermeshing of the policies and actions carried out at various levels of territorial Authority (local, regional, national or European). The integrated approach to CZM is still missing from most of the legislation at National level where a sectoral approach still dominates. Key areas of action for ICZM are environmental impact assessment, coastal land planning, habitat management and pollution control. Public awareness and participation are crosscutting themes in every coastal management effort and need special empha-

Bathing Water Directive compliance in EU countries during 1991-97 (percentage of beaches complying with at least the mandatory values of the Directive — Figure 3.14.10



The situation after the long implementation period is still improving, although results do not show consistency within the Member States.

Source: European Commission, DG XI

sis. Examples of good ICZM in the Netherlands, Poland and the United States, are shown in Box 3.14.3.

The need for better management of coastal zones has stimulated a growth of interest in ICZM at the EU level, especially in the last decade, and has led to political commitments and numerous measures, even though the tentative to launch an EU framework directive on ICZM was unsuccessful.

The current EU 'Integrated Coastal Zone Management Demonstration Programme' is a response to Council's request in 1992 for the overall Community strategy on integrated coastal zone management. It is a joint initiative of DG XI, DGXIV and DGXVI consisting in 35 projects, which, for the geographical distribution and range of problems encountered, represent the diversity of the ecological, economic and social situations of the European coastal zones. The Programme aims to:

- provide concrete technical information about the factors and mechanisms, which either encourage or discourage sustainable management of coastal zones and,
- stimulate a broad debate and exchange of information among the various actors involved in the planning and implementation of coastal zone management, including those at the local, regional, national and European levels.

The results of the 'The Integrated Coastal Zone Management Demonstration Programme' and the initiative of the Framework Directive for Water should provide concrete examples on how to tackle the coastal zone management issues as they occur in the Member States. However, although the EU might have a role in leading and co-ordinating the approaches to ICZM, decisions on management and implementation should be made locally, regionally or nationally (see Box 3.14.4 & 3.14.5). Only by maximising experiences and expertise at the local level and allocating budgets to projects which promote environmentally, economically and socially sustainable management can ICZM achieve the desired results.

Box 3.14.3 Marine and coastal environment in Cyprus: reasons for concern

The coastline of Cyprus is 784 km long. Sensitive coastal areas include sand-dune systems, banks of shingle, cliffs, and coastal wetlands, all of which are subject to intense pressure. Coastal ecosystems provide habitats for flora and fauna such as the seagrass *Posidonia oceanica* beds and sea turtle nesting areas. Sea turtles have been protected by Cyprus law since 1972. A turtle hatchery at Lara (beach area on the Akamas Peninsula), the only one of its kind in the Mediterranean managed under detailed regulations, has been in operation since 1978. This project was set up by the Government, partly financed by the EC´s MEDSPA project. The hatchery is a success and the Department of Fisheries releases into the sea approximately 6.000 hatchlings a year. The Lara beach area is protected by various specific measures for the period June to September. Regular sightings of the rare Mediterranean monk seal *(Monachus monachus)* have been reported in past years, but no breeding has taken place and it is uncertain whether monk seals have disappeared entirely from the Cyprus coastline.

As is the case with the rest of the East Mediterranean, the coastal areas of Cyprus are not rich in marine life. The lack of marine life is mainly due to the relative isolation of the Mediterranean Sea and its oligotrophic nature, rendering it more vulnerable to small inputs of nutrients and pollution.

Monitoring for tar on beaches and dissolved hydrocarbons in the sea water is carried out through the MEDPOL Programme. No port reception facilities for bilge or ballast waters exist in Cyprus, although regulations on their establishment and operation have been recently prepared. An oil-pollution combating unit is in place, a national oil spill Contingency Plan has been implemented and sub-regional oil combating arrangements have been established with Egypt and Israel, with EU support.

Under the Fisheries Regulations, standards have been adopted for substances in effluent and the environmental quality of recipient sea waters. There are also prohibitions on the disposal of lubricating and other oils and in the use of organotin-based anti-fouling paints in the marine environment. It should be mentioned that the greatest part of the marine waters of Cyprus is of very high quality and sea pollution problems are highly localised.

Tourism industry represents 18% of the Cyprus GDP. Up to 80% of foreign tourists visit the coast of Cyprus. Hence the pressure in coastal areas of Cyprus is growing and the fragile ecosystems are subjected to increasing misuse and over-exploitation. Tourist infrastructure development, urban expansion, industrial and port development, and road infrastructure development add to the pressures. Direct threats to the systems include localised domestic pollution, agricultural inputs, and, to a lesser degree, industrial and oil pollution. Excessive strip development along coastal areas has raised concerns that the carrying capacity of several coastal areas may already have been exceeded.

In addition, several other specific problems are also impinging on the well-being of species and ecosystems. These are: petroleum pollution and development of artificial beaches (breakwaters); aquaculture. In order to minimise local effects, aquaculture is now carried out 'offshore'.

Box 3.14.4 Examples of Coastal Zone Management

In the Netherlands the concept of restoring resilience of the coastal zone was launched in 1996 during public forums of major actors/stakeholders from the governmental, business, academic and nature conservation communities. Increasing natural resilience by restoring the strength of the buffer capabilities of the coastal areas is seen as a response to the increasing pressure of urbanised population and as an anticipation to the impacts of climate change, such as accelerated sea-level rise. The essence of this concept is to provide more space for dynamic coastal development in the different coastal compartments (dunes, coastal sea, urban waterland etc.) through drastically revising the water and sediment regimes and integrating the different functional uses of the coastal zone, land in water and water in land.

In Poland, by the 1991 Coastal Act, a coastal belt was established, consisting of a technical belt and a protective belt. Since 1996 effective mechanisms and co-ordinating activities were functioning. Especially in Poland, with its rapidly increasing economic development, the key issue in ICZM plans is the balance between natural dynamics and the pressure from economic and urban development. Finding this balance requires strong vertical and horizontal integration: co-operation between all responsible actors at different levels of government and different sectors of the economy and non governmental organisations (NGOs). Since March 1997 three Regional ICZM consultative bodies have been installed in which representatives of all levels of government, science, industry, NGOs and landowners participate. They stimulate co-ordination of activities in the coastal zone by initiating preparation of ICZM plans within the coastal 'voivodships' ('provinces').

The United States recognised the desirability of diversity. The US Coastal Zone Management Act 1972 sets out the basic objectives of ICZM, and requires American States to draw up coastal management programmes that will meet those objectives. However, it leaves each State free to choose its own methods, and consequently each has devised its own system. There is no necessity for each coastal State to have an identical system of ICZM, provided that the methods they adopt work and are capable of operating in harmony for the benefit of the coastal zone as a whole.

Box 3.14.5 Management plan for the Wadden Sea: how to preserve a unique environment without excluding people from the area

The natural environment

The Wadden Sea is an area very special and rich in wildlife shared between the Netherlands, Germany and Denmark. The landscape is characterised by a shifting pattern of submerged and exposed tidal flats, sandy beaches and dunes, low-lying salt marshes, sand and sediment, fresh and salt water, nutrient-poor saline soils in the islands, but also woods and grassland area. These varied conditions make the Wadden Sea an ideal habitat for flora and fauna: it is the most important area for waterfowl in North West Europe and the habitat for the largest population of common seals in the North Sea.

Human intervention ...

Many features of the landscape have been created over time by human intervention: for centuries people living along the coasts have practised small-scale land reclamation; a fair amount of land around the Wadden Sea has been recovered in the past with consequent reduction of salt marshes; the construction of dikes and embankments has created sharp divisions between areas of salt and fresh waters. These fixed constructions hamper the natural adaptability of the system to sea level rise and bottom subsidence and have reduced natural salt-fresh transitions.

... and activities

Fishery has always been an important activity: blue mussels are fished from the channels and the tidal flats, and used mainly as 'seed material' for mussel culture. Mainly in the Netherlands cockles are dredged from the flats. The deeper channels are trawled for shrimps. In years with low shellfish stocks food shortage for birds has occurred. There are strong indications that shellfish fisheries have been an important factor in the decline of mature mussel beds.

Beneath the bed of the Wadden Sea natural gas and oil are extracted and exploration licences for new gas fields are being negotiated. Due to the unique natural environment, hundreds of thousands of tourists visit the area, representing the major economic resource, but also a potential disturbance to wildlife and environment. In addition to maritime and air traffic, military activities take place in the area. Finally, the Wadden Sea receives the pollutants loads of several major rivers, including the Elbe and the Rhine.

'Management plan for the Wadden Sea'

The Dutch, Danish and German governments are keen to preserve the natural environment of the Wadden Sea, but unwilling to exclude people from the area. Already since 1978 a political cooperation framework between the three states is in operation. This has resulted in 1997 in the adoption of the Wadden Sea Plan (WSP) in which the accumulated agreements of the previous two decades have been integrated according to a catalogue of common Targets. The Targets aim at the conservation, restoration and development of all the out standing ecological features, through active intervention and through the regulation of those activities which can represent threats to the environment. Two examples: The Target 'to increase the area of wild mussel beds' has guided blue mussel fisheries in such a way that in principle no fisheries will take place on the tidal flats, providing chances for wild mussel beds to recover and guaranteeing food supply for birds. Also areas have been designated where mussel fishery is excluded. The Target 'to increase the naturalness of salt marshes' stimulates the reduction of artificial drainage and intensive grazing.

The Wadden Sea Plan invites all stakeholders to participate in discussing the way in which the Targets can be implemented. The open-end nature of the Targets leave sufficient room for such a dialogue. The results will be used in the process of evaluating the Plan in the period up till 2001, the year in which the next intergovernmental conference is due.

References

AMAP 1997. *Arctic pollution issues: a state of the Arctic environment report.* AMAP, Oslo, 188 pp.

ANON, 1997b. *Status report on the marine environment of the Barents Region.* The Joint Norwegian-Russian Commission on Environmental Co-operation. The Working Group on the Marine Environment of the Barents Region. The Norwegian Ministry of Environment, 97 pp.

ANON. 1997a. *The Norwegian North Sea coastal water. Eutrophication. Status and trends.* Report by Norwegian national group of experts, State Pollution Control Authority, Oslo, 90 pp.

Blue Plan, 1998. *Mediterranean Commission on Sustainable Development, Tourism and Sustainable Development in the Mediterranean Region,* Blue Plan (Conference at Antalya), 1998.

Brown J., Kolstad A.K., Lind B., Rudjord A. L., Strand P., 1998. *Technetium-99 contamination in the North Sea and in Norwegian Coastal areas 1996 and 1997.* NRPA report 1998:3 Norwegian radiation Protection Agency, Østerås, Norway.

Bryant D., Rodenburg E., Cox T., Nielsen D, 1995. 'Coastlines at Risk: An Index of Potential Development-Related Threats to Coastal Ecosystems,' *WRI Indicator Brief* (World Resources Institute, Washington, D.C., 1995).

CORINAIR Emissions Inventory, 1990 (1996 version).

Corine Coastal Erosion Project, 1998. *Corine Coastal Erosion Atlas.* Luxembourg: Office for Official Publications of the European Communities, 1998.

Council Regulation (EC) No 1075/96 of 10 June 1996 amending Regulation (EC) No 1626/94 laying down certain technical measures for the conservation of fishery resources in the Mediterranean (OJ No L 142, 15.06.1996).

Council Regulation (EC) No 1626/94 of 27 June 1994 laying down certain technical measures for the conservation of fishery resources in the Mediterranean (OJ No L 171, 06.07.1994).

EEA, 1996 (Modified from GISCO 1996). Pan-Europerean Administrative Regions 1:1 000 000. European Environment Agency, Copenhagen.

EEA, 1998. *Europe's Environment: Second Assessment.* European Environment Agency, Copenhagen. Office for Official Publications of the European Communities & Elsevier Science Ltd., 293 p.

EEA/UNEP-MAP (in press). Mediterranean Sea: Environmental State and Pressures.

Elofsson, K., 1997. *Cost effective reductions in the agricultural load of nitrogen to the Baltic Sea.* Beijer Discussion Paper Series No. 92: 55 p.

EUCC (European Union for Coastal Conservation), 1997. *The European Coastal Code – EUCC, Draft 2, 1997.* A Contribution to Action Theme 5 of the Pan-European Biological and Landscape Diversity Strategy.

EUCC (European Union for Coastal Conservation), 1997. *The European Coastal Code – EUCC, Draft 2, 1997.* A Contribution to Action Theme 5 of the Pan-European Biological and Landscape Diversity Strategy.

European Commission, 1994. *Cooperation for European territorial development (Europe 2000+),* Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1995. The prospective development of the northern seaboard. Office of Official Publications of the European Communities, Luxembourg.

European Commission, 1999 (forthcoming). *Economic assessment of priorities for a European environmental policy plan (working title).* Report prepared by RIVM, EFTEC, NTUA and IIASA for Directorate General XI (environment, nuclear safety and civil protection).

GEF/BSEP, 1997. *Marine Biological diversity in the Black Sea. A Study of change and decline*. Eds. Yu. Zaitsev & V. Mamaev. United Nations Publications, New York. 208p.

GESAMP, 1997. Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. *GESAMP Reports and Studies No 58.* 84p.

Grenon M. & Batisse M., 1989. *Futures for the Mediterranean Basin,* The Blue Plan, Oxford University press.

HELCOM Environment Committee (EC), 1998. Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and the Kattegat. *The state of the Baltic marine environment in 1998.* Summary report, published 2 October 1998.

HELCOM, 1996. *Third periodic assessment of the state of the marine environment of the Baltic Sea,* 1989-1993.

HELCOM, 1998. *Final report on the implementation of the 1988 ministerial declaration.* Balt. Sea Environ. Proceedings No. 71.

Interdisciplinary research in the Mediterranean Sea: *A synthesis of scientific results from the Mediterranean Targeted Project (MTP) phase I, 1993-1996.* Edited by E. Lipiatou. EUR 17787 EN, Research in enclosed seas series-1 . 1997.

Layton D., R. Edson, M. Varela, and B. Napier 1997. *Radionuclides in the Arctic Seas from the former Soviet Union: potential health and ecological risks. Arctic Nuclear Waste Assessment* Programme (ANWAP), Office of Naval Research (ONR), USA.

MAP/REMPEC, 1996. *An overview of maritime transport in the Mediterranean*. September 1996.

Rigg K, Salman A. Zanen D., Taal M., Kuperus J. and Lourens J., 1997. *Threats and Opportunities in the coastal areas of the European Union.* A Scoping Study. Report For the National Spatial Planning Agency of the Ministry of Housing, Spatial Planning and Environment, The Netherlands.

Sweitzer, J., Langaas, S. and Folke, C. 1996. Land cover and population density in the Baltic Sea drainage basin: A GIS database. *Ambio, 25 No 3:* 191-198.

Tiganus, V., 1997. Present state of marine biodiversity in the Romanian Black Sea Waters, p 61-62 in. *Mediterranean marine biodiversity workshop*, Nicosia Cyprus, 1-3 May 1997, CIESM,DGXII, NCMR.

UNCED, 1992. *Agenda 21*, ch.17, 44 pp

UNEP-MAP/Blue Plan, 1998. *Tourism and Sustainable Development in the Mediterranean Region.* Synthesis Report of the Working Group, Monaco 20-22 October 1998.

VASAB (Vision and Strategies Around the Baltic Sea 2010), 1994. *Visions and Strategies around the Baltic 2010: Towards a Framework for Spatial Development in the Baltic Sea Region.*

Zaitsev, Yu.P., 1992. Recent changes in the trophic structure of the Black Sea. *Fish Oceanogr.*, 1(2): 180-189.

Web sites

http://www.fws.gov/cep/coastweb.html

WRI1. World Resources Institute: http://www.wri.org/wri/enved/oceans/tgo-fact.html

Ministry of Transport, Public Works and Water Management, the Netherlands: http://www.minvenw.nl/

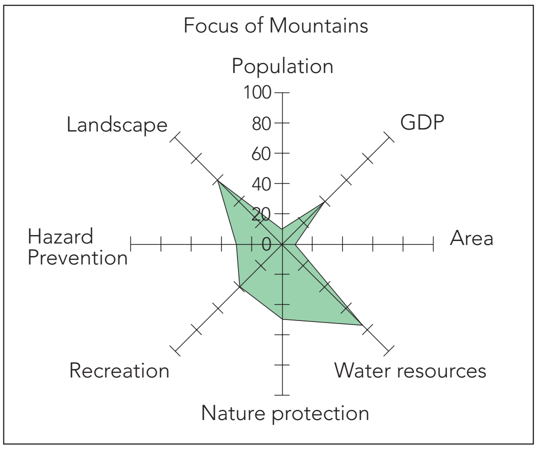
DG XI EU Demonstration Programme on Integrated Management In Coastal Zone 1997-99 europa.eu.int/comm/dg11/iczm/home.htm

Baltic 21, 1998. An agenda 21 for the Baltic Sea region. www.ee/Baltic21. http://www2.fimr.fi

3.15. Mountain areas

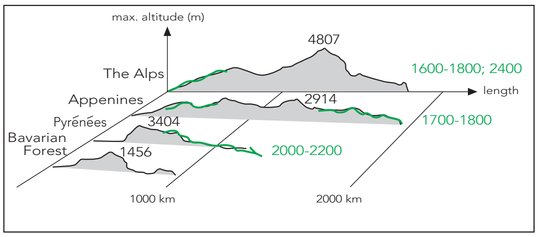
- The 'ideal world' of mountain areas is now threatened by socio-economic shifts, increasing tourism and traffic impacts, and changes in land use. In the Accession Countries more mountain areas must be expected to become endange red through rapid economic development.
- Environmental and social damage has already occurred or must be anticipated in mountain areas through significant changes in precipitation patterns, species and habitats distribution, changes in runoff rates, and water pollution, loss of soils and increase of man-made natural hazards.
- Present EU policies often exhibit inconsistency with respect to mountain areas and do not take adequate account of their special requirements.

Important Mountain Features in the European context illustrated by a qualitative estimation — Figure 3.15.1



Source: EEA

Overview of main features of some European mountain ranges — Figure 3.15.2



The top of the mountain is only part of the story. Mountain areas are systems of interlinked valleys, ridges and peaks. The phenomena of mountains is also a matter of altitude and slope. Diverse geology, geography and climate characterize European mountains. Despite their perceived remoteness, mountains offer an important dimension to rural, urban and coastal areas.

Source: EEA processing

1. Mountains – the undervalued ecological backbone of Europe

Mountains provide vital resources for the whole of Europe (Figure 3.15.1): for example, high runoff rates, and the storage and distribution of freshwater over time and space make mountains a major source for Europe's water supplies.

Mountain areas are important part of the ecological jewellery of Europe, providing aesthetic and recreational landscapes, high biodiversity of species and habitats embedded in sustainable land use systems. Extending through different altitudinal zones mountains have a wide variety of habitats, including – in the remotest regions in Europe – the last retreat for animals with large habitats. The extreme physical conditions make mountains a fragile environment, where natural phenomena, often increased by man-made land uses or misbehavior, interfere with human activities and then cause natural hazards.

Despite their remoteness, mountains suffer from direct and indirect pressures on their natural resources, many of which are interlinked, whose key factors are difficult to identify. Population change results from declining agriculture and few profitable income opportunities, furthering the trend of land abandonment. Transport networks, for which mountains constitute a barrier, tend to fragment the land, while tourism is both attracted by and damaging to mountain landscapes.

Mountain Areas vary significantly throughout Europe (Box 3.15.1). Sometimes these are isolated small mountains, often they are huge mountain massifs stretching over hundreds of kilometers, and providing an ecological backbone to much of the continent. For ther purposes of this chapter mountain areas are defined to include locations above 1 000m sea level (Figure 3.15.2), as well as all areas having a slope greater than 5 degrees, but excluding areas with a surface area less than 100 square kilometers.

Figure 3.15.3 **Mountain areas share in European countries**

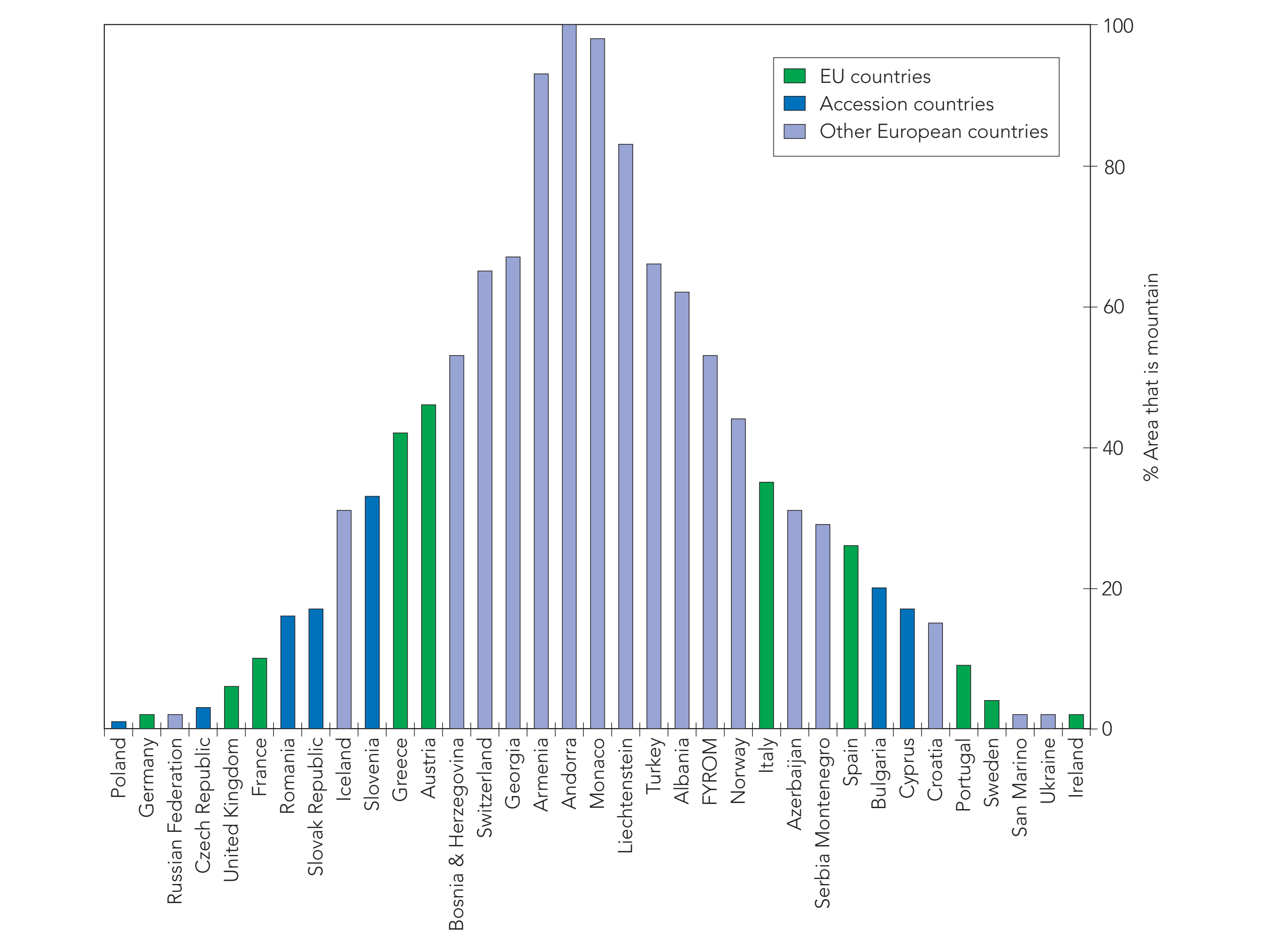
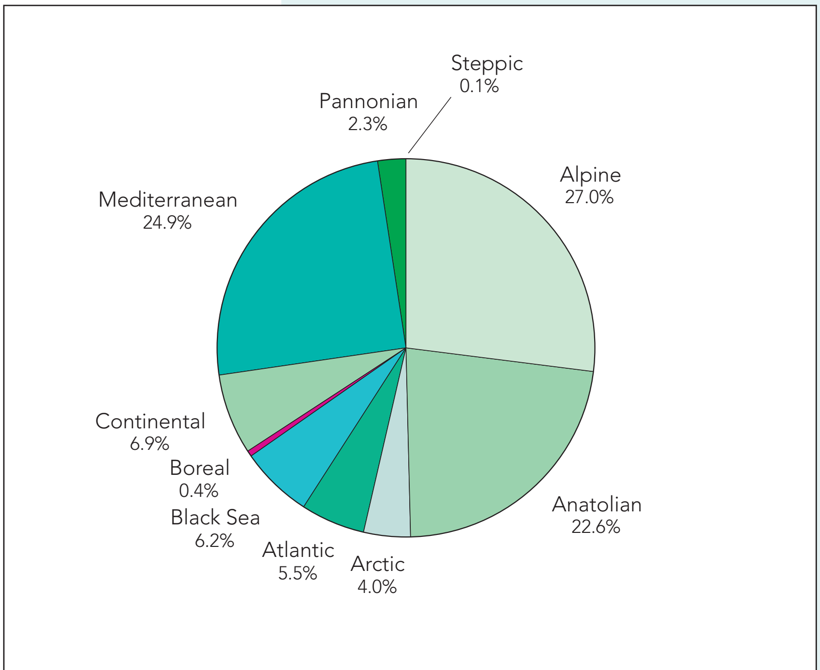


Figure 3.15.4 **Biogeographic regions of European mountains**



Talking of mountains means 14% of the EU and 11% of the Accession Countries' land area. Only few EU countries do not have mountainous areas such as the Netherlands, Denmark and Belgium; others such as Austria and Bulgaria, have a high proportion of mountain areas.
Source: EEA

Box 3.15.1 A glance over the thousands of European summits

In Europe mountains are found in the geomorphological zones of the Fenno-Scandinavian Shield and the central and southern European highlands. The eastern and central Europe Accession Countries will add new mountain areas to the EU nearly the size of Austria, for instance the Bohemian Forest, Carpathian Mountains and Rhodopes.

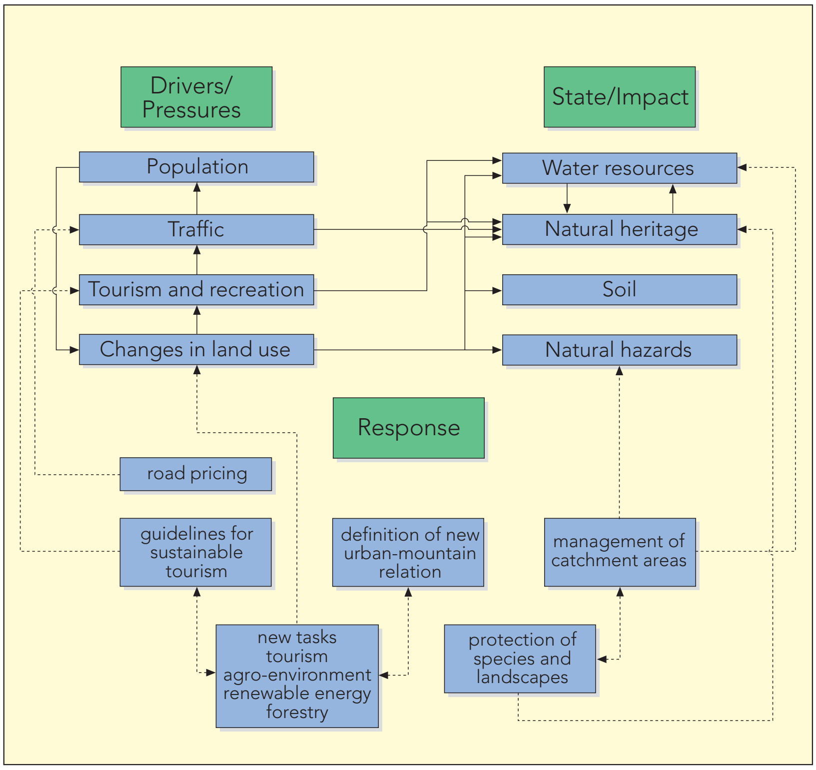
Although much of the available information on the mountain environment relates to the Alps, Europe has a great variety of mountain regions, from Scandinavia to Mt. Etna in Sicily, and from the vast Spanish sierras to the densely wooded Carpathians (Figure 3.14.3 & 3.15.4).

Distribution over biogeographic regions shows that mountains in the Mediterranean and Anatolian regions are in about the same abundance as in the Alpine region.
Source: EEA

Mountains are widely recognized as important and sensitive ecosystems, but little progress has been made in developing comprehensive policies, particularly at EU level, to build upon the good intentions set out in mountain charters. Although European policies were first applied to mountains in the 1970s (under the Less Favored Area, LFA, framework) and mountain areas are now subject to numerous EU, national and regional policies, there remains a lack of coordination between measures at different levels relating to various sectors.

Mountains are probably the most prominent examples where multifunctional land uses have partly still survived, but are now at risk. For mountain areas it is crucial to adopt a comprehensive, spatially integrated policy which is able to reflect and support the multifunctionality which has been the sustainable concept in mountains for many generations.

Interactions in mountain areas — Figure 3.15.5



Adapting the DPSIR framework to the special needs of spatial issues, some relevant relations in mountain areas may be highlighted by this simplified model. In general every policy action should bear in mind the network of direct and indirect interactions which is affected by the relevant policy.

Source: EEA

2. How can the environment of remote mountains be threatened?

Fragile environmental conditions have brought about highly adapted and sophisticated land uses. Demographic and economic changes (and particularly the growth of tourism) have complex effects which call for holistic responses (Figure 3.15.5).

2.1. What makes population, traffic, tourism and land use change the main driving forces and pressures in mountains?

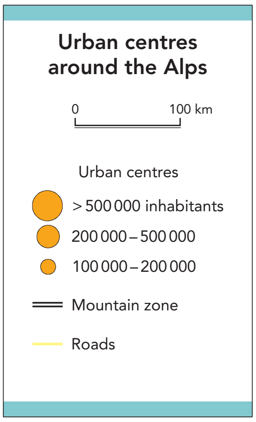
2.1.1. Population is outmigrating and overageing

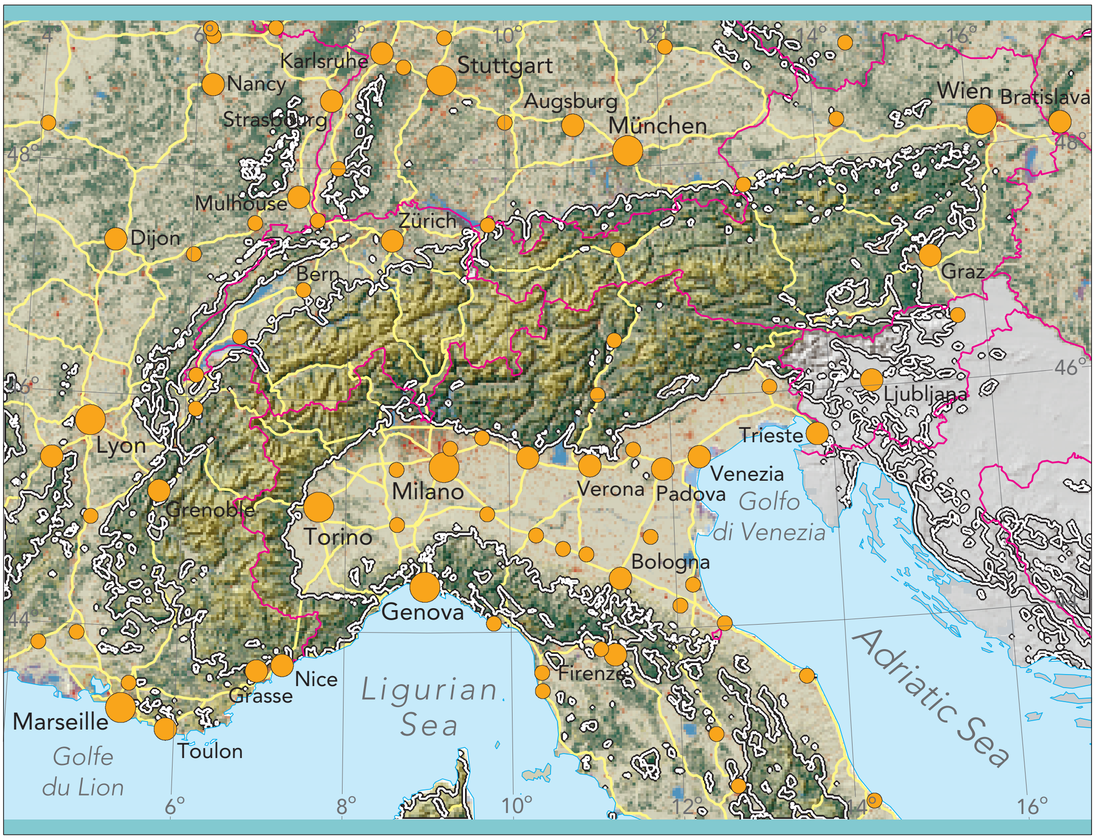
Many mountain areas have declining and ageing populations due to outmigration of workers, the use of residences as second homes, and inward migration of pensioners. Loss of population might reduce the capability for upkeeping the landscape and means an additional burden for suburban areas into which people are moving. Mountains also become subject of exploitation as a natural resource for urban consumption from lowland regions. There are at least 38 cities above 250 000 inhabitants close to mountain ranges in the EU and Accession Countries, such as Milan, Geneva, Birmingham, Rome, Granada and Thessaloniki (Map 3.15.1).

Population density varies considerably with altitude, so that some mountain areas are extremely sparsely populated, and comparable to Arctic regions, while the densely inhabited valleys have similarities with lowland regions. In 1990 the vertical distribution of total alpine population concentrated 93% below 1 000 m above sea level (a.s.l.), 53% below 500 m a.s.l., and only 7% above 1 000 m (Bätzing, 1997). Another aspect of population density is a significant variation with seasonal or daily peaks, i.e. summer and winter tourism inside mountains, international holidays or short weekend trips from surrounding city dwellers.

The shift and migration within mountain countries can be illustrated by some Alpine countries. In the period from 1870 to 1990 the Alps experienced a total population increase from 7 million up to 11 million people, but the proportion living in mountain areas dropped from 7.4% to 5.8%.

Population changes are connected to changes of employment opportunities and structures. The shift from a traditional multifunctional and multi-sectoral way of living of mountain people to external employment and enterprises is, besides insufficient infrastructure, a main reason for population changes. This means in general terms a shift





Map 3.15.1
Urban settlements around mountains; the example of the Alps

Source: EEA, GISCO – Eurostat

from the primary to the tertiary sector. This trend has special significance in mountain areas, where often traditional and sustainable activities are substituted by pure economically orientated activities. For example formerly multi-skilled mountain people working in agriculture, forestry, pastoralism or dairy farming are now employed in the tourist business or industry. Thus agriculture alone is no longer an economic pillar for mountain towns.

These changes in employment may be highlighted by the area of Aletsch in Switzerland. Here the primary sector dropped from about 70% in 1950 to 12% in 1980, tourist accommodation increased from about 65 beds in 1940 up to 7 250 beds in the 1980s. About 900 local residents now cater for about 700 000 overnight stays per year (Messerli, 1989).

2.1.2. Tourism and recreation in mountains: a double-edged sword

Promoted as an economic incentive for remote areas, tourism has in some mountain regions evolved monostructured, vulnerable economies, and generated pressures on the environment. Notwithstanding the vogue for 'green tourism', intensive, environmentally threatening tourism continues to develop; a similar trend can also be expected in Accession Countries. Tourism and recreation facilities exert pressure on the environment through land-use development and increased road traffic. Additionally, many outdoor sports affect the more undisturbed and nearly inaccessible areas such as gorges or rock faces (Garcia-Ruiz, Lasanta-Martinez, 1993; Lichtenberger, 1979).

The economic importance of mountain tourism is illustrated by a Greek study which estimated that the recreational value of mountain areas is 10 times greater than the value of forest timber (Vakrou, 1998 quoted in EOMF, 1998).

Tourism development varies considerably. In the Alps, for instance, only 10% of all Alpine communes have large monostructured tourist infrastructure and 40% have no tourism (Bätzing, 1997), and since the mid-1980s figures for tourism have been stagnating or decreasing in some Alpine regions, after several decades of steady growth (Elsasser/Frösch/Finsterle, 1990; Bätzing, 1990; Romano, 1995). Nevertheless, there are plans for further tourist facilities, such as ski runs in the Pyrenees and developments to cater for new recreation activities, particularly in the Accession Countries where tourism is important as a source of foreign exchange.

2.1.3. Traffic networks are governed by needs outside mountains

Transport infrastructure development (Figure 3.15.6) has often facilitated outmigration or commuting to urban centres and increased transit and tourist traffic, particularly day tourism in the catchment areas of big cities.

For instance nearly 150 million people a year are crossing the Alps, 83% by road and 17% by railway (Figure 3.15.7). A rapid increase in long-distance traffic crossing the Alps is expected at a rate of 100% for freight and 50% for passenger transport within the next 20 years (European Commission, 1994; CIPRA, 1998).

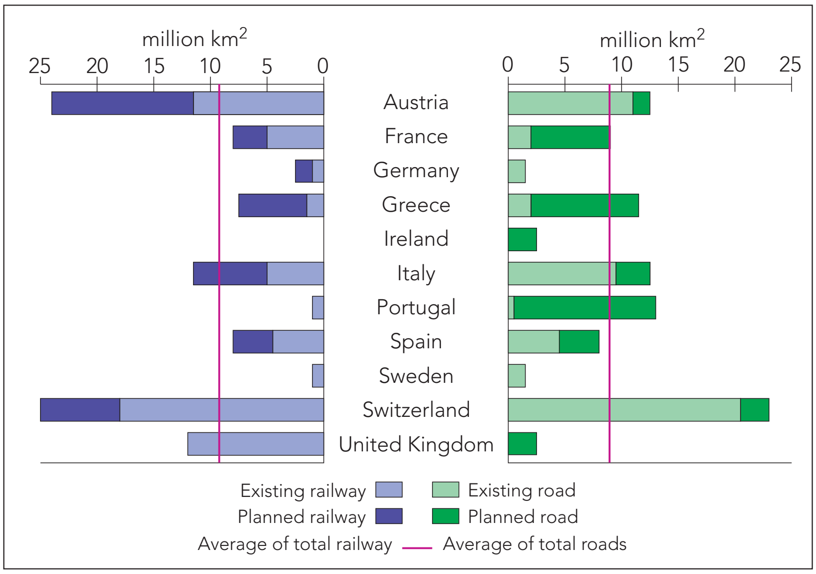
Traffic network impacts are concentrated in valleys where people live. It is therefore not surprising that two-thirds of the Alps' population suffers from traffic noise. In Tyrol 87% of high ozone levels are caused by traffic and in the 1980s lead concentration in mother's milk close to the Brenner motorway exceeded other regions by seven times (Rhomberg, 1998). Other traffic-caused impacts are fragmentation of untouched areas, deterioration of recreation areas, and socio-economic, double-edged effects such as better accessibility to mountains or changing competition between mountains and lowlands. While transport network density is higher in the Alps than in other European mountain ranges, rapid increases may be expected for Accession Countries' mountains.

There have been calls in mountain areas for better integration of transport and compensation for environmental disbenefits, and protests by local populations have resulted in highway blockades, for example on the Brenner Pass (between Austria and Italy) or the 1994 plebiscite in Switzerland on freight transport.

2.1.4. The sustainability of land uses is set at risk

Mountain agriculture has responded to economic pressures in two ways (Box 3.15.2). One reaction is intensification, in the valleys and on high mountain pastures and good accessible slopes shifting from extensive meadows to intensively grazed pastures. The other is extensification in terms of abandonment or afforestation. Both these changes cause a significant decline in biodiversity and root density. Land abandonment will induce snow gliding, changes in water storage capacity and water transport in soils, the onset of soil podzolisation and a potentially higher frequency of natural hazards (Cernusca *et al.*, 1996, Höller *et al.*, 1998).

Trans-European Network (roads and railways) in mountainous countries — Figure 3.15.6



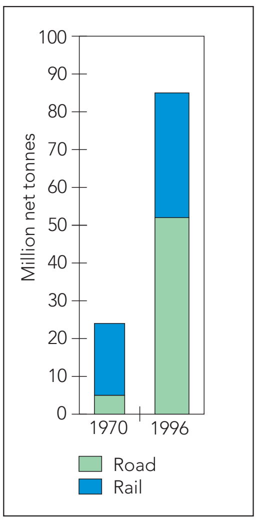
Here an index of meters of road/railway per km² of mountain area shows where increases of infrastructure and changes of modal split exist and are planned.

Source: EEA, European Commission (TEN)

Forest areas extend through natural re-growth on abandoned farmland or afforestation (Figure 3.15.8). Forests are, of course, often the main natural land cover in mountains. Depending on the new forest type, local conditions and existing biotopes, changes may positively or adversely affect species diversity, landscape attractiveness and tourism.

In the eastern and central European countries, changes are driven in particular by the transition towards a market economy.

Freight transport in the Alps (1970-1996) — Figure 3.15.7



The trend of freight transport per year through the inner Alpine arch, between Mont Cenis/Fréjus and Brenner shows an overproportional shift towards road transport.

Source: CIPRA

Box 3.15.2 Evolution and change of land use in the Alps (after Bätzing, 1990)

Over time different, highly adapted land-use systems slowly evolved the Swiss Alps, under the harsh and hostile conditions of the mountain environment, in which land mismanagement can have disastrous consequences.

Main features in the Swiss Alps as derived from Messerli (1989)

4000 B.C.	Transhumance starts (migrating shepherds). Roman and German mountain agriculture. Walser and Schwaighof economy.	
14th/15th century		Forest degradation through clear-cutting and overuse; increase of rock falls and avalanches.
16th/17th century production; wealthy communes.	Boom time of cheese and cattle overgrazing and degradation of pastures.	Population increase causes
19th century	Start of some industrialisation for use of charcoal and hydropower in eastern Alps; collapse of traditional, multi-functional land use.	Forest degradation through clear-cutting for industry (charcoal), grazing in forests and overuse; increase of floods.
20th century	From 1920 beginning of tourism in belle-epoque hotels; from 1950s broad tourism trend.	Tourism, ski tourism in particular; forest degradation through air emissions; land set-aside; cause increasing erosion.

Generally Alpine land-use systems followed principles which maintained a sustainable cultural landscape and probably achieved in modern terms 'sustainable development'. Guidelines included careful site selection, examination of the suitability for land uses, and a high proportion of land restoration and maintenance, requiring responsibility and high human labour input.

Certain environmentally relevant measures were defined, such as forest protection to prevent rock falls and avalanches (e.g. in Andermatt, Switzerland, 1397); definition of number and type of livestock for pastures at different altitudes and limitation to areas available for winter fodder in the valleys. Permanent restoration such as collecting rocks from pastures, removal of forest regrowth, seeding of open soil patches and fertilizing were practised.

Similar systems are reported also for the Pyrénées, Vosges, Black Forest, Scandinavian Mountains and Dinaric Alps.

The traditional knowledge of land management, still a living example of sustainable development, is rarely taken seriously, more appreciated as a touristic attraction and at risk of disappearing; for economic reasons, intensive land uses, such as mass tourism, do not favour sustainable development.

In future it seems likely that polarisation within mountain areas between very intensively developed, economically prosperous regions and remote, marginalised ones will continue. Certainly there are some promising attempts to promote new, multi-functional land-use models, but it remains questionable whether these will succeed as widespread solutions.

Pastures are enlarged by the cutting of subalpine forests and shrubs, notably in Albania, Bulgaria, Romania, Slovenia, Slovakia and the Ukraine. Hunting tourism causes the overgrazing of some forests by deer (Price, 1995).

2.2. The environmental state of sensitive mountain areas is a valuable indicator for the whole of Europe

2.2.1. Mountains are the first to be hit by climate change

The prospect of climate change (see Chapter 3.1) has significant implications for mountain environments. There are likely to be also indirect effects on human populations and ecosystems in adjacent plains, particularly arid and semi-arid regions with irrigated agriculture dependent on water supplied from mountain areas (Price/Barry, 1997). For Swiss mountains an accelerated structural change in mountain farming is expected with threats to the survival of small mountain communities, due to comparative disadvantages of mountains relative to valleys (Jeker, 1996; Flückiger, 1996). But effects of climate change depend on interaction with other factors and can be worsened or eased by human action. The extent of environmental and economic damage will depend on the resilience of mountain landscapes to buffer the expected extreme weather events. This can be achieved through good landscape maintenance such as through mountain forestry and pastoralism (Breiling/Charamza/Skage, 1997).

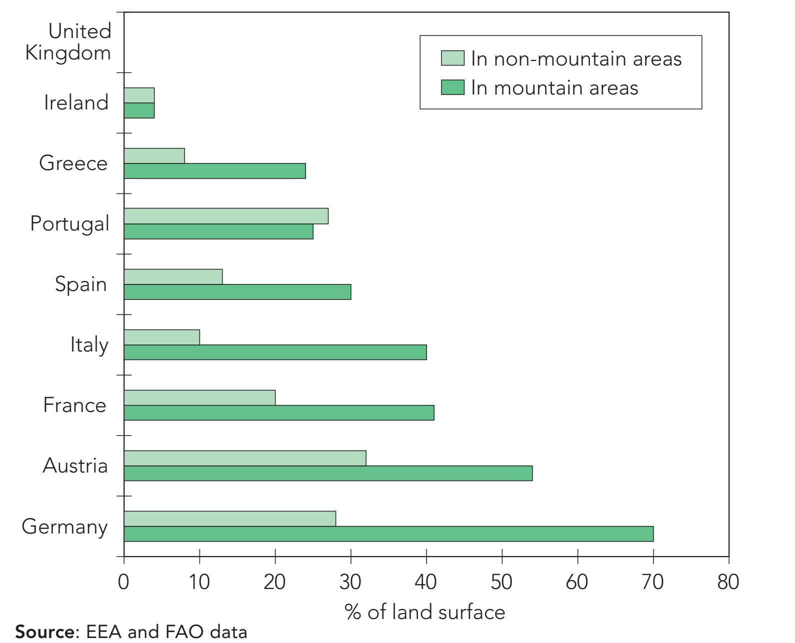
Mountain areas represent within a relatively small area different climatic belts linked to altitude, and are therefore highly sensitive to any climate change (Figure 3.15.9). With an anticipated global warming of about 2-3°C by 2100, higher-altitude ecosystems probably would suffer the greatest impact of global warming through eliminating the entire alpine belt, including the nival zone. An impoverishment of (present endemic) species and biotope fragmentation would be the result of this process. Temperature increases and changes in precipitation patterns would cause changes in snow cover and water reserves, soil instability through reduction of permafrost soils, and also influence the frequency of natural phenomena such as mudflows, floods or droughts (Guisan *et al.*, 1995; Ruberti, 1994; Dubost/Zingari).

Variation of precipitation patterns and water supply might influence agriculture or stock breeding through changes of suitable pasture or fodder for grazing animals.

Changes in snow cover and snow duration may have severe effects on winter tourism. Also without a real change, climate variability will have serious effects (Breiling/Charamza/Skage, 1997). One study predicts that in Switzerland the number of economically viable ski resorts and ski lifts will decline by 67% to 44% (Abegg/Elsasser, 1996). About 3% to 4.5% of Austrian GNP depends on winter tourism: it is estimated that about 10% of Austrian winter tourist revenues are directly lost by a warming of 1.5 degree Celsius (Breiling, 1994) – and that indirect losses are three times higher. On the other hand, regions at higher altitudes with better snow conditions may experience an increase of winter tourism, leading to economic disparities, uncontrolled development and increasing environmental damage (Breiling/Charamza/Skage, 1997).

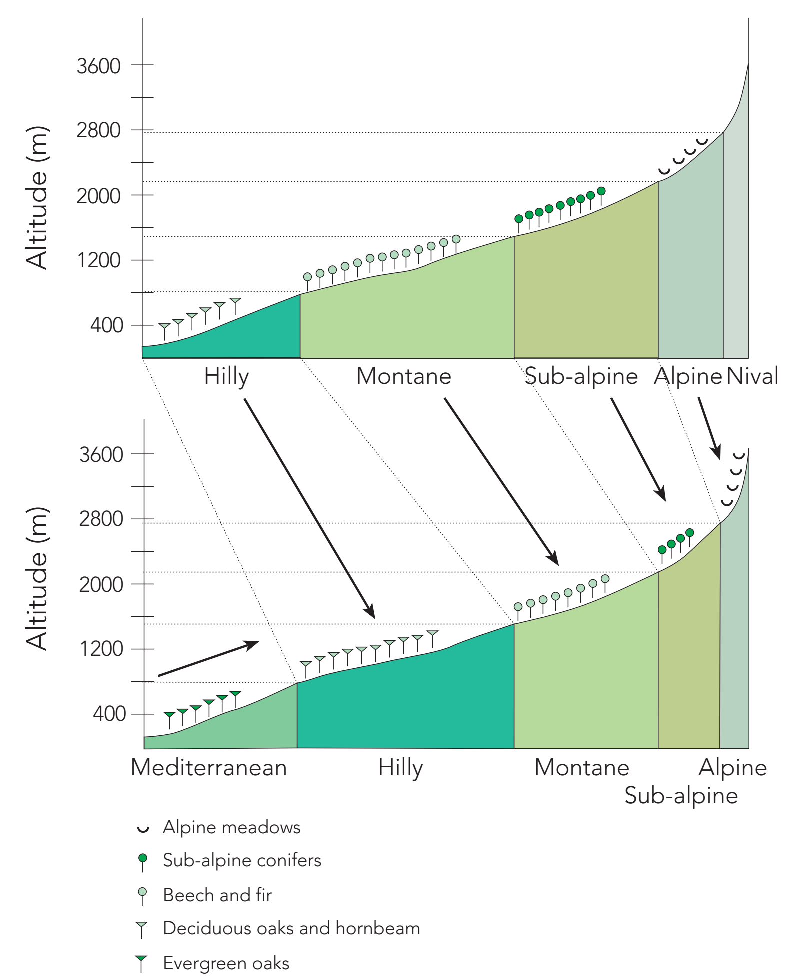
In the Fennoscandian Mountains, the potential alpine zones in Norway might be reduced to a quarter of their present size, followed by endangering of, or strong competition between animal species (e.g. lemming, red fox, arctic fox), due to the reduction of their current habitats. In the Southwestern Alps, a progressive decrease in

Forest shares inside and outside mountains Figure 3.15.8



Source: EEA and FAO data

Climate change: vegetation can be forced upwards in higher altitudinal belts Figure 3.15.9



It must be assumed that each vegetation belt would be replaced by the neighboring zone below, except for some fragmented areas in the Pyrenees and the Alps (i.e. Mont Blanc).
Source: Guisan et al. (eds.), 1995

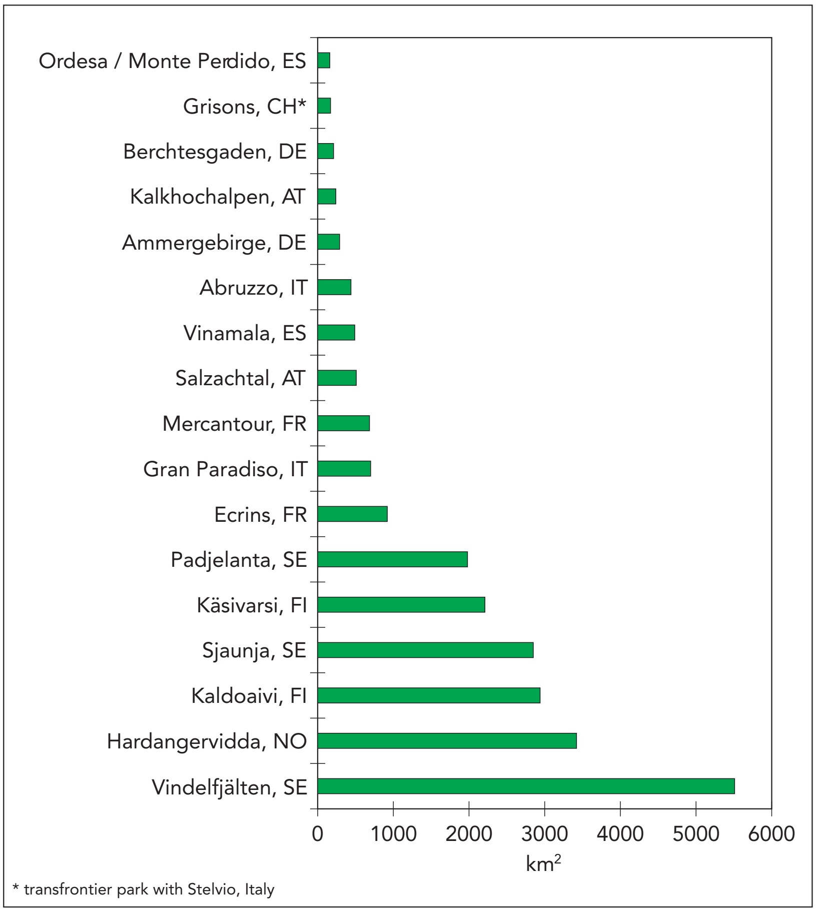
precipitation is expected with steppe-like vegetation patterns. In general, the Mediterranean climate might spread further northward and upward endangering Alpine plant communities and causing extinction of some European tree species in the Central Alps (Guisan *et al.*, 1995; Ruberti, 1994; Dubost/Zingari).

2.2.2. Mountains provide an interwoven natural and cultural heritage

Large unfragmented areas are an important but steadily declining resource, and, while some of these areas enjoy legal protection, there are considerable differences between regions (Figure 3.15.10).

Five of the largest unfragmented (and protected) areas are located at the periphery of the EU, such as in Scandinavia where pressure from population, land use and traffic is relatively low, while protected areas in Middle-Europe (Alps, Middle Mountains) are generally smaller. Unfragmented sensitive areas are often still unprotected (national parks cover only 4.2% of the Alps; CIPRA, 1998). The Accession Countries at present have large unfragmented areas.

Figure 3.15.10 **Range in size of protected mountain areas**



Sizes of selected unfragmented protected areas in different countries of alpine biogeographical region (IUCN categories I-IV serving primarily nature conservation functions, WCMC and Common Database on Designated Areas, EEA).

Source: EEA

Besides their importance for conservation of wildlife and biodiversity, large unfragmented areas offer non-material values such as areas of silence, low emissions of pollutants, natural beauty and wilderness perception. European mountains may be considered as an ecological 'green' network offering migration corridors and guidelines over long distances.

The number of areas in the Alps above 1 500 km^2 not touched by major transport infrastructure dropped from 31 to 14 between 1963 and 1993 (CIPRA, 1998) implying the loss of characteristic species and of species requiring large areas to survive (see also Chapter 3.11). On the other hand, the setting-aside and abandonment of land may in some areas lead to growth of unfragmented areas, as reported from some French Alpine valleys, although land abandonment can harm biodiversity.

Human impacts have often created new ecological conditions in mountain areas, contributing not only to the diversity of landscape character but also generating ecosystems which house a high species diversity. In the Pyrénées 30% of the land below 1 600 m above sea level was cultivated in the last century (Garcia-Ruiz; Lasanta-Martinez, 1993), while approximately 70% of the Alpine region is influenced by human land use (CIPRA, 1998). Besides human impacts on natural or semi-natural landscapes (e.g. lowering timberline in mountains), different land use practices created a great variety of cultural landscapes adapted to existing physical conditions in mountains. Landscapes such as terraces, alpine pastures, Coltura Promiscua in the Appennines and in Portugal, hedge-dominated landscapes such as the 'Egartenlandschaft' in the Bavarian Alps or Chestnut woods in the southern Alps and Cévennes have arisen, giving a distinctive character to regions or local areas.

Cultural landscapes in mountains can be kept stable only by continuous farming suited to local conditions. They are declining due to worsening economic farming conditions, becoming more a subject of government maintenance than of private enterprise, but are discovered by tourism as a relevant resource. Especially endangered landscapes are traditional extensive livestock farming systems (Petit *et al.*, 1998) e.g. alpine and subalpine pastures, arctic and alpine dwarf shrubs, or transhumant grazing, which disappeared completely in the Pyrénées (Garcia-Ruiz; Lasanta-Martinez, 1993).

Mountains also house a large number of ecosystems, species and genetic variety. They have the highest concentration of habitats of most significance for conservation in the EU (Zingari, 1994), with almost 25% of habitats of European interest – of 169 habitat types (defined in Annex I of the Habitats Directive), 42 occur only in mountain areas (Hopkins, 1998). Natural and semi-natural habitats cover a large percentage of Europe's mountain area, while intensive agriculture accounts for only a small proportion (Figure 3.15.11). In Accession Countries, coverage of semi-natural and natural habitats in mountain regions is generally lower than in the EU.

Although biological diversity increased in the last century in Europe, this trend has been reversed in recent years, due to changes in traditional land use: in the Alps a tremendous reduction of species and habitats use is reported (Brugger and Messerli in Zingari/Dubost, 1996).

Mountain areas in particular have become a retreat for species originally distributed in larger areas such as brown bears, wolves, lynx and wild reindeer. The re-immigration of bears since the 1970s from southern Slovenia into the Alps has been confirmed and demonstrates the eligibility of mountains as interlinking ecological networks. Eight of the 35 mammal species listed under the EU Habitat Directive occur predominantly or entirely in mountains (Hopkins, 1998) – information concerning species diversity in mountain areas is mainly available for higher plants (Figure 3.15.12) and mammals. Isolation of populations during ice ages has caused evolution of endemic species, when species were pushed back on areas free of glaciation. For this reason some European mountain ranges (mainly Mediterranean mountains which remained free of glaciation) form centres of plant endemism. They host (predominantly or completely) two-thirds of the continent's flora (Ozenda, 1994 cit. in Dubost, Zingari).

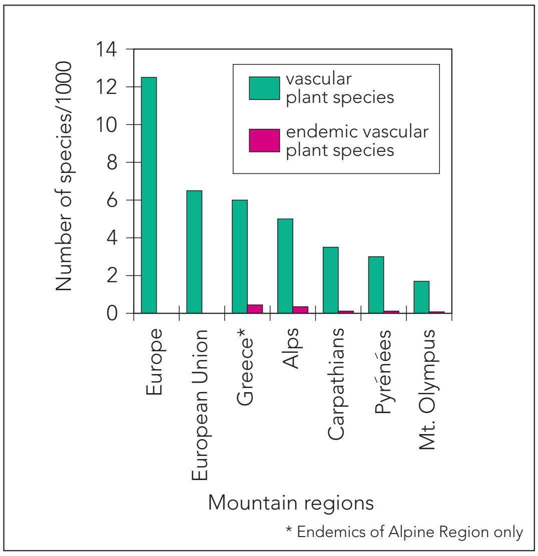
As mentioned in Chapter 3.11 the maintenance of genetic resources is important in many respects; reduction of gene pools may be a risk for the future, in view of adaptation possibilities to future environmental changes. The loss of genetic diversity by

Illustration of land-use intensity in mountains Figure 3.15.11

Relation of agricultural and semi-natural areas inside and outside mountains, considering the relevant area.

Source: EEA

Number of vascular plant species in European mountains Figure 3.15.12



Mountains are inhabited by a remarkable proportion of European species of vascular plants. Endemic plant species in mountains can be estimated for only the five mountain ranges in the figure to make up about 30% to 42% of the vascular plants occurring only in Europe (depending on the estimated number of these). Here one has to consider that mountain ranges in total cover only 14% of Europe.

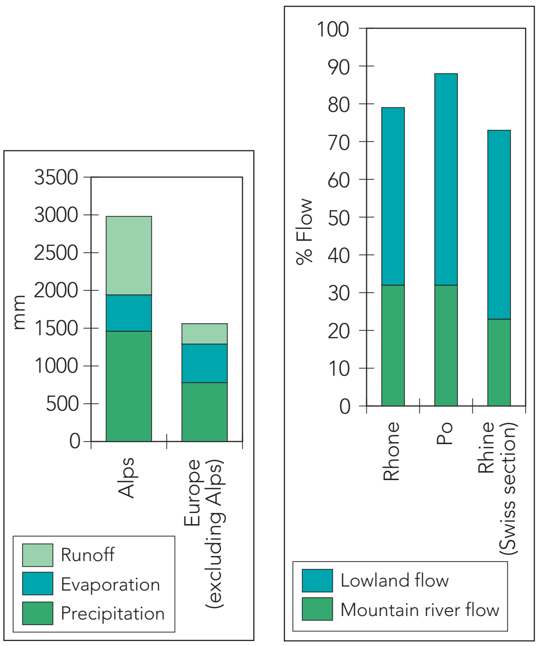
Source: Stanners & Bourdeau, 1995; Ozenda, 1988; Blandin, 1992 disturbance of gene pools also occurs in mountains, such as with the chamois subspecies cartusiana of the French Alps hybriding with the common, introduced chamois subspecies rupicapra, or hybriding between wild and domesticated reindeer in Norway.

2.2.3. Mountains are the watertowers of the lowlands

The water resources of mountains cover the most vital functions of mountain and lowland people (Figure 3.15.13). Notable functions are the provision of high-quality freshwater, irrigation water for food production, the economic value of hydropower generation, and water supply for natural wetlands in plains. But these benefits of mountain waters are threatened by degradation of water quantity and quality, and discontinuity of flow. The growing demand for water, mainly in eastern and southern European countries, as shown in Chapter 3.5, will make the preservation of these functions of paramount importance in future.

Mountain height enables water to flow to far distant areas and to serve as a source even for semi-arid areas, while seasonal differences in the flow regime of rivers are attenuated by the temporal distribution of mountain water. The rainfall in high mountains may be stored in ice, snow or mountain lakes; for instance in Switzerland 136 km^3 of rainfall are stored in lakes and reservoirs and 74 km^3 in glaciers – five times the total annual outflow from Switzerland (Mountain Agenda, 1998). In spring and summer the discharge of mountain rivers supplements the earlier high flows of the lowland section which occur in winter and autumn.

Figure 3.15.13 **Importance of the Alps for the water flow in Europe**



In the Alps precipitation is higher and evaporation is lower than in the average of Europe. Therefore the Alps produce higher runoff rates. As a result, small mountain areas are responsible for an overproportional flow of rivers in lowlands as shown for the rivers Rhône, Po and Rhine

Source: EEA; Mountain Agenda, 1998

Relatively unpolluted rivers, in terms of chemical and biological quality, generally are situated in catchments in mountainous and forested regions where the population density is low. Lakes in mountains also represent some of the least nutrient-polluted freshwater in Europe. However, high-altitude lakes are known to be subject to acidification (Stanners, Bourdeau, 1995).

Pollution of mountain rivers occurs through waste-water discharge, or water abstraction. Other impacts work indirectly such as accelerated surface runoff caused by surface sealing for infrastructure, soil changes through land-use abandonment, less water storage through deforestation or air-pollution induced forest damages. Natural extreme rainfalls then become extreme strong runoffs, which are linked to natural hazards discussed later in this chapter. But higher runoff rates do not only change the quantity but also may worsen the quality of water by diluting sediments and eroded soil.

Runoff rates are also affected by river channelisation for flood control of towns or protection of farmland in valleys, damming for water storage or hydroenergy generation. The change in water flow will be followed by alterations in physical, chemical and biological parameters, such as sediment discharge, bank erosion and reduced or altered biodiversity of riparian zones, for example if fish spawning areas are destroyed. The effects of these changes on the hydrological system call for a common watershed management framework for mountains and lowlands.

From a technical viewpoint mountain valleys are well suited for hydro-energy and water-storage reservoirs because of their steep gradient and 'natural' damming in the valley, which reduces construction requirements; however, there is often a noticeable environmental cost (Figure 3.15.14).

Reservoir construction involves the loss of farmland, changes in natural habitats and landscape, a rise in groundwater levels and a change in microclimate. The river will turn into a hybrid between river and lake and the environmental conditions such as current, nutrients and light will change. Environmental problems of reservoirs include contamination, eutrophication, difficulties of fauna migration, sediment trapping, water-level variations and a loss of biological biodiversity (Kristensen, Hansen, 1994); Leonard, Crouzet, 1998). Assessments by the European Topic Centre for Inland Waters suggest that reservoir construction in Europe is stagnant after a period of strong increase mainly in southern European countries.

2.2.4. Soils in mountains – demanding multi-functionality

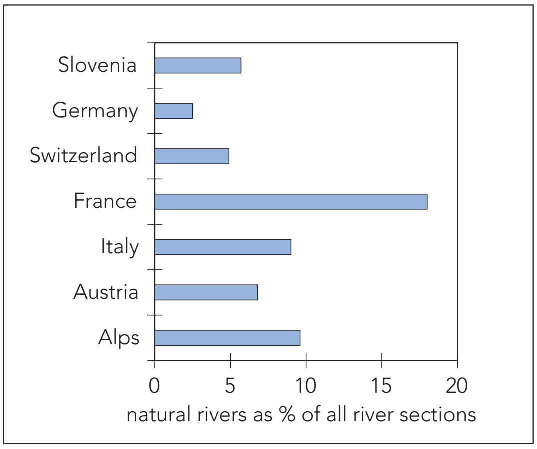
In mountains soils at higher elevations are quite different in terms of temporal development, stability, and thickness of topsoil from soils in lowlands (see also Chapter 3.6). These features make soils in mountains more sensitive to degradation and require specific adapted land-use patterns which are often met by the traditional silvo-agro-pastoral land uses.

The development of soils in high mountains shows certain characteristics different from lowland soils:

- soils develop more slowly because of lower temperatures, a short vegetation period and frequent interruption by erosion; consequently soils are not highly evolved types, such as lithosols, rankers and rendzinas which often consist of only a shallow soil layer covering the geological substrata; soil types often occur according to elevation belts;
- shallow soils allow land use mainly as grassland or forestry;
- soil generation, predominantly by physical processes, causes the so-called 'catenas' phenomenon in mountains, featuring different kinds of soils according to the gradient (Ozenda, 1988). Different geological layers and ice-age substrates serve as parent material for soil generation, which produces complex mosaics of different soils on a single mountain slope (Ellenberg, 1982, Ozenda, 1988). These features contribute to the considerable diversity of mountain ecosystems;
- in humid climates leaching of nutrients into lower soil layers is frequent where the nutrients are no longer accessible for vegetation; in the alpine and sub-alpine belt grazing, cutting and constant input of natural fertilizers balances the natural phenomenon of podzol-evolution (Messerli, 1989).

Mountain soils are mainly affected by degradation through erosion and (on acid parent

Natural sections in Alpine rivers Figure 3.15.14



According to the criteria of pristine water quality and a nearly untouched river flow, the example of Alpine rivers highlight the loss of natural sections. Only 10% of Alpine rivers, which is about 900 km, may be regarded as natural rivers, mainly due to the absence of hydropower. The ecological quality of river courses depends – among other things – on the diversity of river beds and minimum flow.

Source: Fabrice, Dubost, 1992

material) through acidification and pollution (Stanners, Bourdeau, 1995). Mountain soils are highly sensitive to erosion because of the shallowness of soil layers, the long time frame for their development (up to 4 000 years for mature soil) and the risks of natural hazards due to increasing soil erosion. As shown in the potential risk map in the *Dobris* report, mountain areas present a large proportion of the potential high-risk areas in Spain, Portugal, Greece and Italy (Stanners, Bourdeau, 1995). In areas with non-calcareous bedrock and abundant coniferous forests or alpine shrubs, soils are more exposed to natural acidification and are thus particularly susceptible to artificial acidification.

Steep slopes, frequent torrential rainfalls, and pressures such as unsustainable forestry, overgrazing, loss of traditional agriculture, land abandonment and fires are most abundant in mountain areas. In addition to overgrazing due to increased livestock and clear cutting, recent causes of soil erosion and compaction include tourism and sporting and recreational activities (walking, skiing, mountain bikes, off-road vehicles, etc.). Indirectly, soil erosion may cause contamination of surface- and ground-water. Deposits of eroded materials in riverbeds, lakes and water reservoirs might increase flood risks and can damage infrastructures such as roads, railways and powerlines.

2.2.5. Living with risks – natural hazards in mountains

The extreme environment makes mountain areas prone to natural phenomena such as landslides (Table 3.15.1), rockfalls, mudslides, avalanches, floods and earthquakes (see also Chapter 3.8). The stability of the slopes is often

Table 3.15.1 **Landslide disasters 1995 - 1998**

Area affected	Frequency	Events	Victims / Costs
Switzerland: Bristen, Obwalden, Villeneuve, Tessin, Glarus, Grisons, Vaud, Ticino, Fribourg, Tödi, Randa, Lärch	12	landslides; mudflows; rockslides; rockfalls; severe storms; heavy rains; hail; forest destroyed; roads, railroads buried/blocked; houses flooded; cars damaged; power and drinkingwater supply interrupted.	injured: 8; > 71.7 M euro;
France: Salle-les-Alpes, Dieulefit, Briancon	3	landslides; rockfalls; heavy rains; severe storm; roads and railroads buried; houses, cars damaged.	injured: 2
Liechtenstein: Triesen	1	mudslide; severe storm; 50 houses affected, roads closed.	2.3 M euro
Austria: Braz, Stubachtal, Lienz	3	landslides; rockfall; heavy rains; severe storm; riverbanks burst; bridge destroyed, Intercity derailed; houses destroyed.	deaths: 3 injured: 17
Germany: Breitachklamm, Garmisch-Partenkirchen; Bayrischzell, Glottertal	4	landslides; rockfall; slow rock flow; Glotter River blocked; bank burst; trees downed; roads blocked; houses flooded; power failure.	
Norway: Finneidfjord	1	mudslide; houses destroyed; roads severly damaged.	deaths: 2
Italy: Cortina d'Ampezzo, Piedmont, Alto Adige; Milan; Sorrento, Darfo di Boario, Campania, Caserta, Salerno, Avellino, Sarno, Quindici, Siano	6	landslides; mudslides; heavy rainstorm; flash floods; high wind speeds; hail; losses to lemon and olive plantations roads, railroads damaged/blocked; hundreds of houses, cars damaged; train derailed; valleys isolated; tourist camp isolated.	deaths: 6 injured: 22
Italy: Umbria, Le Marche, Folino, Assisi, Colfiorito	1	earthquake; houses and Franziskus basilica damaged.	deaths: 164 (feared 135 more); injured: 215 homeless: 40 000 130.4 M euro
Spain: Gijón	1	landslide, heavy rain.	

Source: Munich Re, NatCatService, 1998; Schweizerische Rückversicherung, 1998

modified by human activity through disturbance of vegetation (deforestation, overgrazing) and groundwater conditions or the construction of infrastructure (see Camparia case study, Chapter 3.8). The factors which increase soil erosion (see above), may also increase the risk of land slides.

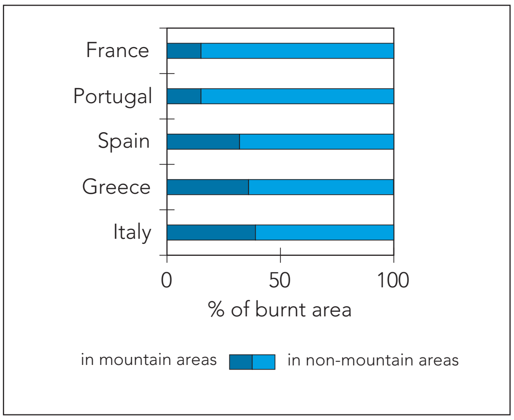
Nine out of ten earthquake disasters in Europe occur partly or wholly in mountain areas, and often in Mediterranean and sub-Mediterranean climatic regimes. Earthquakes and floods are predominant (60%) but the number and proportion of disasters identified with landslide and avalanche appear much greater (Hewitt, 1997; Mountain Agenda, 1992).

Since 1970 the reported number of natural and man-made disasters has increased due to better information and higher concentrations of population and economic activity in industrial countries (Schweizerische Rückversicherung, 1998). For a general overview see Chapter 3.8.

In the Mediterranean region, forest fires have the largest potential for altering the ecosystem. Every year, some 45 000 forest fires break out in Europe – most of them caused by humans. Many fires are lighted illegally but intentionally to gain sites for grazing livestock, construction or tourist facilities. The anticipated climate change might affect natural-fire frequency, spread and their devastating effects (European Commission, 1997a; Ghazi *et al.*, 1997). The area affected by fires has seen a downward trend, however in Spain and Portugal fires seize large areas (Figure 3.15.15).

Major road and rail tunnels, high bridges and dams are concentrated in the mountains, and are prone to widespread, frequent and financially expensive damage. Expansion of tourism in mountain villages has spread accommodation and infrastructure into risk areas; tragic proof was given in early 1999, when several big avalanches in the Alps caused death and destruction in ski resorts. Technical mitigation measures in turn affect the natural environment. These natural phenomena also create new environmental habitats but, by changing the landscape, they mainly have social and economic effects on humans.

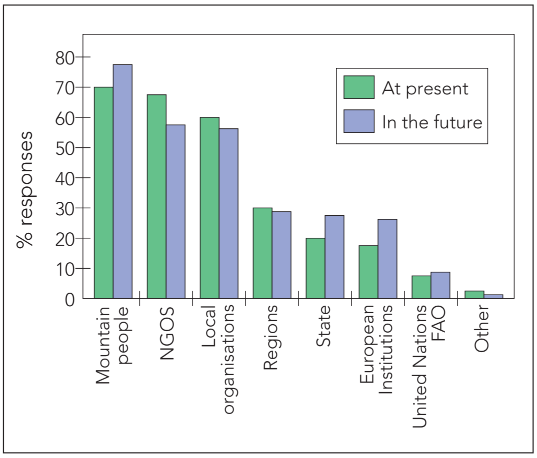
Burnt areas in mountains Figure 3.15.15



Of the total burnt areas in a country, mountains are affected by about 15-39%. The portion of burnt area must be estimated higher in countries with larger mountain areas.

Source: EEA

NGOs' perception of present policies on mountain issues in Europe Figure 3.15.16



Source: Mountain Agenda, 1997

3. Are mountains areas of marginal interest for Europe?

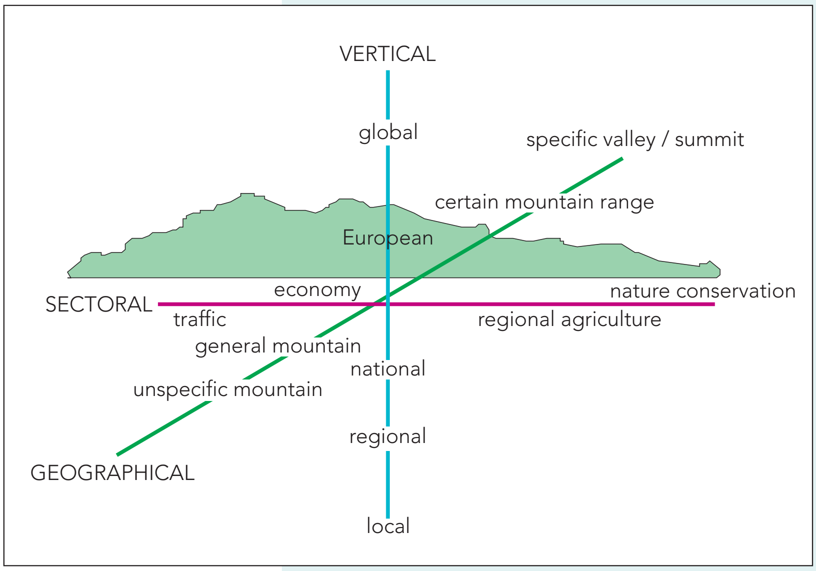
Several sectoral policies, particularly in the fields of agriculture, regions and nature conservation cover mountain areas. However, the sparse population, low economy, underestimated natural values, confounding complexity and transnational situation of many European mountain area make them regarded politically as marginal areas in terms of an integrated, comprehensive mountain policy (Figure 3.15.16 and Box 3.15.3). For these reasons integrated policy approaches such as the framework of Agenda 2000 and European spatial policy, as started with the European Spatial Development Perspective (ESDP) might be keys to integrated mountain policy – which is a vital need to be developed.

3.1. Could spatial policy integrate mountain issues?
A European spatial policy is arising, yet two different approaches still may be observed: one focusing on certain mountain ranges as European regions, particularly the Alps, the other defining mountain areas as a certain spatial category directed at a European mountain policy (Bätzing, 1997).

The regional study areas introduced in EU2000+ (European Commission, 1994), such as the Alpine Arc, are a remarkable step towards a spatial analysis. However, significant disparities remain inside the regions considered, in the Alpine Arc in particular, and do not recognize the special situation of mountain areas.

In the ESDP (European Commission, 1997b) mountain areas are characterized as unprotected and environmentally sensitive areas. Several mountain ranges are 'trans-national areas' which are geographically continuous, transcending national borders. These in particular require a European spatial policy, in terms of watershed management, risk

Figure 3.15.17 **Mountain policies in a mountain system**



Multi-dimensional ways in which policies affect mountains can be illustrated by a 'policy coordinated system'. There is a hierarchy of policy from global to local level (y-axis), sectors of policy from economy to nature conservation (x-axis) and a geography from general mountain policy to specific valleys (z-axis).

Source: EEA processing

Box 3.15.3 How does policy deal with mountains?

Mountains are subject to various types of policy measures (figure 3.15.17). Policy approaches may propose a general mountain policy, may target certain mountain ranges, may affect mountains directly without distinguishing between different mountain areas, or may have purely incidental effects on mountain areas.

Mountains have been directly addressed in few policy documents. On a global scale mountains have been recognised by Article 13 of Agenda 21 as highly sensitive ecosystems and an important source of natural resources. On the European scale the inter-governmental consultation on sustainable mountain development 1996 recommended the need to work towards an integrated policy framework for sustainable mountain development, environmentally sustainable mountain action plans and programmes as well as more sustainable sectoral policies and the assessment of impacts of existing national and European policies. All European mountains have been covered by the European charter of mountain areas (1994) to be elaborated into a European Convention of Mountain Areas. The charter covers almost every political sector which affects mountains and requires a 'comprehensive spatial policy' for mountain areas.

For the Pyrenees, a special charter has been adopted, and efforts are beginning towards the development of charters in the Carpathians and Caucasus. Underlying the Charter for the Protection of the Pyrenees (CIAPP, 1995) are three key objectives: to protect the environment, to allow access for visitors and to support environmentally sustainable economic development. Much further detailed is the framework of the Alpine Convention signed in 1991 by Germany, France, Italy, Lichtenstein, Monaco, Austria, Switzerland, Slovenia and the EU. Since 1990 several protocols which define the principles for different sectors have been drawn up, signed, or are under discussion. None have yet been ratified.

prevention, preservation of biological and landscape diversity, and recreation.

The most relevant EU policies for mountains are listed in Table 3.15.2 and have been introduced in Chapter 3.13. Some measures overlap, others appear contradictory. A first step towards assessment has been done in the European Commission study 'Integration of environmental concerns in mountain agriculture' (Euromontana, 1998). Some examples will be highlighted below, with reference to drivers and environmental problems.

3.2. Pressures of today need to be mitigated

3.2.1. Mountain crossing traffic will further increase

Due to increasing traffic flow more EU-corridors certainly will cross mountains (e.g. transalpine link Rome-Milan-Zurich/Munich; Madrid-Barcelona-Rhone Valley; Milan-Venice-Vienna-Budapest-Kiev; Bologna-Milan-Lyon; Madrid-Bordeaux-Toulouse) (European Commission, 1997b); the same will apply in the Accession Countries (Carpathian, Rhodope or Balkan) as identified in 1996.

Modal split can be sensitive to relative costs, which may in turn be modified by road pricing. This is illustrated by experience in Austria, where a reduction in infrastructure charges to comply with EU legislation was followed by a 16% increase in freight traffic in 1995 (Weissen, 1996). In contrast, as a result of the Alpine convention's traffic protocol, 70% of all goods in transit through Switzerland are transported by rail and the maximum weight for road transport is limited to 28 tonnes per truck (which is lower than in other Alpine countries).

3.2.2. Mountain tourism has learnt but a turnaround is difficult

The harmful effects of intensive tourism have led to restrictions for sport and for

Examples of how EU policy measures cover relevent mountaín issues as recognised in this chapter Table 3.15.2

D = Mountains directly addressed; I = Mountains indirectly addressed

	Population	Traffic	Tourism	Land use change	Natural heritage	Soil	Water	Hazard prevention
Environment Policy								
Birds Directive 79/409/EEC				D	D		I	
Habitats Directive 92/43/EEC				D	D			
Biodiversity Strategy COM 1998 (42)								
Community Directive on EIA , Dir. 85/337/EEC;		I	I		I		I	I
Proposal for a directive for strategic impact assessment of certain plans and programmes (COM(96)511 of December 1996)		I	I	I	I	I	I	I
Proposal for a framework directive on water (COM(97)49 of February 1997)							I	
LIFE II Nature Regulation 1404/96 (OJL 181 of 20.07.96)					D			
Nitrates Directive 91/676/EEC							I	
COM(97)88					I		I	
Regional Policy								
Cohesion Fund			D					
INTERREG II			D	D	D			
REGIS II								
PHARE, TACIS		I	I	I	I			
Common Agricultural Policy (CAP): Accompanying measures								
Agri-environmental measures Reg. 2078/92			I	I	I	I	I	
Forestry measures Reg. 2080/92				I	I	I	I	I
CAP: Structural measures								
Rural development, LFA Reg. 950/97			I	I	I	I	I	
Genetic resources, Reg. 1467/94					I			
Agricultural labels, Reg. 2081/92 and 2082/92			I	I	I			
Improving the efficiency of agricultural structures, Reg. 2328/91				I	I	I	I	
Improving conditions for marketing and processing agricultural products, Reg. 866/90 am. By Reg. 3669/93	I			I	I	I	I	
LEADER II			I	I	I			
Objectives 1 + 5b, including ERDF and EAGGF			I	I	I			
CAP: Other measures								
Organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs, Reg. 2092/91	I			I	I	I		
COM(96) 366 Council Regulation supplementing Reg. 2092/91	I			I	I	I		

Source: EEA, European Commission

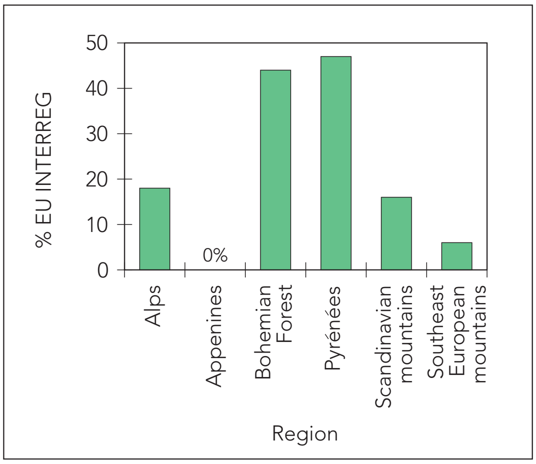
further development in sensitive zones, and – more positively – stimulated development of sustainable tourism. Over half of the budget of the Community action plan to support tourism is earmarked for sustainable tourism projects (Figure 3.15.18). In Spain, the Cohesion Fund programme includes reduction of harmful tourism effects in national parks, while the development of non-intensive tourism in the Aragon region has been co-financed under the Structural Fund 5b objectives.

3.2.3. Regarding land use changes, mainly from agriculture

Land use changes and mountain agriculture are targeted by different measures in the Common Agricultural Policy (CAP) such as the Accompanying measures (agri-environment, forestry) and Structural measures (rural development, objectives 1 + 5b, LEADER, etc.) and the regional policy, such as INTERREG II (Figure 3.15.19). A recent study of existing EU policies (Euromontana, 1998) has concluded that small and multi-functional farms do not receive sufficient aid to compensate for natural handicaps, that agri-environment measures may delay adverse developments and repair some damage but it is 'highly unlikely' that the production-oriented systems can be reoriented, and that other agricultural measures are not focused on environmental benefits. The time-scale for significant policy changes has also been expressed as a major concern of English nature-conservation groups.

Under the Less Favored Areas Regulation about 20% of the total Utilized Agricultural Area (UAA) is supported as less favoured

Figure 3.15.18 **EU support for mountain tourism**



Tourism projects have been supported in the Pyrenees and Bohemian Massif in particular. About 45% of Interreg budget in mountain projects have been spent on projects to achieve sustainable tourism.

Source: European Commission

mountain areas in the EU. These mountain areas are individually and heterogeneously defined by the Member States. It is reported that agricultural income in mountain LFAs lies 45% below the EU-average, but has increased slightly in the period 1987-1993 by 0.7%, while decreasing in other regions. Most of French mountain areas and some Spanish and Italian areas are above this EU-average income, while the situation is worsening in nearly all areas of Greece and Portugal (European Commission, 1997c).

Agricultural labels of origin may play a supportive role in encouraging farming activities which contribute to maintaining fragile ecosystems like mountains. The *'fromages d'alpage et d'estives'* are well-known examples of specific products linked to traditional practices.

Land use changes are also induced by the gravitation of urban agglomerations, and a balance is needed in the urban-mountain relationship. Therefore the general call in the ESDP (European Commission, 1997b) for a new definition of the rural-urban relationship has a particular focus on mountain areas; options include the balance between cities and country, diversification of rural areas, conservation and creative management of cultural landscapes. The benefits of an attractive, environmentally healthy hinterland have been recognised by cities but compensation patterns for the provision of this stewardship are not developed. The example of Munich shows that the high recreation values of lakes and mountains have helped the city to become a highly desired location for high-technology industry.

3.2.4. Forestry and renewable energies

Mountain areas are highly suitable for renewable energy generation such as wind and hydroelectric energy, which could offer additional, sustainable revenues for mountain economies. However, strong opposition can be expected to further hydro-powerstations (CIAPP, 1995).

Abundant forest wood, as a renewable resource, offers another option of renewable energy use for mountains. An example is the development of a low-pollution heating system fueled with forestry output in the Haut-Jura, France, financed by the LEADER fund (European Commission, 1997d).

Under afforestation measures, as supported by the CAP, and due to the 1994-97 national plans, 700 000 ha of new forest will be created and 300 000 ha of forest will be improved in the EU (European Commission, 1997c). This implementation, however, often disregards the choice of tree species and the impacts on soil, water, landscape and biodiversity, and so it has not necessarily been environmentally beneficial (Euromontana, 1998). Within objective 1 and 5b, development of forest functions in terms of erosion limitation, water protection and tourism promotion are supported.

Natural recolonisation is on average higher in mountains than nationwide averages. In France recolonisation in mountains in the past decade has been 50% above the national average (EOMF, 1998).

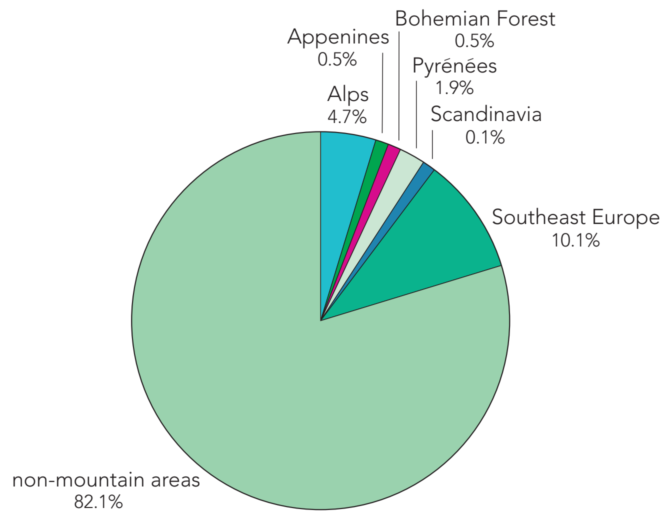
On the other hand increasing forest cover in mountains is becoming a conflict in some regions, where people dislike and therefore oppose the afforestation scheme, such as in the uplands of Navarra, Lorraine, Venice (Zingari, 1998). Their concerns include the safeguarding of open farmland and the protection of bird biotopes or an already densely afforestated landscape (Cammarata, 1997). In a recent study it was stated that the concerns of zonal afforestation plans, such as the selection of locally adapted tree species, have not been met and impacts on soil, water and biotopes must be expected (Euromontana, 1998).

A cornerstone of forest policy is resolution S4 of the Strasbourg Conference 'Adapting the management of mountain forests to new environmental conditions' which was adopted by 25 countries in 1990 and the EU Forestry Strategy recently adopted which stresses problems of specific regions, including mountain regions. The challenge is important as in most countries mountain forest management suffers from the insufficient implementation of forest legislation (Koch, Rasmussen, 1998).

3.2.5. Nature conservation policy
The general evolution of nature conservation policy today focuses more on sustainable development (see Chapter 3.11) and marks an important step towards the multifunctionality concept of mountain areas.

The Pan-European Biological and Landscape Diversity Strategy (PEBLDS) has dedicated in its action plan the entire 'action theme 10' on mountain ecosystems. This focuses on integration of mountains in the pan-European ecological network, establishment of sustainable practice for afforestation, mountain farming and recreation, the potential application of multilateral agreement of the Alpine Convention for the Balkan Carpathians and Caucasus regions and the establishment and strengthening of transfrontier protected areas (Council of Europe *et al.*, 1996).

Interreg programme in mountains Figure 3.15.19



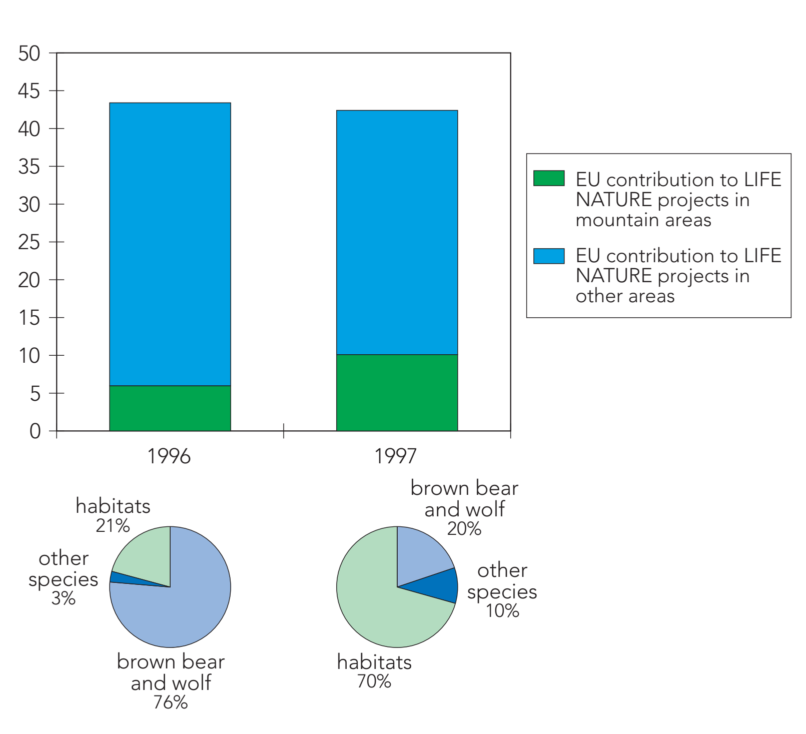
Within the INTERREG programme with a total budget of 585 M euro in the period 1994-1999 (about 17% of which goes to mountain areas) several measures are applied, with a significant focus in south-east European countries. Here one should consider that about half of EU border areas lie in mountains.

Source: European Commission, DG XVI, 1997

The progress in implementation of the Habitat Directive, as described in Chapter 3.6, is shown by the example of the EU Alpine region where mountain areas contain 16% of the number of sites of conservation interest (SCIs), while the region area covers only 9% of the EU. In the second stage of the selection of special areas of conservation (SAC) many mountain areas may be expected to be chosen favorably. Mountains frequently meet the criteria of relationship to migration routes or as part of an ecosystem on both sides of EU frontiers and of a high number of annex I habitats and annex II species. Thus mountains as most extensive areas will probably receive an over proportional percentage of protected areas which should be reflected in national and local policies (Hopkins, 1998).

The Commission instrument for nature conservation LIFE financed about 15% of the 1996 and 25% of the 1997 nature budget in mountain areas with a focus on large carnivore species protection (European Commission, 1997d) (Figure 3.15.20).

Figure 3.15.20 **LIFE Nature support in mountains**



About 75% of the 1996 and 20% of the 1997 EU-LIFE-funding in mountain areas was spent for conservation of the brown bear and wolf; about 3% was spent for conservation of other species.

Source: European Commission, 1997

3.2.6. Natural phenomena can not be excluded

Direct protection from natural hazards is recognised to be far more efficiently provided by mountain forests with a high proportion of natural vegetation than by artificial devices. Switzerland provided eloquent figures for the role of protection, said to be worth up to SFR 3 billion (1.8 billion euros) per year to local communities (EOMF, 1998). A risk-reducing agriculture-forestry combination which might find examples in former multi-functional land-use systems may claim to be one of the most efficient and – in terms of cost-benefit ratio – most successful approaches (Messerli, 1989).

As pointed out in Chapter 3.8 only five countries in the EU provide land-use planning criteria for hazard prevention and five countries still have not developed hazard arrangements at all. It must be strongly emphasised that for mountain areas risk assessment and land-use planning are vital instruments for hazard identification, avoidance and mitigation.

For soil protection also, the concept of multi-functionality, implemented by integrated land use planning, has been recommended for policy action. This should include ecological adaptation of land-use management by using suitability/vulnerability assessments of soil, agro-forestry practices, adjusted stocking levels, rotation farming systems, and measures against forest fires. Results from the Swiss MAB-research programme confirm that the best soil protection in mountains is constant, ecologically adapted agriculture (Messerli, 1989).

3.3. In which direction is policy heading?

The most comprehensive changes for mountains can be expected from the appraisal of EU Regional development plans, the attention on rural development programmes as a new pillar in the CAP and the promotion of direct environmental benefits (European Commission, 1998). It has been announced that the Structural Funds budget will be increased to about one-third of the Community budget which will make the funds a powerful instrument (European Commission, 1997b).

It can be assumed that while new regional objectives will be added through the needs in the Accession Countries, this will require cuts in expenditure on present objectives. It is necessary to assess to what extent this will affect mountain areas in the EU.

In the ESDP further fields of work have been distinguished which significantly meet the need for better analysis of mountain areas in particular, such as the development of indicators, criteria and a typology of areas, which could complement the efforts of regional development in Agenda 2000.

New, economically based policy approaches for balancing the stewardship of mountain areas for lowlands have been proposed by the Mountain Agenda and include, for instance, fees for the entrance to parks and buffer zones, for hunting and fishing, for tour operating, for climbing peaks and for using roads and passes.

3.4. What could policy-makers require for evolving mountain policy?

First there is a general need to recognise mountains as a distinct area and to evolve objective criteria for area definition. This goes hand in hand with the identification of indicators for sustainable land use.

Furthermore better baseline information for decision-maker is necessary. This includes monitoring of mountain environmental conditions. Identification of mountain research needs the interaction of different disciplines and the integration of traditional, long-term experience of local people.

To sufficiently compensate the long-term conservation of natural resources, the goods and services offered by mountain regions and people need to be identified and evaluated. Methods are needed to calculate the costs of maintenance and protection and how to distribute the revenues. Once established periodic re-evaluations should be planned due to changing ecological and economic situations (Mountain Agenda, 1997).

Box 3.15.4 EU research programmes related to mountain issues

The EU has invested about 7.1% (852 M euro) of the 1994-1998 research budget for environment and climate under which the AMBIENTE programme deals with hazard prevention (Ruberti, 1994), the ECOMONT project with land-use impacts, and the ARTERI project with arctic-alpine ecosystems. Other mountain-related research is the MOLAR project on remote mountain lakes, on timberline (FOREST), effects of climate change on alpine and arctic streams (AASER), and desertification in Mediterranean mountains (MEDALUS, MEDIMONT). From other budgets such as the Cohesion Fund, forest-fire combat projects in Greece have been financed and about 105 M euro has been committed to desertification projects in southern Mediterranean countries. Implementation of such policies could be carried out by risk exposure plans (PER) as in the French 1985 mountain law or the risk zones in the Bavarian forest function plans. Erosion and natural hazards are investigated in the EROSLOPE, NEWTECH, FLOODAWARE, SAME projects.

References

Abegg, B., Elsasser, H. 1996. *'Klimarisiken aus touristischer Sicht' in Programmleitung NFP 31 (Hrsg.): 'Klimarisiken – Herausforderung für die Schweizer Wirtschaft'*, pp. 115–126. vdf Hochschulverlag, ETH Zürich.

Bätzing, W. 1990. 'Die aktuelle Siedlungsentwicklung an der Höhengrenze der Ökumene im Alpenraum auf dem Hintergrund des Übergangs von der Agrar- zur Freizeitgesellschaft' in *Siedlungsforschung. Archäologie – Geschichte – Geographie.* Vol. 8. Eds: K. Fehn *et al.*, pp. 165-200.

Bätzing, W. 1997. *Kleines Alpen-Lexikon*. Munich, Beck'sche Reihe.

Blandin, P., 1992. *La Nature en Europe*, Bordas, Paris.

Breiling, M. 1994. Climate Variability: The impact on the National economy, the Alpine environments of Austria and the need for local action. paper presented at conference Snow and Climate, Geneva, September 1994.

Breiling, M., Charamza, P., Skage, O. 1997. *Klimasensibilität österreichischer Bezirke mit besonderer Berücksichtigung des Wintertourismus.* Rapport 97:1 Institut für Landschaftsplanung, Universität Alnarp, Schweden. Forschungsauftrag des Österreichischen Bundesministeriums für Wirtschaftliche Angelegenheiten und des Österreichischen Bundesministeriums für Umwelt.

Cammarata, A. 1997. 'CAP Working Notes Agriculture and Environment'. European Commission. Directorate-General for Agriculture. Brussels.

Cernusca, A. et. al. 1996. 'ECOMONT Ecological effects of land use changes on European terrestrial mountain ecosystems' in *Pirineos.* Jaca, pp. 145-172.

CIAPP Conseil International Associatif pour la Protection des Pyrenees, 1995, Charter for the protection of the Pyrenees. English Summary.

CIPRA, Internationale Alpenschutz-Kommission, ed. 1998. *1. Alpenreport. Daten, Fakten, Probleme, Lösungsansätze.* Berne, Stuttgart, Vienna, Paul Haupt Verlag.

Council of Europe, UNEP, ECNC,1996. The Pan-European Biological and Landscape Diversity Strategy (PEBLDS).

Dubost, M., Zingari, P.C.,no date, *Impact of Climate Change on European Mountain Development.*

Ellenberg, H. 1982. *Vegetation Mitteleuropas mit den Alpen.* Stuttgart, Eugen Ulmer Verlag, pp. 989.

Elsasser, H., Frösch, R., Finsterle, M. 1990. 'Sättigung in Fremdenverkehrsgebieten' in *DISP, Dokumente und Informationen zur Schweizerischen Orts-, Regional- und Landesplanung* Vol. 26, No 100. Zurich, pp. 33-41.

EOMF, European Observatory of Mountain Forests 1998. *The Sustainable future of Mountain Forests in Europe – Facts and Figures.* Contribution by the European Observatory of Mountain Forests to the strengthening, development and follow-up of Resolution S4.

Euromontana, 1998, The integration of environmental concerns in mountain agriculture. Summary. Study for the European Commission Directorate General XI, Environment, Safety and Civil Protection.

European Commission, 1994. Europe 2000+. Cooperation for European territorial development. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1997a, *The threat of natural disasters. What is Europe doing?* Climate and Natural Hazards Unit (DG XII/D-2). CG-09-97-381-EN, European Commission, Brussels.

European Commission, 1997b. European spatial development perspective. First official draft. Presented at the informal meeting of Ministers responsible for spatial planning of the member states of the European Union. Noordwijk, 9-10 June 1997. Office for Official Publications of the European Communities, Luxembourg.

European Commission, 1997c. CAP 2000 Working document. Rural Developments. Ed: Directorate General VI.

European Commission,1997d, *Agenda 21 The first five years.* Office for Official Publications of the European Communties, Luxembourg.

European Commission, Directorate General XI, 1997, Life Nature 96., European Commission, Brussels.

European Commission, Directorate General XI, 1997, *Life Nature 97.,* European Commission. Brussels.

European Commission, 1998. *Partnership for Integration: A strategy for Integration Environment into EU-Policies,* Cardiff, June 1998

European Commission, DG XVI, 1998, http://www.inforegio.org/wbpro/prord/reg_prog/pay_them/themes/cip1/thci_all.htm

EEA. European Environment Agency, Copenhagen

Fabrice, M., Dubost M.,1992. Die letzten naturnahen Alpenflüsse. *Kleine Schriften 11/92.* CIPRA (ed.). Vaduz.

Flückiger, S. 1996. *'Klimarisiken aus landwirtschaftlicher Sicht' in Programmleitung NFP 31 (Hrsg.): 'Klimarisiken – Herausforderung für die Schweizer Wirtschaft',* pp. 105-114. vdf Hochschulverlag, ETH Zürich.

Garcia-Ruiz, J., Lasanta-Martinez, T. 1993. 'Land-use conflicts as a result of land-use change in the central Spanish Pyrenees: A review' in *Mountain Research and Development* Vol. 13, No 3, pp. 295-304.

Ghazi, A. *et al.*, eds. 1997. *Highlights of results from natural hazards research projects.* Climate and Natural Hazards Unit (DG XII/D-2). European Commission. Brussels.

Guisan, A. *et al.*, eds. 1995. *Potential Ecological Impacts of Climate Change in the Alps and Fennoscandian Mountains.* Geneva.

Hewitt, K. 1997. 'Risk and disasters in mountain lands' in *Mountains of the World. A Global Priority.* Eds: B. Messerli; J.D. Ives.

Höller, P. *et al.* 1998. 'Effects of land use changes on snow gliding processes' in *Poster Alpenforum 1998.* Garmisch-Partenkirchen.

Hopkins, J. 1998. 'Achiving the aims of the EC habitats directive: links with reform of agricultural policies in mountain areas' in *Mountain livestock farming and EU policy development. Proceedings of the fifth European forum on nature conservation and pastoralism. Valle d'Aosta, Italy.* Eds: A. Poole *et al.*, pp. 117-125.

Jeker, R. 1996. *'Thesen zur Bedeutung von Klimarisiken für die Schweizer Wirtschaft'* in Programmleitung NFP 31 (Hrsg.): *'Klimarisiken – Herausforderung für die Schweizer Wirtschaft'* pp. 9-24. vdf Hochschulverlag, ETH Zürich.

Koch, N.E., Rasmussen, J.N., 1998. *Forestry in the Context of Rural Development. Final Report of COST Action E3.Danish Forest and Landscape Research Institute.* Hörsholm. European Commission, Brussels.

Kristensen, P., Hansen, H.O., 1994. *European Rivers and Lakes. Assessment of their Environmental State.*

Leonard J., Crouzet P., 1998. Lakes and Reservoirs in the EEA Area Final Draft, Report No PO 23/97-

Lichtenberger, E. 1979. 'Die Sukzession von der Agrar- zur Freizeitgesellschaft in den Hochgebirgen Europas' in *Innsbrucker Geographische Studien*, Band 5. Fragen geographischer Forschung. Innsbruck, pp. 401-436.

Messerli, P. 1989. *Mensch und Natur im alpinen Lebensraum Risiken, Chancen, Perspektiven. Zentrale Erkenntnisse aus dem schweizerischen MAB-Programm.* Berne, Stuttgart, Paul Haupt Verlag.

Mountain Agenda 1997. *Mountains of the World: Challenges for the 21st Century.* Berne, Paul Haupt Verlag.

Mountain Agenda, ed. 1992. *An Appeal for the Mountains.* Institute of Geography, University of Berne, Switzerland.

Mountain Agenda,1998. *Mountains of the World: Water Towers for the 21st Century.* P.Haupt. Bern

Munich Re 1998. *NatCatSERVICE.* Munich, Münchener Rückversicherungs-AG.

Ozenda, P. 1988. *Die Vegetation der Alpen im europäischen Gebirgsraum.*

Ozenda, P. 1994. *Végétation du Continent Européen.* Lausanne, Delachaux et Niestlé, pp. 271.

Petit, S. *et al.* 1998. *MIRABEL – Models for integrated review and assessment of biodiversity in European Landscapes. Overview of Methods and Summary of Model Outputs.*

Price, M.,1995. Wirtschaft und Umwelt der Berggebiete von Zentral- und Osteuropa. in: *Euromontana* (ed.), 1995: Berggebiete Europas, neue Zusammenarbeit für eine nachhaltige Entwicklung. Durch die Euromontana organisierte internationale Konferenz in Krakau (Polen) 4-6 September 1995. p. 49-57.

Price, M.F., Barry, R.G. 1997. 'Climate change' in *Mountains of the World. A Global Priority.* Eds: B. Messerli, J.D. Ives.

Rhomberg, K. 1998. 'Vorfahrt für unsere Gesundheit – Ärzte gegen die Verkehrslawine' in *1. Alpenreport. Daten, Fakten, Probleme, Lösungsansätze.* Ed: CIPRA, pp. 356-358.

Romano, B. 1995. 'National Parks policy and mountain depopulation: A case study in the Abruzzo region of the Central Apennines, Italy' in *Mountain Research and Developmen*t Vol. 15, No 2, pp. 121-132.

Ruberti, A. 1994. *Facteurs climatiques et risques naturels du système territorial alpin.* Ed: European Commission, Brussels.

Schweizerische Rückversicherungs-Gesellschaft, ed. 1998. *Copy-editing: SIGMA, No 3/1998. Naturkatastrophen und Grossschäden 1997: Ausserordentlich wenig teure Schäden.* Zurich.

Stanners, D., Bourdeau, P. 1995. *Europe's Environment. The Dobris Assessment.* Ed: European Environment Agency (EEA). Copenhagen, Earthscan Publications.

TTETN The Trans-European Transport Network 1998. http://eurotext.ulst.ac.uk/policy/transport/networks/ttetn/TTETN008.htm#A29

Vakrou, A. 1998. 'Policy measures to ensure and promote forestry in mountain areas of Greece', COST E3, draft paper.

Weissen, A. 1996. 'Specific Alpine Problems: Transport' in *Green Paper on the Alps: The Alps – Touchstone for Europe.* Eds. M. Pils; P. Glauser; D. Siegrist.

Zingari, P.C. 1994. *Trends in European Mountain Biodiversity. Proposal for a European Science Foundation Scientific Network.*

Zingari, P.C. 1998. Personal Communication.

Zingari, P.C., Dubost, M. 1996 *Research for Sustainable Mountain Development Series*, Vol. 4: European mountain biodiversity and sustainable development.

4.1. Integration of the economy and the environment

Main findings

A variety of policy instruments are deployed to integrate the environmental dimension in economic decision making:

- Environmental impact assessment (EIA) of major projects is now a well-established procedure, although the effectiveness of EIAs depends on their being undertaken sufficiently early in the project cycle to influence project design.
- Legislation (the EU has an estimated 315 environmentally related Directives), the effectiveness of which depends on implementation by Member States (and also by the accession countries).
- Environmental management and auditing (EMAS) covers more than 1 500 registered sites across the EU (over 75% of them in Germany); the EU EMAS scheme is challenged by the international management scheme ISO 14000 which in some respects is less demanding.
- Voluntary Agreements, of which there are more than 300 in the EU, mostly in the Netherlands and Germany. The major issue is to make them credible and transparent, with third-party verification of binding targets.
- Subsidies, which may be environmentally damaging (supporting intensive agriculture or the coal industry) or beneficial (for example agri-environmental support).
- Environmental taxation: the main issue now is to shift from piecemeal environmental taxation to a more thorough ecological tax reform where labour taxes are replaced by environmental taxes.

In addition there are several instruments which have hitherto been less widely used – examples include extended cost-benefit analysis, tradeable permits and green procurement.

The EU Fifth Environmental Action Programme (5EAP) identifies sectors of economic activity which have major environmental impacts:

- Agriculture: eco-efficiency has improved in terms of emissions per unit of agricultural production, and fertiliser and pesticide use per hectare. Organic agriculture still plays a limited role. Agri-environmental measures are being applied on a considerable scale, but subsidies with a possible negative influence on the environment (like a considerable part of price supports) are still common and specific environmental taxation almost non-existent.
- Industry: eco-efficiency has improved for air and water emissions, but not for solid and hazardous waste: there is considerable scope for environmental taxation and voluntary agreements aimed at reduction of the generation of wastes.
- Energy: eco-efficiency is improving as the emissions of most air pollutants per unit of power generated are declining while energy demand is stable. Only about 5% of EU energy comes from renewable sources, and this could be increased by increased funding of renewables and taxes to internalise the environmental damage of fossil fuels.
- Transport: environmental damage is increasing, as a result of growth in the number of cars, road freight and air passengers, and increased congestion, despite improved vehicle fuel efficiency and use of catalytic converters. Environmental taxation on vehicle fuels is now widespread (although aviation fuel remains untaxed), and road pricing may change travel behaviour.

- Households: the number of households in the EU is growing at 1.6% per year, as average household size declines. There is growth in energy use and waste generation, although waste recycling is increasing particularly in countries which have introduced comprehensive programmes with charges for household waste collection and a well-financed recycling network. There is still scope for (higher) charges for household energy and water use. Eco-labelling of products is still developing slowly and covers only a small share of available household appliances.

1. Why and how to integrate economy and environment in the EU

The importance of integrating environmental considerations into economic and sectoral decisions was officially recognised in Article 6 of the consolidated Amsterdam Treaty, which established an obligation to integrate environmental requirements into all EU policies and actions. Recent EU progress in the process of implementation is demonstrated by the outcomes of the Cardiff European Council (of EU Member States; European Commission, 1998a) and the Aarhus Conference (of Ministers of the Environment of UNECE countries), both held in June 1998 (see Chapter 1.1).

As analysed in the previous chapters, environmental problems arise from economic activities – for example air pollution from transport, industry and power generation, or water pollution from households, industry and agriculture (see EEA, 1998, Chapter 14 for a summary). While environmental regulators can make policies that influence these other sectors, it is much more efficient and effective if policy makers in each sector – transport, agriculture, industry etc. – directly consider environmental concerns when they formulate policy. This process is known as the 'integration' of economic or sectoral policy with environmental policy.

Integration is a central objective of the Fifth European Environmental Action Programme (5EAP), which was adopted in 1992. It states that 'the strategy of the Programme is to create a new interplay between the main groups of actors (government, enterprise and public) and the principal economic sectors (industry, energy, transport, agriculture, tourism) through the use of an extended and integrated range of instruments.'

The final purpose of integration is, of course, to reduce the environmental damage from sectoral activities. Evidence presented in this chapter will show a decrease in environmental damage associated with some economic sectors, notably industry, within the EU. This is known as 'decoupling', since there is no longer a fixed relationship between production and the associated negative environmental effects. Decoupling involves a reduction in the ratio of physical emissions or natural resource use per unit of economic output, either from increasing efficiency through technological changes or a shift to a less environmentally damaging products. However, in some sectors, the increased scale of economic activity – such as the growth in the number of cars and households – will lead to growing environmental damage. These so called 'scale' effects may be enough to overtake any gains in reduced damage per unit of output, so that total environmental damage caused by the sector will rise overall. The big question is whether technological growth and product shifts will be rapid enough to keep pace with EU-wide demands for a higher standard of living. The situation is summarised in Table 4.1.1.

Progress towards integration has been made in agriculture, with reduced fertiliser (and pesticide) use per hectare, and a growing area devoted to environmentally beneficial activities. The energy and industrial sectors are also showing some improvements with declining air pollution per unit of output. However, the available data suggests that solid waste and hazardous waste from industry are increasing. Two sectors, where damage is still growing, are transport and households, both because of scale effect and the lack of efficiency gains substantial enough to offset this.

While much of the policy discussion focuses on the environmental damage which is not taken into account (technically speaking, internalised) in economic decision-making, it is important to note that economic systems also fail to account fully for environmental benefits. The agricultural sector not only produces pollution and landscape destruction, but also creates living landscapes that

Overview of sectoral trends relevant to environmental damage in the EU — Table 4.1.1.

Sector	Agriculture	Industry	Energy	Transport	Households
Scale of consump-tion/ production	Utilised agricultural area fell by 0.7% a year from 1990-94	Manufacturing production stable since 1990	Final energy consumption per capita has been stable since 1985	Stock of cars risen by 4% a year since 1986, Road freight has risen by 5% a year since 1980, Air traffic has increased by 7.8% a year since 1985	Number of households has increased by 1.2% a year from 1991 to 1995
Efficiency gains	Fertiliser consumption fell per ha by 1.6% a year from 1985-94	Air pollution per unit of produc-tion declining Industrial waste has increased 1.4% per capita per year since 1985 in selected countries	CO_2, SO_x and NO_x emissions per kWh have declined from 1980-1990	CO_2 emission per vehicle-km has remained constant, NO_x has slightly declined , and SO_x has significantly declined from 1990-1995	Waste per capita has been rising by 3% per year since 1980
Shift to less damaging products or services	Share of agricul-tural land devoted to organic agri-culture is rising, though still relatively low at 1.6%; agri-environ-mental measures now account for 20% of agricultural land, exceeding the target of 17% set out in the 5EAP	-	Renewable energy was 5.3% of total domestic energy consumption in 1996 – the same as in 1985	Passenger rail use, and rail and inland waterway freight have remained static since 1970 and are now less than 20% of total journeys	-

Source: EEA, Eurostat

are widely appreciated by people at large. For example, after deducting environmental damages from the net product of UK agriculture, there is nonetheless an estimated 24% increase in the ‘true’ output of the agricultural sector because of its contribution to biodiversity conservation, amenity and the sequestration of carbon dioxide (Adger and Whitby, 1991, 1993; OECD, 1997a).

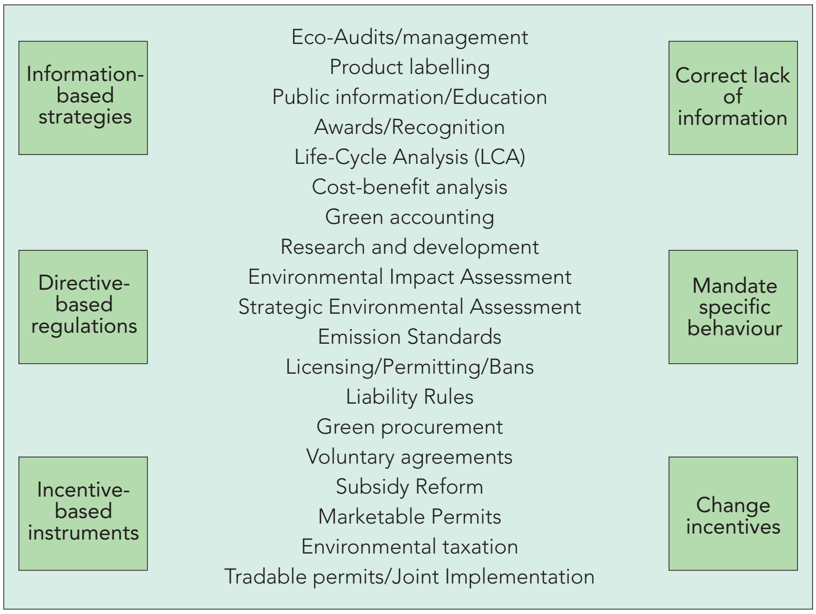
The process of integrating economic and environmental policy is complex, and several possible criteria for judging progress towards integration have been proposed (see Chapter 1.1) (EEA, 1998, Chapter 14; OECD, 1996a). The most effective approach is to examine the extent to which each sector has implemented key instruments for integration. These instruments can be subdivided into their target group (government, firms and public) or their aim (for example, information, regulation, incentives etc.). The 5EAP highlights four main sets of instrument: regulatory instruments, market-based instruments (including economic and fiscal instruments and voluntary agreements), horizontal supporting instruments (research, information, education etc.) and financial support mechanisms. These will be reviewed further in the next section.

2. Overview of key instruments for integrating economic and environmental policy

The main instruments for integration of the environmental dimension in economic decision-making are summarised in Figure 4.1.1. Some instruments, such as environmental taxation, are suitable for more than one sector while others, such as liability rules are targeted at a single sector, in this case, industry. This section will focus on the cross-sectoral instruments – in particular, environmental impact assessment (EIA), regulations, voluntary agreements, subsidy reform and environmental taxation – with sector-specific instruments covered in the sectoral reviews that follow.

While the comparison between information, regulatory and incentive approaches is complex, there is strong evidence that the economic approaches may reduce overall compliance costs for industry and house-

Figure 4.1.1 **Range of instruments for environmental policy**



Source: Adapted from EEA, 1997

holds. Additionally, some economic instruments raise financial revenues, which could be used to reduce other distorting taxes in the economy, particularly those taxes that give disincentives for employment. This is known as the *double dividend effect*, because taxation deters environmentally damaging activities (the first dividend) and other distortionary taxes are reduced (the second dividend). However, other research suggests that the reality is far more complex (Goulder, 1995). Due to these perceived benefits, this chapter reviews all the main instruments, but focuses on the incentive approach: subsidy removal, environmental taxation and voluntary agreements.

For each of the cross-sectoral instruments, there has been progress both at the EU level and Member State level (Table 4.1.2).

2.1. Information-based strategies

Information-based strategies work on the assumption that environmental policy, however devised, works better when besides policy makers, citizens are better informed. EU institutions have been taking an active role in co-ordinating and developing these instruments, both as environmental policy measures and to ensure that they do not lead to barriers to trade (see Chapter 4.2).

2.1.1. Environmental impact assessment

The EU has been active in promoting Environmental Impact Assessment (EIA), and Directive 85/337 has led to a major growth in EIA activity. EIA is widely used in all sectors to reduce environmental damage from major investment projects. There were an estimated 7000 EIAs per year within the EU in the early 1990s, with more than 70% in France. The main problem is to ensure that EIA is done sufficiently early in the project cycle to influence project design. A report for the Commission (European Commission, 1993a) found that: 'there is clear evidence that project modifications have been and are taking place, due to the influence of the EIA process. However, there is also evidence that as yet, its impact is not as widespread as intended and that modifications are mainly confined to those of a minor or non-radical nature'. The amended EIA Directive 97/11/EC aims to overcome some of these problems by broadening and clarifying the scope of projects which are EIA mandatory.

2.1.2. Strategic environmental assessment

One of the main shortcomings of project EIA is that it is applied at a very late planning stage. Therefore, Strategic Environmental Assessment (which applies the principles of environmental assessment to policies, plans and programmes) is also being taken forward by the EU. There is currently discussion on a proposed Directive (COM(96)511) which would require environmental assessment of certain plans and programmes which are part of the town and country planning decision-making processes. This would also include certain sectoral plans and programmes. However, the omission of SEA for policies leaves the Commission behind the forefront of international practice (Sadler and Baxter, 1997). Within Member States, Netherlands has taken the lead, with a statutory requirement for SEA of certain plans and programmes since 1987. Denmark and Finland are similarly advanced, requiring SEA for certain plans, programmes and policies.

2.1.3. Cost-benefit assessment

The importance of cost-benefit analysis was noted in the 5EAP which states the need for the 'development of meaningful cost-benefit analysis methodologies'. There has now been a growing willingness to use such approaches (Pearce, 1998). A number of attempts have been made to evaluate environmental externalities across the EU in sevral sectors, such as energy (European Commission, 1998b), transport (ECMT, 1998) and waste (Coopers and Lybrand *et al.*, 1997). On the operational side, the Structural Funds require that; 'all major project proposals are now required to include an assessment of costs and benefits including those relating to the environment' (European Commission, 1996b). The European Investment Bank has also introduced procedures to evaluate environmental externalities in some sectors (IVM and EFTEC, 1998).

2.2. Regulatory approaches: environmental legislation

While information-based strategies can influence behaviour, they do not generally require compliance (except in the case of US 'right-to-know' type policies). Most environmental policy in the European Union and at Member State level is executed through regulations, or what is called 'command and control'.

With more than 315 pieces of Community environmental legislation, the EU has developed a fairly comprehensive set of environmental Directives. Most of the Directives relate to industry, agriculture and transport, but there are a growing number in the energy and household sector.

Improving implementation is an urgent priority since in 1995 Member States had notified implementing measures for only 91% of the Community's environmental Directives, leaving as many as 20 or 22 directives not transposed (transferred into national legislation) by some Member States. In the same year, 265 suspected breaches of Community environmental law were reported, which is 20% of all infringements registered by the Commission that year. In October 1996 over 600 environmental complaints and infringements were outstanding against Member States, with 85 awaiting determination by the Court of Justice (European Commission, 1996c). In 1998, the latest round of infringement proceedings announced showed that the majority of the EU Member States were still being targeted by the Commission for non-compliance with 12 environmental directives.

Future EU legislation will focus on follow-ups to existing legislation and updating. The greater regulatory challenges are twofold: first, to ensure the widespread implementation of EU legislation in existing Member States and second, to cope with enlargement of the Union, as the economic and financial constraints of the new countries will require complex transitional arrangements. Up to 1998 many Accession Countries were making slow progress in adoption of EU environmental standards (European Commission, 1998c). The main area of weakness was poor institutional capacity in environmental inspectorates. The longer term challenge of enlargement is that there may, in the future, be pressure to make new and even existing environmental legislation much more flexible, and indeed use means other than legislation to attain the goal of environmental improvement in order to take into account the economic and environmental diversity of Member States.

Progress at EU and Member State level in introducing key instruments — Table 4.1.2.

Instrument	EU level initiatives	Member State initiatives
Research and development	Funding in the 5th research framework programme will be EUR 2 billion for the environment	Support for clean technology in many Member States
Environmental Impact Assessment (EIA)	Directive on EIA in 1985 (revised in 1997)	About 7000 EIAs per annum conducted across EU
Environmental management systems	Eco-Management and Audit Scheme (EMAS) from 1993	About 1500 sites registered with EMAS by 1998
Regulations (emission standards, licensing/ permitting/bans)	About 315 environmental related Directives (including updated Directives)	About 90% of EU Directives had been transposed into national legislation, but still weaknesses in implementation
Voluntary agreements	Guidance to Member States (European Commission, 1996a) Agreements on energy efficiency in washing machines and TVs; and CO_2 emissions with auto industry	More than 300 voluntary agreements agreed from 1990-96, mostly for industry, with about 100 in Germany and 100 in the Netherlands
Subsidy reform	Reform of Common Agricultural Policy, Common Fishery Policy, Structural Funds, Cohesion Fund, European Investment Bank	Reform of domestic energy and industrial subsidies underway
Environmental taxation	Guidance to Member States (COM(97)9) Mineral Oils Directive (1992) Proposal for VAT on energy to be harmonised and discussion of pesticide tax	Growth in environmental taxation with Nordic countries leading the way. EUR 6 billion raised by pollution taxes in EU in 1996 – a 100% increase since 1990

Source: EEA

2.3. Incentive approaches

The use of economic and fiscal incentives was emphasised in the 5EAP: 'In order to get prices right and to create market-based incentives for environmentally friendly economic behaviour, the use of economic and fiscal incentives will have to constitute an increasingly important part of the overall approach. The fundamental aim of these instruments will be to internalise all external environmental costs incurred during the whole life cycle of products – from source through production, distribution, use and final disposal – so that environmentally friendly products will not be at a competitive disadvantage in the market place vis-à-vis products which cause pollution and waste.'

2.3.1. Voluntary agreements

During the 1990s, voluntary agreements (VAs) have grown in popularity as a means of internalisation (Box 4.1.1), particularly in the industrial sector; 'Environmental agreements with industry have an important role to play within the mix of policy instruments sought by the Commission. [...] They can offer cost-effective solutions when implementing environmental objectives and can bring about effective measures in advance of and in supplement to legislation. In order to be effective, it is essential, however, to ensure their transparency and reliability.' (European Commission, 1996a).

Table 4.1.3 shows that all Member States have experimented with some form of voluntary agreements. In 1996 some 305 *national* agreements were recognised in the European Union but many more exist at sub-national level (European Commission, 1997a). They are focused on many different sectors but 20% of these were in chemicals;

Box 4.1.1. How do voluntary agreements work?

Voluntary agreements (also known as covenants or negotiated agreements, as they may not be strictly voluntary) involve a polluter negotiating with a regulatory authority to reduce pollution or modify resource depletion. VAs may take several forms. EEA (1997) distinguishes those which determine the target for reduced environmental impact, from those where the target is already established, with the VA focusing on the detailed implementation of action to achieve the target. The term 'voluntary agreement' covers a wide range of commitments, varying in terms of their legal characteristics, reporting mechanisms, monitoring arrangements, etc.

Voluntary agreements differ from conventional regulatory policy in several ways. First, the actual target of policy may be part of the VA. In other cases, however, the VA is simply substituted as the means of achieving a target that would have been implemented anyway. Second, formal legislation is generally avoided, although the threat of that legislation often remains. The VA effectively becomes a means of 'putting the polluter's house in order' in order to avoid the legislation. In other cases, the threat is of sanctions for not achieving the VA target, rather than the threat of legislation to mandate the target. The difference in effect here may be negligible and the extent to which such agreements are truly 'voluntary' has been questioned (Segerson and Miceli, 1996).

Voluntary agreements remain controversial as a policy mechanism for achieving environmental goals. On the positive side they impart considerable flexibility to the polluter as to how to meet an agreed target. In this respect they are likely to minimise compliance costs, an important feature of modern environmental regulation. From the polluter's point of view they may also have a benign public image: the industry is seen to be taking action on its own, even if there is a less well publicised threat of sanction behind the agreement. From the regulator's standpoint there is the advantage of avoiding costly legislation, although this may be offset by the need to monitor the agreement and put pressure on to achieve the environmental goals (European Commission, 1997c).

As to environmental effectiveness, there is contradictory evidence about the extent to which firms achieve the environmental targets in VAs. In the USA there is some evidence that firms in VAs over-comply (Schmelzer, 1996), whilst some European studies find that environmental goals are rarely met at all (Bizer, 1999). The EEA assessment of six cases (EEA, 1997) judged that agreements had been effective in a few cases but that insufficient information was available to assess the remainder. For those VAs where the target itself is negotiated, there are some suspicions that the resulting goal is less than would have been the case had legislation occurred. This perception tends to be reinforced if the VA excludes representation from environmental interests; i.e. is exclusively between polluter and regulator. Not all policy areas are suitable for conventional approaches, however, and VAs may be especially suited to contexts where highly technical and complex factors make conventional legislation difficult. This is a well-known issue in regulation, namely one where the information rests with the polluter and the costs of acquiring the information by the regulator are very high (so-called 'asymmetric information').

Finally, doubts have been cast about other aspects of VAs. Because of their potential for high publicity that benefits the industry, there is an incentive to 'free ride'; i.e. for a single firm to secure the benefits of the publicity without undertaking any aggressive measures. The extent of this free-riding is generally unknown (Storey, 1996). There are also concerns about the extent to which VAs can restrict competition and will affect trade within the EU, by forcing co-operation between competitors. At the moment there appears to be no evidence that this is the case, but some commentators perceive it as a real risk.

At the moment, experience is too new for the effectiveness of such agreements to be determined. The EEA survey (1997) suggests that they have been partly responsible for observed environmental improvements, and have been associated with the introduction of environmental management schemes in some firms. On the other hand, Bizer (1999) reviews eight voluntary agreements and finds that none of them can be regarded as cost effective – i.e. none produced a better environmental solution than alternative forms of regulation.

12% in food products, tobacco and beverages; 11% in transport, communications and storage; 11% in metals; 10% in non-metallic mineral products; 10% in electricity, gas and water supply; and 10% in rubber and plastic products. Sector definitions can overlap somewhat. The Netherlands and Germany account for some two-thirds of prevailing agreements. Voluntary agreements are unlikely to be suitable for all sectors; in particular, they are not easily applicable to heterogeneous sectors such as agriculture. Most agreements have been for waste management, followed by air pollution and climate change. Examples include agreements on producer responsibility for packaging in Sweden, Germany and the UK, and an agreement in Portugal between the Ministry of Environment and the paper industry.

To date most VAs have been concluded within Member States, but there is now a desire to initiate more EU level agreements. The first EU level agreement came in 1997 with a 20% improvement in energy efficiency by 2000 (from a 1994 baseline) agreed with the washing machine and television/video recorder industry. In October 1998, a landmark agreement was reached between European car manufacturers and the Commission that average CO_2 emissions from cars would be reduced by 25% from 1996 to 2008. The Commission is now discussing voluntary agreements with the EU airlines industry and the pulp and paper industry. In addition to actual agreement, the EU issued a Communication in 1996 to Member States (European Commission, 1996a) that presents guidelines for the use of voluntary agreements. The Communication stresses that while VAs have some advantages, they should be more credible and transparent with third-party verification of binding targets.

Environmental agreements by Member State and sector, 1996 — Table 4.1.3.

	5EAP Sector					
Member State	Agriculture	Energy	Industry	Transport	Tourism	Total number
Austria			✓			20
Belgium		✓	✓			6
Denmark	✓	✓	✓			16
Finland			✓			2
France		✓	✓			8
Germany		✓	✓			93
Greece		✓	✓		✓	7
Ireland			✓			1
Italy			✓			11
Luxembourg		✓	✓			5
Netherlands	✓	✓	✓			107
Portugal	✓		✓			10
Spain			✓			6
Sweden	✓	✓	✓			11
UK			✓			9
EU15						312

Source: EEA, 1997

2.3.2. Subsidy reform
Both at EU and Member State level, there are major subsidy programmes that affect environmentally important markets, such as energy, agriculture, transport, heavy industry and fisheries. Due to the existence of subsidies, product prices can be lower, even at a level that may not cover private costs. While such subsidies are often introduced for sound social and economic reasons, they sometimes have deleterious effects on the environment because they encourage wasteful production or the excessive use of damaging inputs (e.g. fertilisers, pesticides) (Table 4.1.4). Generally, subsidies are declining, although subsidies to agriculture through the Common Agriculture Policy (CAP) and to the coal industry in certain countries remain high, and may have considerable negative environmental impacts. There is widespread agreement that subsidies should, as far as possible, be reduced in an effort to reduce environmental damage. In undertaking subsidy reform, it is possible to introduce environmentally beneficial subsidies which are in effect payments for the provisions of external benefits. For example, as part of CAP reform, there has been an increase in payments to farmers for environmentally positive land use. These benefits include the provision of amenity and natural assets such as woodland, lakes and ponds, stone walls and traditional buildings. A fuller description of the sector specific subsidies is given in Sections 3-7 below.

2.3.3. Environmental taxation
Environmental taxation was stressed in the 5EAP and Member States have been active in increasing taxation, particularly in the

Table 4.1.4. **Potential environmental effects of sectoral subsidies**

Sector	Approximate size (EUR)	Type of subsidy	Potential environmental impacts
Agriculture	65 billion (1997)	Commodity price support. Subsidies on inputs (fertilisers, pesticides, capital, water). General support (R&D, extension).	Negative impacts: increased pollution from intensive agriculture and habitat destruction due to price guarantees. Positive impacts: agri-environmental schemes, support for environmentally beneficial activities.
Energy	9.3 billion (1995)	Support to coal producers. General support to fossil fuels. Support to electricity sector.	More pollution from coal and fossil fuels in general. Reduced energy efficiency.
Transport	0.44 billion (1995) to road freight	Revenues collected from road users is less than expenditure on road maintenance etc.	More road transport and hence more air pollution, noise etc.
Industry	25.2 billion (1994) – excluding Germany (=17.4 billion, 1994)	Subsidies to encourage location in certain areas. Subsidies for certain industries (steel, ship-building and textiles).	Increased production in some environmentally damaging industries (e.g. steel).

Source: Steele, Hett & Pearce, 1999 based on data from OECD, 1998a; IEA, 1998; ECMT, 1998; European Commission, 1997b

Nordic countries. However, progress at the EU level remains slow up to now; the Commission's 1992 proposal for an EU-wide CO_2/energy tax was not adopted (see Section 2.2 in Chapter 3.1). The EU adopted in 1992 the Mineral Oils Directive, a fiscal harmonisation measure setting a minimum level of excise duty on motor fuels in all Member States. There are now a number of initiatives to increase activity in this area in line with the concerns raised in the 5EAP: 'As such charges become more widespread and have real environmental impact and in consequence, generate greater financial income, some intervention at Community level may be necessary to ensure that charging systems are designed in a transparent and comparable way, and to ensure that distortions of competition within the Community are avoided'. There are proposals to impose minimum rates of excise duties on energy across the EU and for a framework for pesticide taxes. In addition, the European Commission issued in 1997 a Communication on environmental taxes and charges in the Single Market (European Commission, 1997c) which concludes that there is considerable room for Member States to introduce fiscal instruments in keeping with the legal and competition rules of the Single European Market.

At the Member State level, most states have taxes on motor fuels but significant differences remain in other areas, in particular agricultural inputs, air transport and water. Three major surveys by the OECD (1989, 1994, 1997b) show the use of economic instruments is on the increase, although progress has been modest. In 1987, European countries had around 137 examples of economic instruments; environmentally beneficial subsidies played a significant role, accounting for the vast majority of instruments in place in Germany and just under one-half of those in Finland. In 1992, the total number of instruments had increased to 157 and in 1997 the total number was 134, but subsidies were excluded from the survey and more countries were surveyed. Although overall progress has not been dramatic, substantial changes have taken place in some countries. Denmark effectively more than doubled its use of non-subsidy instruments in the five years between the two surveys, as did Germany. Since 1992 further changes occurred, with the Scandinavian countries substantially increasing the use of economic instruments, along with the Netherlands, Belgium and Austria (Figure 4.1.2). The number of taxes alone, however, has a limited value as an indicator of progress. Tax revenues from the UK, for instance, are higher than in many other countries.

The revenue from transport and pollution taxes represented only 1.8% of total EU tax revenue in 1996, although this proportion is larger for the Netherlands (5.5%) and Denmark (4.9%). By 1996, pollution taxes raised EUR 6.7 billion in the EU, while transport taxes raised EUR 45 billion. For pollution taxes this is a 100% increase in revenue since 1990. Transport taxes are very variable between Member States (see also Sections 6.5 and 6.6 below). Taxes classified as energy taxes, however, represented a larger proportion, at 5.3% of EU tax revenue on average, up to around 8% in Portugal and Luxembourg and around 7% for Italy and the UK. While the number and revenues of environmental taxes have been growing, their magnitude still remains low and they still make up a limited proportion of the total revenue from taxes and social contributions and a very small proportion of GDP (Figure 4.1.3).

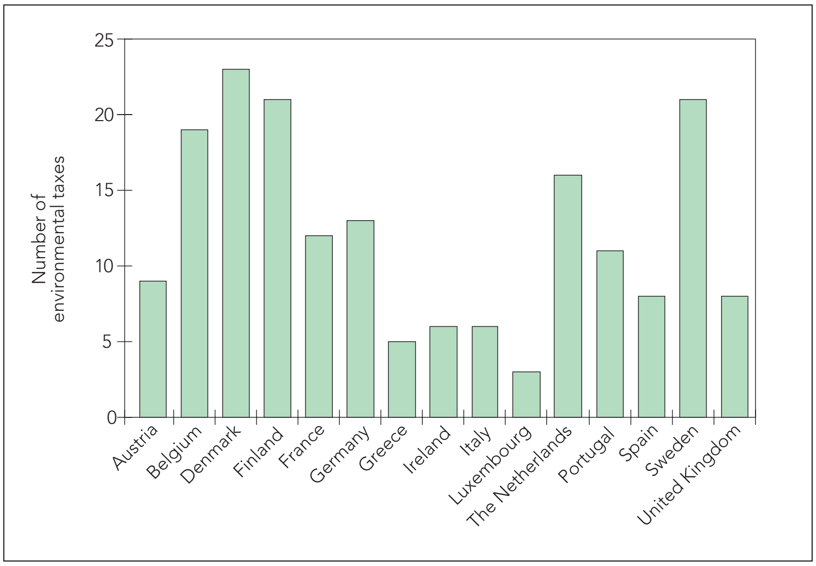
The progress in adopting economic instruments in the economies in transition is not included in the OECD and EEA surveys. A UNEP Compendium of case studies of economic instruments in central eastern European Countries (UNEP, 1997) suggests that economic instruments are quite widespread, reflecting the fact that an environmental tax base existed in some countries before transition, although such taxes were generally ineffective (Box 4.1.2).

Further progress on economic instruments can take place in three areas (EEA, 1996): their extension to more countries, increasing harmonisation and capability at the EU level, and developing new tax bases. Extension to more countries requires that other countries follow the more radical steps taken by the Netherlands and Scandinavia. Increased harmonisation is often advocated because of fears that environmental taxes, especially energy taxes, will have effects on competitiveness within the Single Market, thus providing a justification for action at EU level in accordance with the subsidiarity principle. But many environmental taxes will tend to be modest fractions of industrial production costs, so that competitiveness effects will be small or non-existent. Additionally, environmental damages vary by Member State so that the economic rationale for harmonisation is not always present. Nonetheless, moves towards harmonisation clearly provide one way in which the scale and extent of economic instruments can be extended. Steps to develop new tax bases are already in progress with discussion of innovative charges on pesticides and air fuels, but could also include water resources and hazardous chemicals.

In the longer term, there may be a more radical shift away from taxing 'goods' like labour towards taxing 'bads' such as environmental damage. This was discussed in the Commission White Paper on Growth, Competitiveness and Employment (European Commission, 1993b) which concludes: 'Finally if the double challenge of unemployment/environmental pollution is to be addressed, a swap can be envisaged between reducing labour costs through increased pollution charges'. Some countries are already applying this. The tax reform in Denmark provided for marginal income taxes to be lowered by about 8-10% between 1994 and 1998, and for the phasing in of new green taxes worth EUR 1.6 billion (EEA, 1996). The total redistribution of the tax burden in Sweden was equivalent to 6% of GDP, while the tax shift between labour and energy accounted for 4%. The 1998 French budget included a new generalised pollution tax grouping taxes on water, air pollution and waste, which will be used to lower taxes on labour. Similar reforms have taken place in Norway and the Netherlands, whilst the UK has introduced a landfill tax with the revenues being used to reduce labour taxes and support environmental trusts. It is likely that in the future, this shift to taxing environmental damage to reduce labour taxes, known as 'ecological tax reform', will grow.

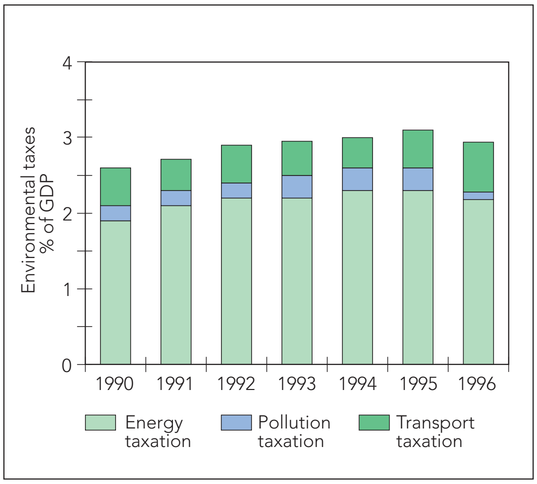
The result of this shift is that, when environmental taxes are combined with reductions in distortionary taxes, not only does the environment improve, but there may also be positive economic effects. This is known as

Number of environmental taxes in EU countries, 1996 Figure 4.1.2



Source: OECD, 1997b

Energy, pollution and transport taxes as % of GDP in the EU, 1990-96 Figure 4.1.3



Note: for comparison with other diagrams taxes are shown here as percentage of GDP and not, as is more common, as percentage of total revenues from taxes and social contributions.

Source: Eurostat

Box 4.1.2. Economic instruments in economies in transition (central and eastern Europe, Accession countries)

Pollution charges have traditionally been in place in the transition countries. Due to their levels being too low and the lack of institutional mechanisms for full collection, they had little effect in the 1980s. Currently, though, economic instruments are gaining importance in the 'new' environmental policy.

In Poland emitters of air pollutants must have a valid permit which in turn is contingent upon demonstrating the fate of emissions using dispersion models. All permitted polluters must then pay a charge on emissions and fines if emissions exceed the standard set. Fines are about 10 times the emission charges. The emission charge was US$2 per tonne of SO_2 emitted in 1990 increasing to US$96 in 1996. Revenues raised in 1994 totalled some US$105 million from the SO_2 tax alone. Revenues are hypothecated to various environmental funds at local, regional and national levels. To date the charge has probably not encouraged the introduction of abatement equipment beyond major enterprises since it is too low. Nonetheless, compliance appears to be improving, and environmental funds play a positive role.

Hungary introduced a packaging waste charge in 1996. Charges are paid according to the weight of the packaging material, with a discount for the degree of recycling beyond some obligatory target. The recycling may be undertaken by the payer of the charge or through a binding contract with a recycling organisation. Major packaging corporations and users of packaging have already instigated recycling measures. The charge rates are mainly based on the costs of treating packaging waste and are levied at the first point of sale to minimise the complexity of the charge system. Actual revenues are projected to be around US$13 million per annum.

In the Czech Republic large and medium-sized polluters have, since 1992, had nine years by which to comply with air emission standards comparable to those in the EU. Emission charges cover nearly 90 pollutants and are an integral part of the programme of compliance. Charges were set to be similar to average abatement costs, when these were known, with a discount for contexts where technologies are under development, and a surcharge of 50% for non-compliance. Other charges are based on effluent and waste. The revenues from the waste charge are recycled to the communities in the locations where the waste site is located – effectively a form of compensation. Natural resource charges on converted agricultural land, groundwater, surface water and mineral extraction are also in place.

Sources: Lehoczki and Sleszynski, 1997; Balogh and Lehoczki, 1997; Seják, 1997.

the 'double dividend' and has recently been estimated at an EU level (Jarass, 1997). Work by the Norwegian Tax Commission suggests that raising environmental taxes equal to 1% of GNP, and reducing labour taxes by an amount equal in revenue terms would raise employment by 0.7%, reduce the consumer price index by 1.2% and raise disposable incomes by 0.2% by the year 2010 (Moe, 1996). A recent study for the UK finds that seven new environmental taxes could help create 391 000 jobs (Cambridge Econometrics, 1997).

2.3.4. Tradable permits and joint implementation

The 5EAP highlights the possibility of more innovative economic incentives: 'It will be important to study also the extent to which possible options such as tradable permits could be utilised to control or reduce quantities (of pollution)'. With such programs a fixed total quantity of allowed pollution (emission budget) is set and allocated in the form of tradable permits to the regulated community. The polluters have the choice which policies or measures to use to comply with the overall target. Among the possible compliance options is the acquisition or transfer of tradable permits. Similar programs can be used to limit or control resource extraction (e.g. fish catch, water use). While this approach has yet to penetrate Europe, they are commonplace policy weapons for the control of air pollution in the US and for fisheries management in the US, Australia and New Zealand (OECD, forthcoming 1999). Germany is about to introduce a trading scheme for volatile organic compound emissions from small industry. The onset of further restrictions on sulphur and nitrogen emissions in Europe and the implementation of the Kyoto Protocol to the Framework Convention on Climate Change are likely to see more attention to tradable quota systems in Europe.

2.4. The use of policy instruments in the EU: a summary

The sectoral distribution in the use of the main policy instruments discussed above is summarised in Table 4.1.5. Due to the character of the various sectors, the applicability of the instruments varies, which is one of the reasons behind the distribution shown. In this respect it needs to be stressed that, as mentioned before, such a quantitative overview certainly is not intended for progress evaluation towards some targets.

3. Agriculture

The agricultural sector is still rich in market distortions which encourage harmful agricultural practices. The Agenda 2000 reforms promise to further the current progress in this area. However, integration with a real and large-scale effect on the environment has yet to be realised. Overall, progress towards internalisation in agriculture is moving in the right direction by reducing environmentally damaging subsidies and introducing economic instruments, but at a slow pace.

3.1. Environmental assessment of the sector
The agricultural sector has shown declining air emissions and fertiliser use since the late 1980s (Figure 4.1.4). The decline in fertiliser use can be attributed to several factors, including increased use of manure, and technical change (see Chapters 2.2 and 3.5). This trend is likely to continue with stricter implementation of the Nitrate Directive and the CAP reforms. The decline in livestock numbers has helped to reduce methane and ammonia emissions, although livestock farming still contributes significantly to total methane emissions (42%) (see Chapter 3.1 and 3.4). The number of pigs is still rising, with high concentrations in certain parts of the EU and accompanying manure problems. The overall livestock density has not declined, which also points to the continuation of the nutrient load in areas with intensive farming systems. Pesticide use (in tonnes of active ingredient) has stabilised in the EU, although the newer pesticides are more biologically powerful and applied in smaller quantities. Energy use per unit of production continues to grow, although energy use in agriculture amounts to a very small proportion (less than 2.5%) of overall energy consumption. Agriculture is the largest consumer of water in southern Europe, and this is increasing. One positive trend is that the share of agricultural area in the EU devoted to organic agriculture has been steadily increasing, although at approximately 1.6% in 1997 the effect of this is probably insignificant. The social context of the agriculture-environmental debate cannot be ignored. In the 1980s, about three million people in the EU12 left agriculture, a decline of almost 40%, highlighting the importance of diversification of the rural economy (see Chapter 3.13).

The environmental impacts of agriculture in the Accession Countries are mixed. Intensification has occurred, but in areas outside the collective farms and following the declines in output since 1990 the use of inputs such as fertilisers and pesticides was relatively low in most countries and the associated pressures on nature and wildlife were less than in much of western Europe (European Commission, 1998d) (see Chapters 2.2 and 3.13).

Summary of use of instruments in each sector within the EU (in %) — Table 4.1.5.

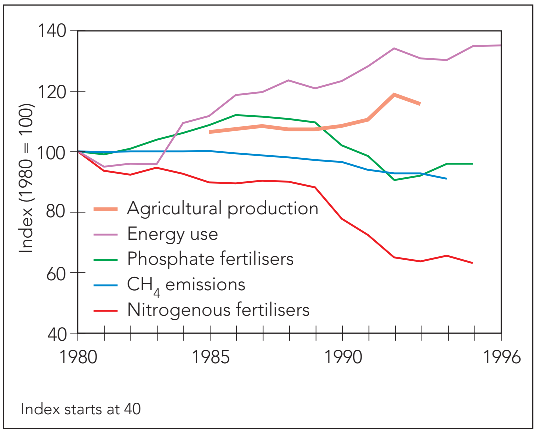
	Agriculture	Industry	Energy	Transport	Households
EIAs per year (period 1989-1991: 7000 per year)	16	26	8	30	20 (waste)
Directives (315 in total)	30	40	5	14	9
Voluntary agreements (305)	3	88	5	4	-
Environmental taxation (134 taxes)	3	9	18	54	16
Environmental Management Systems (1714 registered EMAS sites)	-	88	4	8	-

Sources: EIA: derived from European Commission, 1993a; EC Directives: Haigh, 1998; Voluntary agreements: European Commission, 1996a; Environmental taxation: OECD, 1997b; EMAS: ERM (forthcoming).

There are many ways to reduce environmental damage from agriculture. The assessment will focus here on measures targeting both inputs (pesticides, fertilisers, and water) and outputs (agricultural area and livestock density).

3.2. Quantified environmental damage
In comparison with other sectors such as energy and transport, the agricultural sector has not been the subject of attempts to measure environmental damages on a systematic basis. A recent investigation of UK agriculture (Pretty et al, 1999) estimates the external costs in 1996 to be almost EUR 2.3

Agricultural production and selected emissions to the environment — Figure 4.1.4



Source: EEA

billion, of which EUR 320m is from damages to water resources, EUR 700m is attributed to air emissions, EUR 140m is damage to wildlife, landscape and genetic diversity, and around EUR 1 billion is damage to human health from BSE ('mad cow disease') and related diseases.

3.3. Regulations

Several EU policy measures are beginning to exert a greater influence on the agricultural sector and its environmental impacts, including the Nitrate, Pesticides and Habitat Directives (see Chapters 2.2, 3.5 and 3.11). However, legislation has not always been successful, for example the widespread failure to implement the 1991 Nitrate Directive which has resulted in legal proceedings by the Commission against 13 of the Member States (ENDS, 21 October, 1998). The EU has also passed two Directives (EEC 2092/91 and EEC 2078/92) setting up a harmonised framework for organic production and organic livestock farming.

3.4. Subsidy reform and agri-environmental measures

The European Union subsidises agriculture on a substantial scale. The main forms of subsidy are (a) market price support whereby farmers are guaranteed prices that are often above world prices, and (b) direct payments to farmers. Other forms of support also exist. Direct payments have been growing since the 1992 CAP reforms, the aim being a gradual reduction in price support to be replaced by direct payments with targeted objectives, including payments to set aside land from agricultural use and programmes to promote environmental objectives (see Chapter 3.13). Whereas price support accounted for virtually all EU subsidy in the mid 1980s, currently direct payments are having account for over two-third of the agricultural budget. Most, but not all, switches from price support to direct payments have been environmentally beneficial (OECD, 1997a, c; OECD, 1998a,b).

In 1997 total agricultural subsidies (both environmentally beneficial and environmentally damaging) amounted to some EUR 65 billion, or some EUR 440 per household. By far the greater part of this sum (60%) is accounted for by milk and beef (Figure 4.1.5). The trend of subsidy is downwards from a peak of over EUR 90 billion in 1990, but the 1997 subsidy (for the EU15) is about the same as that in 1986 (for the EU12), so that the actual fall in the total subsidy is slightly larger than shown in the figures.

The general effect of the 1992 CAP subsidy reform has been beneficial to the environment, although in some cases policy changes have shifted input-intensive activity from one location or one activity to another. However, a Commission progress report on the 5EAP (European Commission, 1996d) argued that: 'the CAP reform did little to systematically integrate environmental concerns. Even if secondary positive effects can be expected from the reduction of price supports and from extensification, it should be avoided that these reductions will lead to the abandonment of agriculture in certain less favoured zones, which would have negative impacts on biodiversity and the landscape.'

In terms of introducing environmental beneficial subsidies the main EU instrument has been the so called agri-environmental measures (Regulation EEC No 2078/92) which provide 50% EU financing for schemes that improve the environment and contribute to rural development. Between 1993-1997 the EU budget for this was EUR 5 billion – about EUR 1 billion per year – but still only 1.5% of what is spent on CAP as a whole. Generally these schemes have been well subscribed, with agri-environment measures accounting for 20% of agricultural land and exceeding the target of 17% set in the 5EAP (see Box 3.13.7 in Chapter 3.13). However, research in the UK (National Audit Office, 1997) found that payments were sometimes set below levels to compensate farmers for average profit foregone. There are also concerns that the scheme requires only very modest environmental improvements from farmers, as has been the case in some German schemes. In addition, CAP provides an 'extensification premium' to producers whose stocking density is particularly low. There is also funding for environmentally sustainable farming, such as integrated pest management in the fruit and vegetable industry.

The CAP reform included in Agenda 2000, on which agreement was reached in March 1999, responds to the challenge of enlargement which will lead to 50% increase in agricultural land and a doubling of the farm labour force, so that maintaining the present CAP structure would be very expensive and lead to large EU surpluses in sugar, milk and meat. The political agreement reached on Agenda 2000 includes a 15% cut in the cereals intervention price in two steps starting in 2000/2001, a cut in beef price guarantees by 20% by 2002 and in the dairy sector a 15% cut in intervention prices in three equal steps starting in 2005/2006. In all cases, lost income will be replaced by direct payments, with provision for Member States to define environmental conditions for farmers to receive the direct payments – an approach known as ‘cross compliance’. There will also be a greater role given to the agri-environmental measures and increases in the extensification premium.

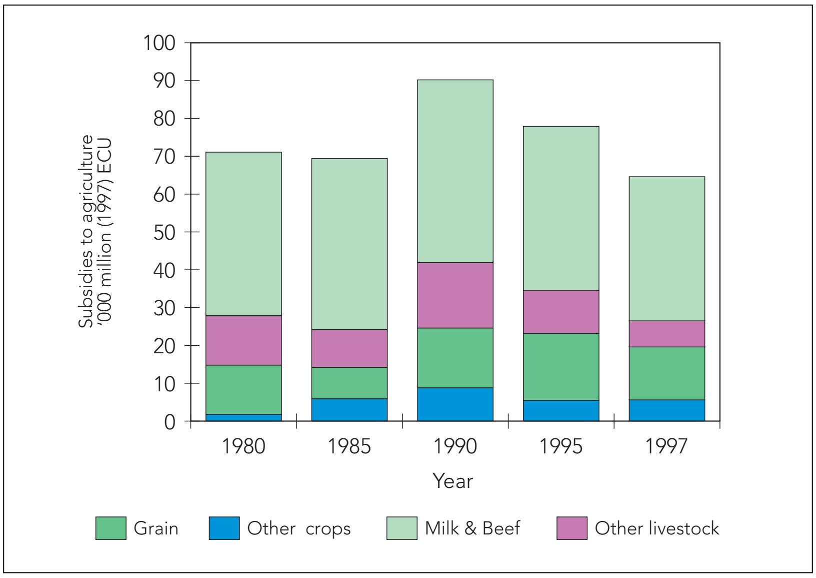
However, these proposals have been criticised as not going far enough: the total spending on rural development and the environment will only be 10% of the CAP budget; there is still no clear timetable for the phased removal of production support; and, it is left to the countries how to apply ‘cross-compliance’.

At the national level, perhaps the most obvious subsidies with an environmental effect are to irrigated agriculture in southern Europe. Municipalities supplying water to agricultural units in the Po Basin in Italy are required to charge prices based on cost recovery but in practice numerous exemptions are granted. In Spain, agricultural abstraction is subject to a levy which is not related to volume of water used, but to area of land, and there is a shortfall between recovered costs and the costs of supply. In other countries, subsidies may take the form of exemption from taxes: this is so in Portugal where irrigation water is exempted from a new tax introduced in 1995 and in the Netherlands where farmers are exempt from the groundwater extraction tax (see Chapter 3.5).

3.5. Environmental taxation

Economic instruments that affect agriculture include taxes on pesticides and fertilisers and charges on excess manure. Compared to other sectors, experience with environmental taxation in the agricultural sector is very limited (Table 4.1.6). Pesticide taxes of 3% and 5% of retail price levels have been introduced in Denmark and Sweden and are under discussion in the UK and the Netherlands (European Commission, 1997c). In 1998, the Danish tax on insecticides was increased to 54% of the retail price and the tax on other pesticides to 33% of the retail price. The European Commission recently commissioned feasibility studies on the possibility of introducing EU-wide taxes on pesticides and fertilisers, and an EU-wide framework could be proposed if diverse action by Member States is perceived to threaten to distort the single market. There is yet little consensus about these taxes across the EU, but the consultations and discussions continue.

Agricultural subsidies in the EU, 1980-1997 Figure 4.1.5



Note: 1997 figures are estimates. Figures shown are for producer subsidy equivalent.

Source: OECD, 1998b

4. Industry

Attempts at integration in the industrial sector have been underway for at least the last two decades. During this period, air and water emissions have declined although waste generation has been stable or increasing. While traditionally regulations alone

Environmentally related taxes and charges in the agriculture sector, 1996 Table 4.1.6.

Environmental tax measures	A	B	D	DK	E	F	FIN	GR	I	IRL	L	NL	P	S	UK	CZE	HUN	POL	IS	N	CH
Fertilisers														*						*	
Pesticides				*			*							*						*	
Manure charges												*									

Note: List of country codes at the end of the chapter.

Source: OECD, 1997b

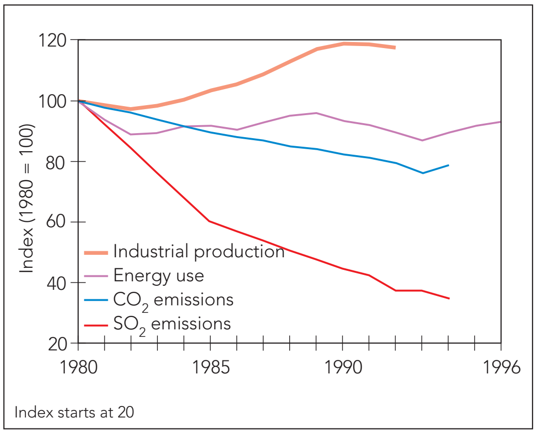
were used, there is now growing reliance on more innovative approaches such as voluntary agreements, environmental management, liability and green procurement and environmental taxation. These instruments are still only developing and there is scope for wider appliance across the EU.

4.1. Environmental assessment of the sector

The industrial sector was historically the first target of environmental concern and so the range of instruments to promote integration is most comprehensive in this sector. Despite increasing industrial production over the 1980s, emissions to air have significantly declined, especially emissions of SO_2 (Figure 4.1.6).

Figure 4.1.6 **Economic and environmental trends in the industrial sector, 1970-96**

Source: EEA



These developments can be partly linked to changes in legislation – the industrial sector was among the first to be targeted by EU environmental legislation, and several problems have been addressed through improved efficiency or end-of-pipe measures. The changing structure of the EU economies has also undoubtedly contributed to these changes (see Chapter 2.2).

Information from countries where data is available shows that the generation of industrial solid and hazardous waste has generally been stable or increasing. In most countries, industrial waste generated per capita exceeds the amount of municipal waste, except in Portugal and Denmark. As Chapter 3.5 shows industrial water abstraction in most European countries has been declining in the 1980s, primarily due to economic recession and technological improvements. Environmental damage from industry in the Accession Countries is lower in absolute magnitude compared to the EU15, but the intensity (e.g. waste generated per unit of GDP) is greater (OECD, 1998c). Liability for environmental damage (especially for soil contamination) is an important issue in these countries.

There are many strategies to reduce damage from the industrial sector. This section will focus on the key instruments available including regulations, environmental management, subsidy reform and environmental taxation. Eco-labelling and product standards are reviewed in Section 7.4 below. Voluntary agreements are not covered here as they have already been reviewed in Section 2.3.1 above.

4.2. Environmental expenditure

Quantitative estimation of the aggregate environmental damage from industry is exceedingly difficult. However, there is some information available on identified annual expenditure by industry on compliance with environmental regulations. The current expenditure for maintaining and operating environmental protection facilities, including payments to others for waste and waste water treatment, is in the order of 0.1 to 0.5% of GDP. Investments each year are in the same order of magnitude (Figure 4.1.7).

4.3. Regulations

In the past, the main instrument in the industrial sector has been regulation at the Member State level, harmonised by EU Directives. At the EU level the key Directives relate to hazardous waste, air emissions from industrial plants, chemicals and integrated pollution control through Integrated Pollution Prevention and Control (IPPC). IPPC has dramatically changed the way industrial pollution is regulated in many countries. The most important industrial Directive currently under discussion is an overhaul of EU controls on dangerous chemicals.

4.4. Environmental management systems

Environmental management (also known as eco-audit) is a voluntary scheme for producers designed to alert both producers and consumers on the need to use natural resources responsibly and minimise pollution and waste. The EU Eco-Management and Audit Scheme (EMAS) was adopted in 1993 and became operational in 1995 with the first awards made by accredited environmental verifiers appointed in each Member State. Companies wishing to register their sites with EMAS must adopt a company environmental policy, conduct an environmental review of all environmental issues and impacts, and in light of this review establish an environmental management system at their site. This management system must be audited at least every three years and the results of the audit and the initial environmental review must be used to prepare an environmental statement which is disseminated 'as appropriate' to the public (Haigh, 1998).

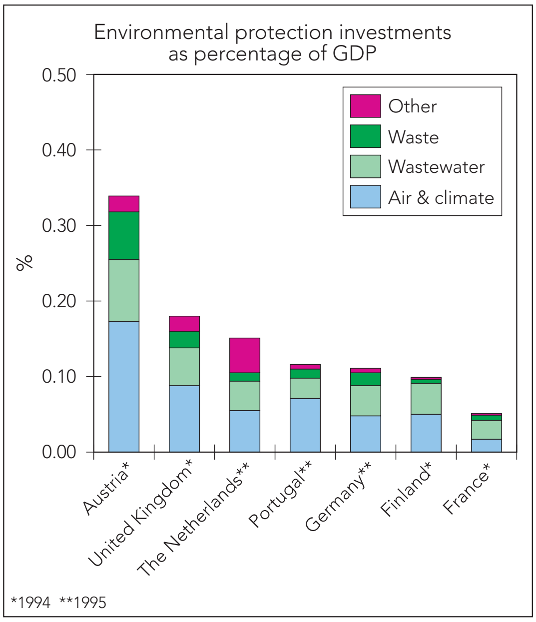
By 1998 there have been 1500 sites registered with EMAS, with about 75% in Germany. Interestingly, while most sites are industrial, there are also a number of transport and energy related sites. While the numbers applying for EMAS is growing, it is a tiny proportion of the estimated 1.7 million industrial enterprises in the EU. A study by the Commission to review EMAS (Hillary, 1998a) found various shortcomings. One of the problems is the overlap between the EU EMAS and its international equivalent ISO 14000, although attempts were made to register for ISO 14000 even after having received EMAS. The main reason is that for many global enterprises the ISO 14000 is more attractive as its marketing potential is not limited to Europe as in the case of EMAS (Hillary, 1998b). It is also argued that ISO 14000 is less demanding than EMAS since it does not require the publication of a validated environmental statement or continuous improvement in environmental performance (only in the system). Some fear that this may lead to pressure to ease some of the EMAS requirements (Haigh, 1998). In November 1998, the Commission published its proposals to revise EMAS to increase take-up and credibility, proposing to extend the scheme to sectors other than manufacturing.

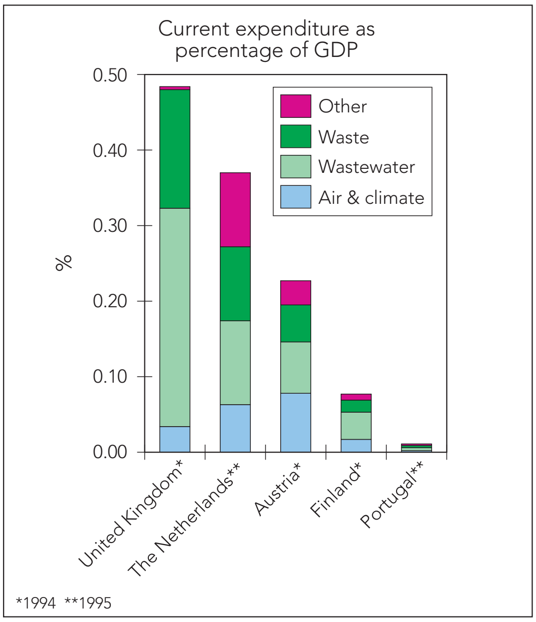
There has been only very limited quantitative attempts to evaluate EMAS. An Austrian study found that firms undergoing EMAS registration earn their investment in less than 14 months on average, through reduced production costs (Austrian Economic Chamber, 1996). In March 1996, Deutsche Bank announced favourable rates of interest for EMAS registered sites because it regards EMAS validation as a clear sign of reduced environmental risks. In addition, a number of German insurance companies view the existence of EMAS as a favourable factor when assessing company premium levels (Taschner, 1998).

4.5. Environmental liability

In January 1998, the Commission published a Working Paper on an EU environmental liability regime, and a White Paper was

Environmental protection investments and current expenditure for environmental protection by industry — Figure 4.1.7





Notes: The category 'other' includes soil and groundwater, noise and vibration, biodiversity and landscape, radiation, research and development and other activities. For many countries data is available for a few of these categories only. Totals can thus not be compared. Comparison is further limited by the varying structure of the economies. For instance, the high expenditure on waste water treatment in the UK is due to the privatisation of waste water collection and treatment in that country. Due to the nature of the activity the amount of investment can vary considerably from year to year. For Austria only 1994 figures are available.

Source: Eurostat

expected in May 1999. The liability would apply to 'operators' and 'any waste operator (including the waste producer)'. It would not be applied retroactively, but it would allow public interest groups to have legal rights to take cases and the burden of proof would be on industry. Although it will probably take up to 2002-3 for the liability regime to come into force, opposition to the White Paper by the industry has already started with claims that this will mean significant costs to the industry.

At the Member State level, Finland has already introduced liability legislation. About

2000 Finnish industrial firms have been legally obliged to purchase environmental liability insurance from January 1, 1999. The new insurance requirement covers the situation where a firm that has caused environmental damage cannot be found or is bankrupt, or where the source of damage cannot be agreed. The law is not applied retrospectively and therefore does not apply to cases of soil contamination caused before 1999.

4.6. Subsidy reform

In general, industrial subsidies in the EU declined considerably between 1992 and 1994, (Germany was the exception, as subsidies increased during the unification process). In 1994 subsidies amounted to EUR 42.6 billion (European Commission, 1997b). There was a substantial decline in those types of aid most likely to go to mobile investment projects (e.g. regional aid, R&D, and general aid programmes). There has also been an increase in the use of more transparent forms of aid in virtually every Member State (e.g. grants and tax reductions) versus a decrease in less transparent types of aid (e.g. loan guarantees and equity participation). In the OECD, more than 50% of sectoral programmes designed to benefit a single industry go to the shipbuilding, textile or steel industries, which together represent approximately only 9% of manufacturing GDP in OECD countries (OECD, 1996b). The environmental impacts of subsidy reform are unclear, although they should be beneficial in energy-intensive industries such as iron and steel.

In terms of environmentally beneficial subsidies, Austria, Denmark, Greece and the Netherlands operate subsidies for industrial pollution control. A number of schemes (Denmark, Greece and the Netherlands) are aimed at the development and demonstration of clean technology, e.g. up to 40% of the costs to the industry. In Austria, enterprises can claim up to 30% of the costs of wastewater treatment plants. In the Netherlands, there is a subsidy to promote clean processing of waste from the fishing industry with the budget of DFL 0.18 million in 1997. In addition, Austria, Denmark, France, Finland, the Netherlands and Portugal apply more relaxed accountancy rules, i.e. accelerated depreciation, for environmental investments.

4.7. Environmental taxes and charges

The main environmental levies affecting industry seems to be charges on (hazardous) waste generation followed by charges on water effluent (Table 4.1.7). Effluent charges are well established and were imposed in France since the 1960s and since the 1970s in the Netherlands. In both countries the charge was related to oxygen-demanding materials and heavy metals and helped stimulate a reduction (Tuddenham, 1995; Hotte *et al.*, 1995). Industry is also affected by general energy/CO_2 taxes. Charges on environmentally damaging inputs to the industrial production process such as oils and solvents are not as widespread.

5. Energy

Economic instruments are in common use in the energy sector. However, to reach targets of 12% of energy from renewables and 18% of electricity from co-generation in the context of more liberalised energy markets and falling oil prices will require tough policy measures, which might include increased subsidies to renewables and co-generation, greater use of voluntary agreements with electricity companies and higher taxes on fossil fuels.

5.1. Environmental assessment of the sector

Atmospheric emissions from power generation, have declined since the 1980s (Figure 4.1.8). These declines have been most marked for sulphur dioxide (50% decline from 1980 to 1994) and nitrogen dioxide (23% decline from 1980 to 1994). This has been the result of fuel shifts and technical improvements, such as increased generation efficiency, and pollution abatement, such as the installation of 'scrubbers' to reduce acidifying and summersmog related emissions. However, it is likely that the potential for such efficiency improvements and pollution control is now declining as, for instance, fuel shifts can be applied only once. Future reductions in atmospheric emissions, such as the 8% cut in greenhouse gas emissions required by the Kyoto Protocol (see Chapter 3.1), will need to come from greater use of renewables. Whilst there is considerable variation across Member States, on average only 5% of the EU energy supply in 1995 was from renewables, mostly hydro and biomass. There is thus clearly considerable potential to expand renewables particularly in countries where their use is low, such as Belgium, Ireland, the Netherlands and the UK. On average 9% of EU electricity comes from co-generation (also known as combined heat and power), but this percentage is much lower in Greece, France and

Table 4.1.7. **Environmentally related taxes and charges in industry, 1996**

Environmental tax measures	A	B	D	DK	E	F	FIN	GR	I	IRL	L	NL	P	S	UK	CZE	HUN	POL	IS	N	CH
Lubricant oil charge							*													*	
Oil pollution charge							*														
Solvents				*																	
Water effluent charges			*	*		*						*	*			*	*	*			
Tax on ground water extraction			*									*									
Hazardous waste charge	*	*	*			*	*						*			*	*	*	*	*	
Land fill tax or charge									*			*			*						

Source: OECD, 1997b

Ireland. In the Accession Countries the environmental effects of energy generation are smaller in absolute magnitude, but the intensity (as measured by energy supply per unit of GDP) is greater compared to those of the EU15 (IEA, 1998) (See Chapter 2.2).

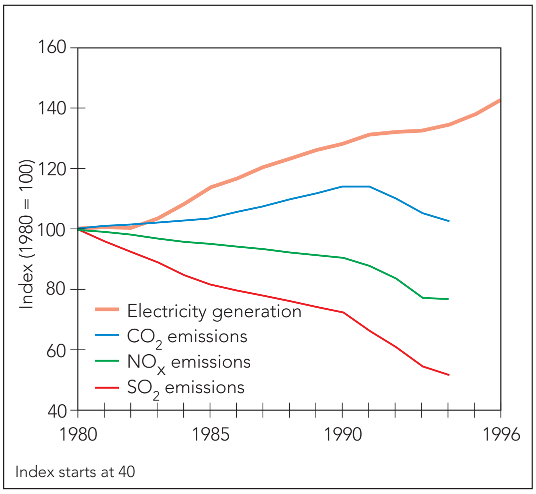
The main strategies to reduce environmental damages from the energy sector are to reduce energy demand (through energy efficiency), lower environmental damage from fossil fuel sources, switch to natural gas and renewables and increase co-generation. The issue of energy efficiency is reviewed in detail in the sections on households and industry, so here the focus is on fuel shifts, increased use of renewables and co-generation.

5.2. Environmental damage

The most developed sectoral study of environmental damage, the ExternE programme of DGXII, is for energy production (European Commission, 1998e). It presents estimates of mainly air pollution damage in units of EUR/kWh or EUR/tonne of pollutant, which can readily be compared with costs of pollution abatement. Damage categories include human health (morbidity and premature mortality), corrosion and soiling of buildings and materials, crop losses, global warming and freshwater pollution.

The most significant damages are those caused by emissions of particulate matter, due to its impacts on human health (morbidity and mortality) (see Chapter 3.10). This is followed by nitrogen dioxide, which in combination with volatile organic compounds contributes to the formation of ozone, which impacts on morbidity and mortality and also damages crops. The role of carbon dioxide in total damage, through its contribution to global warming, is also significant. In this case, it is the sheer volume of carbon dioxide emissions which result in such high total damage estimates: amongst the various pollutants, carbon causes the lowest damage per tonne.

Figure 4.1.8 **Economic and environmental trends in the energy sector, 1980-96**



Source: EEA

5.3. EU policy

EU energy policy was most recently set out in the 1996 White Paper which gives three main objectives: security of supply, improved competition and protection of the environment. While the Commission argues that market liberalisation will help renewables, others disagree arguing that they may be undermined by their higher price (IEA, 1999). In 1996 the Commission published a Green paper on renewables and this was followed up with a White Paper in 1997 (European Commission, 1997d) which stated that: 'Renewable sources still make an unacceptably modest contribution to the Community's energy balance.' The document proposed a target of 12% penetration of renewables by 2010 in the EU. However, the target was not approved by the Energy Council and a proposed Directive will only call for 5% share in electricity production for each country. To achieve this objective, the recent Directive on the Internal Market in Electricity allows Member States to give preference to renewables. The Commission also proposed that 18% of EU electricity should be produced by co-generation by 2020 – a doubling from the current figure – and this was welcomed by the Energy Council.

5.4. Subsidy reform

Energy subsidies targeted to fossil fuels are one of the largest subsidies with possible environmental effects (Figure 4.1.9). The UK systematically reduced subsidies to coal production to below EUR 0.2 billion by 1995. However, German subsidies remain high, at EUR 4.7 billion in 1998, and Spanish subsidies were over EUR 1 billion in 1996 (IEA, 1998). Germany expects to have reduced its coal subsidies to EUR 2.8 billion in 2005.

Reduced subsidies to coal production will most probably lower emissions of conventional air pollutants and carbon dioxide. The extent of this environmental effect depends on what is used as a substitute for subsidised coal. In some cases, for example, it is likely to be imported coal, whereby the extra demand for imported coal will likely have the effect of raising world market prices since the EU is a major coal consumer. The rise in world-market prices would in turn encourage worldwide reductions in coal usage, reducing carbon dioxide emissions (Anderson and McKibbin, 1997). In other cases the substitute would be natural gas which has a lower environmental impact per unit of energy than coal: the environment impact is therefore directly beneficial.

However, subsidisation has other effects, for example by encouraging energy-intensive industries to locate in subsidised areas. There is some evidence that aluminium smelters, for example, have been encouraged by subsidies. Since aluminium is an energy-intensive industry, the subsidy also has the effect of discriminating against the use of recycled secondary aluminium which is far less energy intensive (Koplow, 1996). Various studies have shown that there are triple-dividends from reducing subsidies: energy costs fall because substitute sources are encouraged, environmental impacts are reduced and government finances improve (OECD, 1997d). Individual case studies suggest, however, that environmental benefits could be quite small: the gains from removing subsidies range from around 1% of the sector's contribution to carbon dioxide emissions in a selection of EU countries, to 5% in Norway. For comparison, significant effects of up to 16% of emissions would be secured in Russia (OECD, 1998d). More substantial environmental impacts arise if the analysis is extended to worldwide impacts through the effects on the world market price of coal.

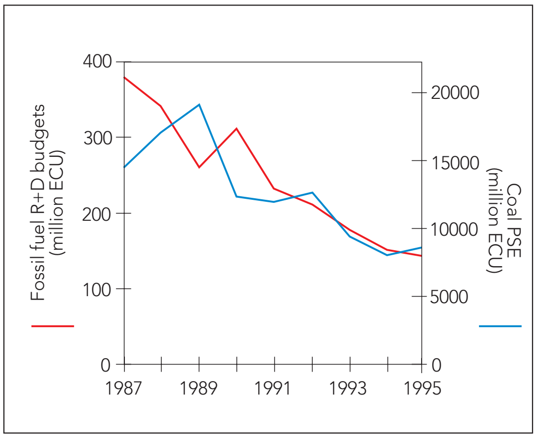
The main focus of EU energy subsidies is on the production side. By contrast, subsidies in eastern Europe focus on keeping consumer prices down. Since 1990 supplies from the Russian Federation have dropped and the effect has been a substantial reduction in subsidies**.** The scope for further reductions, especially in the coal sector, appears large but there are clear trade-offs between subsidy reduction and employment concerns (World Bank, 1997).

In terms of environmentally beneficial subsidies, many countries have introduced subsidies for renewable energy and this was welcomed in the recent Commission White Paper on Renewables. In Denmark, wind

Figure 4.1.9 **Subsidies to coal and to fossil fuel research and development, 1987-1995**

Note: Total subsidies for coal are shown in producer subsidy equivalents (PSE) for Germany, Spain plus the UK. Fossil fuel Research and Development budgets are for EU15.

Source: IEA, 1998



energy has been promoted by an investment subsidy and electricity tax repayment. In Germany, generous subsidies through a minimum tariff are provided making Germany the second largest wind generator in the world (after the US). In the UK, subsidies through competitive tendering for a renewable quota have led to a substantial decline in the costs of generation, although the UK remains the country with the lowest reliance on renewables in the EU at only 0.7% of total energy consumption. The competitive tendering approach is also used in France and Ireland, and it seems that this more cost-effective approach will be included in the forthcoming Directive prepared by the Commission. At the EU level, subsidies are provided by the ALTENER programme which has now been extended.

5.5. Environmental taxation

Environmental taxation on the use of fossil fuels was welcomed by the European Commission, as a means to increase the competitiveness of energy from renewable sources (European Commission, 1997d). This is especially important given the decline in world oil prices and the ongoing liberalisation of electricity markets. Recent taxes focus on CO_2, as well as nitrogen and sulphur oxides (Table 4.1.8). The Netherlands, Austria, Belgium and the Scandinavian countries have introduced CO_2 taxes. More recently, in January 1999, Italy became the first southern European country to introduce a CO_2 tax, which will be used to fund a wage subsidy to employers. While efforts to introduce an EU-wide CO_2 tax have not – thus far – met with success, progress is being made on a Directive that would for the first time impose EU-wide minimum rates of excise duty on most energy products. However, the proposal requires unanimity to be passed and a decision has been delayed to May 1999. Sweden introduced in 1992 a NO_x charge on large combustion plants which led to a fall in NO_x emissions per unit of input energy from 159mg/MJ to 103mg/MJ by 1993 (OECD, 1997d).

5.6. Joint implementation

One of the most innovative instruments is *joint implementation* (JI) under the Framework Convention on Climate Change. JI in general involves an agreement between two countries whereby one country (the investor) reduces pollution in the second country (the host) and counts the reduction in pollution as a credit against some national target. JI exists under the Montreal Protocol (see Chapter 3.2) with 'trades' in CFC emissions and is enabled under the Second Sulphur Protocol under the UNECE Convention of Long Range Transboundary Air Pollution (see Chapter 3.4). A specific application based on the JI notion is the 'Activities Implemented Jointly (AIJ)' phase of the Climate Change agreement (see Chapter 3.1). This was initiated in 1995 and will terminate in 2000. Under AIJ investor countries fund or undertake emission reduction or sequestration projects in host countries. In the pilot phase, no credits are constituted or counted against national emission targets. The Kyoto Protocol opens the way for project-based JI between Annex I countries (OECD plus the economies in transition) and the developing countries. Since the source or location of greenhouse gas emissions is irrelevant to the effect on global climate change, JI projects offer mutual gains: the investor undertakes emission reductions at lower cost; the host benefits through the transfer of improved technology, e.g. power station technology or a sequestration project (afforestation, reduced deforestation), which may stimulate economic development and improve the environment. Currently about 100 official AIJ projects are implemented. Numerous AIJ

Environmentally related taxes and charges in the energy sector, 1996 Table 4.1.8.

Environmental tax measures	A	B	D	DK	E	F	FIN	GR	I	IRL	L	NL	P	S	UK	CZE	HUN	POL	IS	N	CH
CO_2/ Energy taxation	*	*		*			*					*		*				*		*	*
Sulphur tax	*			*		*								*				*		*	
NO_x charge						*								*		*		*			
Other excise taxes			*	*	*	*	*	*	*	*	*	*		*	*		*			*	

Source: OECD, 1997b

projects with the involvement of European countries as the host exist, especially in Russia, the Czech Republic, the Baltic States, Poland, Hungary, Romania, Bulgaria and Croatia. European investor countries include Sweden, the Netherlands, Norway, Germany, France and Belgium.

6. Transport sector

While many instruments are being applied to reduced transport damage, these are being overwhelmed by the rapid rise in demand for transport. There remain implicit subsidies to commercial freight and the airline industry through untaxed kerosene. While environmental taxes on fuel have been successful in increasing demand for unleaded petrol, they have not had much effect on reducing driving. Serious consideration needs to be given to comprehensive urban road-pricing schemes which no EU country has implemented yet.

6.1. Environmental assessment of the sector
Transport is the fastest growing sector relevant to the environment (Figure 4.1.10; see Chapter 2.2). Passenger vehicle-kilometres and freight tonne-kilometres grew by 1.8% and 3.2% respectively in 1995, while passenger-air miles grew at 11 %. Emissions from motor vehicles have significantly increased as car ownership has risen (and the number of people per car has declined in the EU from about 2 in the early 1970s to about 1.6 in the early 1990s). Environmental damage per vehicle-km has remained fairly constant as measured by carbon dioxide and nitrogen dioxide emissions per vehicle-km, although sulphur dioxide emissions per vehicle-km have significantly declined. This lack of progress, despite pressure on car manufacturers to improve fuel efficiency, arises from the gap between actual and test values for fuel efficiency due to poor driving behaviour and urban congestion which prevents the fuel efficiency being achieved (IEA, 1997).

Cars now make up about 80% of passenger-kilometre journeys, while heavy good vehicles make up about 76% of freight tonne-kilometres, and there are limited possibilities for switching to more environmentally friendly alternatives such as clean vehicles, public transport, cycling or even walking. The development of low emission cars powered by electricity, gas or biofuels has been slow in most countries. There is some penetration of gas cars in the Netherlands and Italy, biofuel cars in Sweden and electric cars in Italy, but they still make up a small share of the fleet. It is projected that the share of passenger transport by car in the Accession Countries will increase from 45% of the total in 1994 to 80% in 2030.

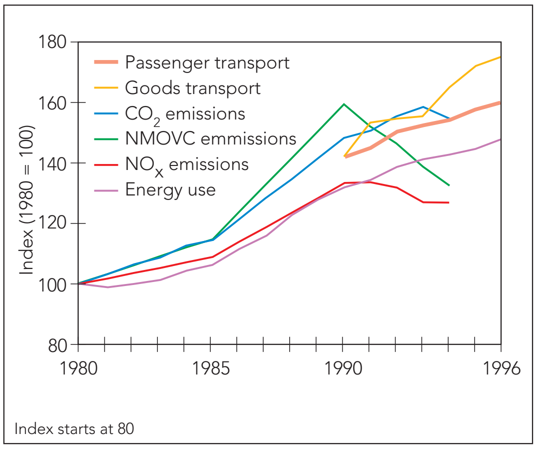
Growth in the use of motor vehicles also causes environmental effects in an indirect way. Investments in road infrastructure, which lengthened Europe's roads by 3% in 1996, have effects on nature and biodiversity. Similarly, the production of vehicles is a polluting process. The stock of vehicles is growing at 4% a year.

Attempts to integrate environmental concerns into the transport sector were recently outlined in a report by the Transport Council presented at the Vienna European Council in December 1998. This report highlighted the need for measures that: enhance fuel efficiency and reduce emissions and noise; make the best use of available infrastructure; and, achieve a shift to less environmentally damaging modes of transport. As a first step the report argued that progress is required in transport pricing and environmental costs, the revitalisation of rail transport and the promotion of inland waterways, maritime transport and combined transport. The way these measures have been introduced in the past years is reviewed below, focusing on the different instruments available, including regulations, voluntary agreements, subsidy reform and environmental taxation.

6.2. Quantified environmental damage
Externalities from road transport comprise: noise nuisance; local, regional and global air

Figure 4.1.10 **Economic and environmental trends in the transport sector, 1970-96**

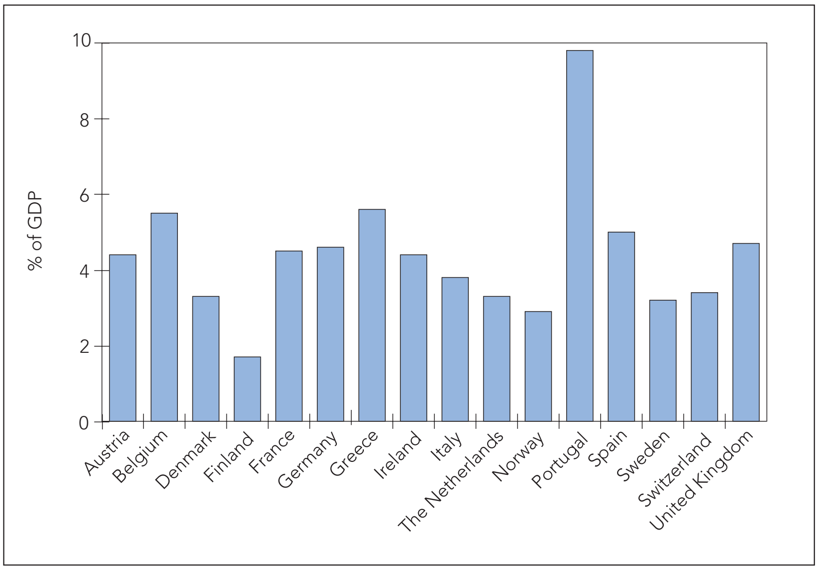
Source: EEA



pollution; water pollution from road runoff; risk of accidents and congestion, although the last two categories are disputed in a number of studies. Figure 4.1.11 shows the estimates of the monetary costs of environmental damage from road transport as percentage of GDP for each country.

Figure 4.1.11 suggests that road transport may generate damage equal to some 2-5% of GNP. These estimates are consistent with the EU-wide damage estimates reported in ECMT (1998) of some 4.1% of GNP (see Section 3 in Chapter 3.12). However, methodologies and data sources vary and it is difficult to be precise about the exact contribution of the different types of externality. Moreover, treating all accident costs as externalities is controversial. As long as individuals are aware of risks when they make their decision to travel, that risk is 'internalised' and does not constitute a genuine externality. The overall scale of transport externalities is therefore open to some debate. ECMT (1998) reports minimum damage costs of 2% of GNP for Poland and estimates of 4-5% for the Czech Republic, which is comparable with the EU countries.

Environmental damage from road transport as % of GDP, 1991 — Figure 4.1.11



Source: Maddison *et al.* (1995) plus modifications.

6.3. Regulations

Regulations have traditionally been the main instrument for reducing vehicles emissions, often in the form of EU Directives, although this is now being complemented by the use of voluntary agreements. The latest new standards on car and light van emissions and fuel quality agreed in 1998 under the Auto/Oil measures are expected to make new vehicles in the EU about 70% less polluting in 2010. The new Directives will also require new vehicles to be fitted with on board diagnostics to monitor emissions, petrol- engined vehicles by 2000 and diesel-engined vehicles by 2005 (see also Chapters 3.4 and 3.12, Section 4.1).

6.4. Voluntary agreements

Voluntary agreements have been used on the Member State level to make the car industry financially responsible for scrapping old cars in an approved manner. Many countries, including Germany, Austria, the Netherlands, UK, France and Italy have voluntary agreements in place. At the EU level, a landmark voluntary agreement was drawn up with the EU car industry to agree a 25% reduction in average carbon dioxide emissions from new cars between 1998 and 2008.

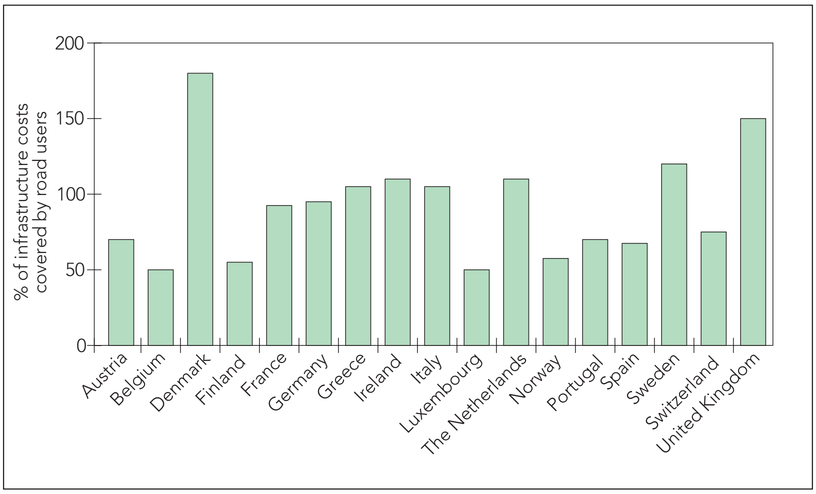
6.5. Subsidy reform

Subsidies to the transport sector primarily comprise non-recovery of the full costs of providing infrastructure, e.g. roads provision and damage repair, policing and emergency services, road lighting and safety barriers. Other costs may include the provision of free parking space, often encouraged by local zoning regulations (e.g. a given amount of parking space per building). These subsidy elements need to be distinguished from the failure to charge for *external costs* such as noise, air pollution and social severance effects (see next Section). Failure to recover infrastructure costs results in an effective subsidy and hence a distortion of competition between modes of travel.

Nearly all (95%) of the relevant subsidy is to rail, not roads – which is the result of public service obligations or the positive intention to support a more environmentally benign mode of transport. Only freight transport by road 'receives' a subsidy as about 82.5% of infrastructure costs are covered by relevant taxes. The results show that the subsidy to road and rail for EU plus Norway and Liechtenstein is EUR 8.93 billion, which amounts to some 0.15% of GDP of (ECMT, 1998).

However, within these European numbers there is very high variation (Figure 4.1.12). Road users in Denmark, Sweden, the Netherlands, Ireland, and the UK pay considerably more than the infrastructure costs, while road users in Belgium, Finland, France Luxembourg, Norway, Spain and Switzerland are subsidised by more than 15% of total costs. For rail, the variation is much less

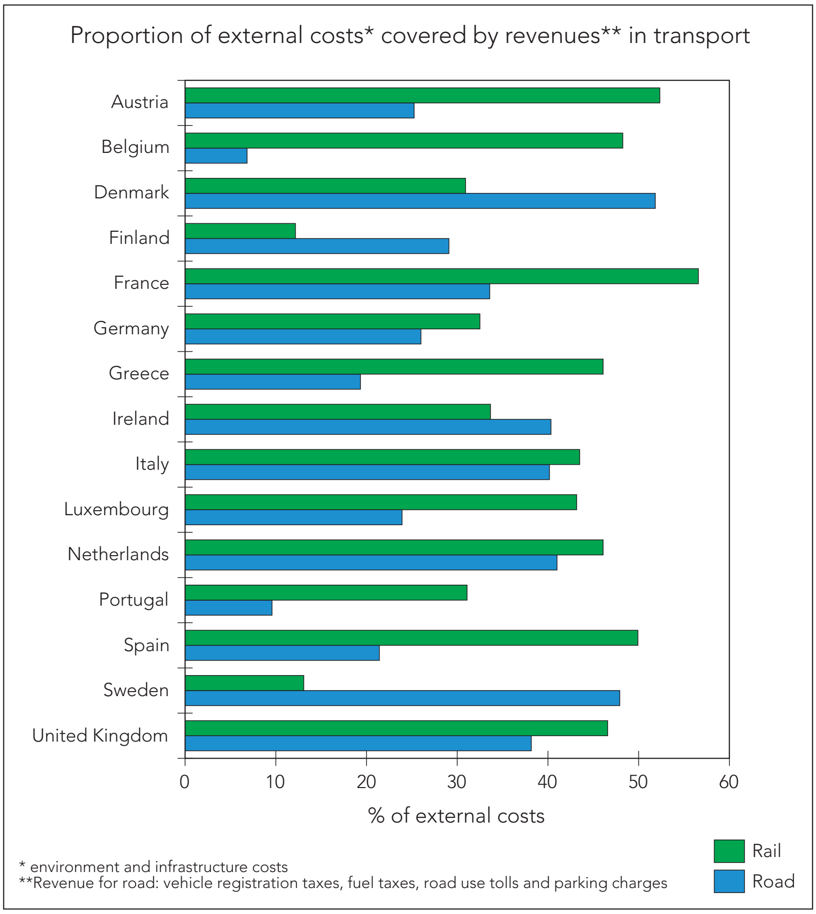
Figure 4.1.12 **Percentage of infrastructure costs covered by road users, 1995**



Source: ECMT, 1998

marked, with a fairly uniform subsidy of about 45% of total costs except in Finland and Sweden with very subsidised rail services (ECMT, 1998).

Figure 4.1.13 **How much of the external costs and infrastructure costs of freight transport are covered by taxes and charges?**



Note: Data is lacking for Air and Maritime transport.

Source: IWW/INFRAS, 1995; ECMT, 1998

Subsidies can also include tax exemptions. Transport subsidies in Germany may amount to some EUR 10.7 billion (Federal Environmental Agency, 1997). Nearly half of this sum is accounted for by the differential tax rate between diesel and gasoline (EUR 4.6 billion) and a third by oil tax exemption for aviation and inland navigation. The remainder comprises cost-deductions for commuting to work, and various exemptions from vehicle excise duty, depreciation allowances etc.

The most significant environmental impact of transport subsidies are to the airline sector, in particular the exemption of kerosene from excise duties, and the absence of VAT on ticket sales. A negative environmental effect arises due to the substitution effects (travel by air rather than other modes) and the volume effects (increased air travel). The own price elasticity for flying is relatively high, estimated at between -0.8 and -2, so that a 1% increase in prices leads to a 0.8% to 2% decrease in demand for flying (European Commission, 1997c). Some countries have been pressing the International Civil Aviation Organisation (ICAO) to accept aviation fuel taxation by 2001, and there is discussion of imposing either a tax on internal EU flights – more than half all flights from EU airports – or a charge based on km flown in EU aerospace (a feasibility report is due in 1999). In January 1999, Norway unilaterally imposed a tax on kerosene which would raise prices by about 25%. However, the tax is revenue neutral as Norway also reduced its existing environmental levy on air passengers.

The European Commission has been active in trying to encourage a reduction in transport subsidies and a switch to marginal cost pricing. The 1995 Commission Green paper ‘Towards fair and efficient pricing in transport’ stressed the importance of marginal cost pricing and this was followed up in 1998 with a White Paper on Fair Payment for Infrastructure Use (European Commission, 1998f). This gives concrete proposals for increased charges on commercial road use.

In terms of environmentally beneficial subsidies, many countries support public transport. At the EU level there has been funding for the Trans-European Transport Networks (TENs, see Box 2.2.9 in Chapter 2.2) which now benefits the railways following pressure by the European Parliament. In relation to the future TENs budget line, the European Council in June 1995 decided that 75% of the total allocation of EUR 1 800 million on transport projects should be spent on 14 TEN priority projects, among which rail and combined transport amount to 90%.

There are also a number of environmentally friendly subsidies for cleaner transport technologies such as the 'car stock modernisation subsidy' granted by the French government to all new car purchasers. Similarly, since 1990, Greece has been applying tax exemption for new cars fitted with a catalytic converters provided the buyer has already scrapped his/her old car. Around 300 000 old cars were scrapped and pollution considerably reduced already in the early stages of the policy.

6.6. Environmental taxation

An EU expert group appointed to advise the European Commission on transport pricing has recommended an EU-wide charge on external costs, stating 'Costs that are already incurred somewhere in the economy will be borne directly by those causing them: this will encourage a decrease in the overall level of these 'external' costs'. This approach was accepted by the Transport Council of Ministers in their report on sectoral integration to the Vienna Council of Ministers: 'The Transport Council will carry forward work on the issue of the integration of quantified environmental costs into transport pricing in the Community'.

Figure 4.1.13 shows the extent to which relevant taxes and charges on road and rail freight transport cover the estimated environmental damages ('externalities') and infrastructure costs.

A first step towards full coverage of environmental costs was taken in December 1998 under the 'Eurovignette' Directive, which aims to harmonise road charging of heavy lorries through the EU single market. From July 2000, annual charges will range from a maximum of EUR 1 550 for the heaviest and most polluting lorries to EUR 750 for the lightest and cleanest lorries. A similar approach will be implemented in Switzerland which will charge all Heavy Goods

Environmentally related taxes and charges in the transport sector, 1996 Table 4.1.9.

Environmental tax measures	A	B	D	DK	E	F	FIN	GR	I	IRL	L	NL	P	S	UK	CZE	HUN	POL	IS	N	CH
Motor Fuels:																					
Leaded / unleaded (differential)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*
Diesel				*			*							*			*	*		*	
CO_2/Energy taxation				*			*							*						*	
Sulphur tax														*						*	
Other excise taxes (other then VAT)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				*	*	
Gasoline (quality differential)							*							*		*	*				*
Vehicle-related taxation:																					
Sales/Excise/ Regist. tax diff (cars)	*	*		*			*	*	*	*		*	*	*			*		*	*	*
Road/ Registration/ tax diff (cars)	*	*	*	*	*				*	*		*		*		*	*		*	*	*
Employer-paid commuting expenses taxed	*		*	*	*		*						*	*	*	*	*	*			
Air Transport:																					
Noise charges		*	*			*						*					*	*		*	*
Other charges													*	*						*	

Source: OECD, 1997d, e

Vehicles per transit, with heavier and more polluting vehicles paying a higher charge. Table 4.1.9 shows that indirect taxes on vehicles are widespread as are fuel taxes which are more closely linked with the amount of travel. The importance of transport taxes in terms of revenues varies considerably between the countries. In 1996 for France, Ireland and Luxembourg transport taxes were around 1% of total revenues from taxes and social contributions, while in Denmark, Ireland, Spain and the Netherlands they amounted to 4%.

While fuel taxation is an important first step, road pricing is sometimes considered as a more effective restraint on vehicle use. For example, in the Netherlands a 30% fuel price increase would reduce urban traffic by 4.8% and overall national traffic by 7.1% (NOVEM, 1992). However, in the UK road pricing through a toll in urban areas would have a much larger effect (due to the higher price elasticity of demand) so a 1% increase in tolls leads to a 1% fall in traffic demand (Goodwin, 1992). So far, no EU Member State has introduced urban road pricing, although legislation is underway in the UK. Norway has introduced tolls in Bergen and other cities, leading to a 6-7% decline in traffic in the first year and rising car occupancy (Larson, 1988).

7. Households

Overall, evidence on the environmental influence of the household sector is lacking. However, trends in consumption patterns dominate improvements in packaging, energy-efficiency and resource use, and this emphasises the importance of trying to influence or restrict demand. It is difficult to evaluate the effectiveness of many policies to this end, either because they have been in place for too short a time to allow for a thorough investigation, because they are not operating in isolation but affected by other wider changes in a country's economy, or because they seek to influence behaviour which is not easily observable, e.g. households' energy-saving measures. Preliminary evidence (OECD, 1998e) demonstrates that packages of measures, addressing several aspects of sustainable consumption, are particularly successful.

7.1. Environmental assessment of the sector

This section focuses on three main environmental impacts from households: air emissions, solid waste and water use. Figure 4.1.14 gives an overview of relative performance in these areas.

Generally, the patterns are linked to per capita income levels of the countries: increased income levels spur demand for consumer goods, and therefore richer countries tend to produce more emissions and waste. Conversely, higher income countries are more likely to provide the infrastructure for households to be connected to water treatment networks. The contribution of households to environmental stresses can be significant (Table 4.1.10): the share of household CO_2 emissions as a percentage of total emissions is over 20% on average, reaching almost 40% in France, due to the structure of electricity production (with a high share of nuclear energy) in this country.

Trends in consumption patterns have, to date, overwhelmed improvements in the efficiency of energy and resource use (OECD, 1998e) (see Chapter 2.2). Growth in household energy consumption, the number of households, ownership of durable household goods and private cars have been driving forces for energy consumption and emissions. Influencing households' consumption patterns is therefore a potentially powerful means of addressing environmental problems.

Serious efforts to change consumption patterns are underway across EU Member States, due to increased recognition that current patterns are unsustainable and concrete evidence that changes in practices can deliver significant environmental improvements without major negative effects on living standards (OECD, 1998e). There is considerable scope for governments to curb the impacts of the household sector, and a growing array of policy instruments available to affect consumer behaviour. Strategies for reducing damage from the household sector generally focus on energy efficiency, waste reduction and recycling (including packaging) and lowered water pollution through a range of instruments, including regulations, subsidy reform, environmental taxes, consumer information and eco-labelling.

7.2. Quantified environmental damage

The only attempt to quantify environmental damage in the household sector relates to waste. While there are several studies on the economic value of environmental damage from waste disposal, the wide variety of methods used for disposal in the European

Union makes generalisation difficult (see Chapter 3.7). One wide-ranging study suggests that environmental damages from landfill average some 2-20 euros per tonne of waste, and from incineration 11-23 euros/ tonne (Coopers and Lybrand *et al.*, 1997). Since some 100 million tonnes of municipal waste goes to landfill in the European Union, external costs from this aspect of landfill alone could amount to EUR 200 million to 2 000 million. For incineration the figure would be about 30 million tonnes and EUR 330 million to 690 million. The figures are speculative because of the limited nature of the physical data and the absence of detailed country-by-country estimates of environmental costs.

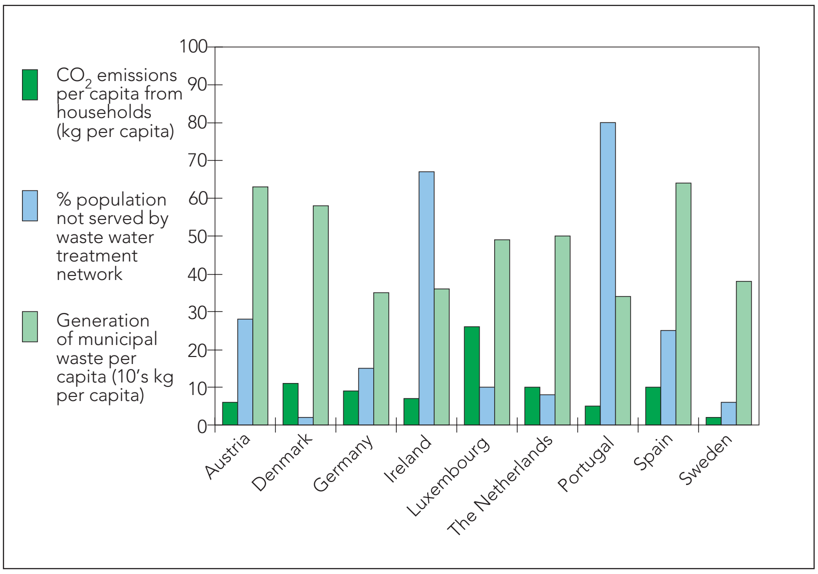
Little information is available on household contributions to atmospheric emissions. Nevertheless, the data on CO_2 emissions in Table 4.1.10 suggests that household energy use in the EU causes environmental damage of over EUR 1 billion per year.

7.3. Regulations

As analysed in Chapter 3.5, Member States are on track to comply with the Directive on urban wastewater treatment (European Commission, 1997e). The law will eventually require collection and secondary treatment of wastewater from all urban centres in the EU. The EU is currently developing minimum energy efficiency standards for household equipment such as refrigerators, which could be used to constrain household demand for energy. Energy efficiency improvements have contributed significantly to constraining household demand for energy to date: Table 4.1.11 shows the reduction in energy intensity of new appliances in Germany from 1978 to 1985 and Denmark from 1970 to 1994. The table gives the ratio of tested new appliance electricity use in the recent year to that of the earlier base.

A number of other regulatory measures have been taken by individual Member States, which will have the effect of reducing the impacts of households on the environment. Water consumption in Austria has been significantly reduced by the mandatory installation of 3/6 litre dual-flush toilets in new and replacement buildings; in France, standards for insulation of new buildings require the use of double glazing, which should allow for a 10% reduction in heating; in the UK, water companies have the power to restrict the use of hose-pipes in regions suffering from water shortage.

Environmental pressures from households (selected EU countries) — Figure 4.1.14



Notes: percentage of population not served by waste water treatment, all data for 1990; generation of municipal waste: all from 1992 except Austria, Germany, Sweden: 1990; CO_2 emissions: Portugal: 1990; Denmark 1991; Germany, Luxembourg: 1993; Austria, Ireland: 1994; Netherlands, Sweden: 1995.

Source: EEA, Eurostat

Percentage of CO_2 emissions attributable to households, selected European countries, latest available year — Table 4.1.10.

Country	DK	D	F	IRL	NL	A	P	FIN	S	UK	N
% total emissions CO_2	18	16	39	20	21	28	12	17	23	34	14

Source: Eurostat

Reduction in energy intensity of new appliances — Table 4.1.11.

	refrigerator	freezer	washer	dishwasher	oven
Germany	21	37	18	29	16
Denmark	29	40	35	55	13

Source: IEA (1997)

In the area of waste, regulations in the form of waste reduction and recycling targets have been important in bringing about impressive increases in recycling. For example, 20% of beverage cartons were recycled in 1997 in the EU with Germany leading the way at 69% with France, Italy, Spain and the UK at less than 2%. By 1997, over half of all steel packaging was recycled in 8 Member States.

7.4. Consumer information and eco-labelling

Provision of information is a potentially potent way of influencing household demand by allowing consumers to make informed choices about the environmental impacts of their consumption decisions (see Chapter 4.2). Many Member States have developed effective eco-labelling schemes, such as the German Blue Angel scheme, and the EU has sought to develop an EU wide eco-label with a flower logo. By the end of 1997, there had been 183 EU eco-labels issued to products. However, the implementation of the scheme is still seen as too slow and in 1997 Denmark decided to follow the much more advanced Nordic Swan scheme rather than the EU eco-label. Revising the EU label has been under discussion since 1996 and in 1998 the Commission accepted that Member State schemes should operate alongside the EU scheme, and that the scheme will remain a simple pass or fail rather than a graded scheme which was seen as too complicated for consumers. Some countries have also taken a more dramatic approach with an Integrated Product Policy, which addresses the whole lifecycle of a product. This is now being discussed at the EU level (European Commission, 1998g).

Measuring the success of eco-labelling schemes is difficult (see Chapter 4.2, Section 3.2). Eco-labelled products have captured significant market share only in the Swedish market, where for example, eco-labelled detergents have 90% market share (Eiderstrom, 1998). The OECD (1997f) found that eco-labelling programmes were in general more successful in areas which had already benefited from high consumer environmental awareness.

The importance of providing consumer information is illustrated by the penetration of compact fluorescent lights (CFLs) which are 60% more energy efficient than incandescent light bulbs. Only 30% of households in the EU have more than one CFL, but Denmark and the Netherlands have the highest use of CFLs due to extensive public promotional campaigns. The sales of CFLs doubled in Sweden following a public information campaign at the start of 1998.

The balance of evidence suggests that household concern about the environment is increasing (see Chapter 4.2), although investigations of actual changes in behaviour is more limited.

7.5. Subsidy reform

In the water sector, efforts to encourage reduced water subsidies for households were made in the draft Water Framework Directive, but some Member States objected to an explicit reference to 'full cost recovery'.

Table 4.1.12. **Environmentally related taxes and charges for households, 1996**

Environmental tax measures	A	B	D	DK	E	F	FIN	GR	I	IRL	L	NL	P	S	UK	CZE	HUN	POL	IS	N	CH
Batteries		*		*										*			*				*
Plastic Carrier Bags																	*	*	*		
Disposable Containers		*		*			*										*	*	*	*	
Tyres				*													*				
CFCs and/ or halons																*	*	*			
Disposable razors				*																	
Disposable cameras				*																	
Water charges			*	*		*	*							*	*	*	*	*		*	*
Sewage charges			*	*	*		*					*	*	*	*	*	*	*	*	*	*
Municipal waste charges			*	*	*	*	*					*	*	*		*	*	*	*	*	*
Waste disposal charges	*	*	*	*	*	*	*		*	*		*	*		*	*	*	*		*	*

Source: OECD, 1997b

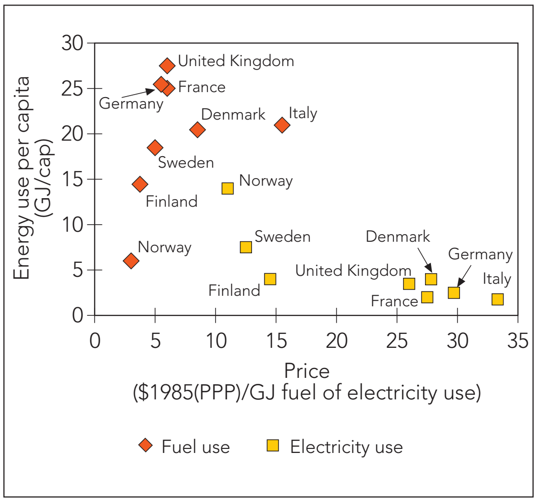
Household consumption is increasingly being charged to cover operating costs, but the capital costs of water supply are often still subsidised. Metering is widespread in Europe, but some households still lack meters, particularly in Norway, UK and Ireland. In Ireland, domestic water consumption is completely subsidised following a decision in 1996, and new water supply is financed solely by central government, often with the use of Structural and Cohesion Funds. Similarly, Italian domestic water supply continues to be subsidised, although charges have increased substantially in the last twenty years. It is thought that 70% of capital expenditure is financed from local and central government. In Spain, an estimated 50% of water supply infrastructure costs are met from public sources, and there is an unknown subsidy to municipal operational costs. The effect of removing consumer subsidies can be dramatic. In the former East Germany, subsidy removal and metering led to a 30% decline in water use (OECD, 1997g).

7.6. Environmental taxation

Table 4.1.12 provides an overview of progress on environmental taxes applicable to households in the EU, EFTA and Accession Countries at the end of 1996. Most countries have introduced some sort of environmental taxes or charges which fall on households, but progress in some, particularly Denmark and Hungary, is far more advanced than average.

The case for use of economic instruments as a means of altering household behaviour is compelling. Figure 4.1.15 demonstrates that prices have a clear influence on households' behaviour. Household fuel use, relative to income, tends to be higher in low price countries, a result that holds especially true for electricity.

Household Energy Use and Prices, 1993 Figure 4.1.15



Note: Data on energy use is adjusted to a common winter climate.

Source: IEA, 1997

References

Adger, N. and Whitby M., 1993. 'Natural Resource Accounting and the Land Use Sector: Theory and Practice'. *European Review of Agricultural Economics*. 20, 1.

Adger, N., and Whitby M., 1991. 'Land Use Externalities in National Accounting', in J. Krabbe and W. Heijman (eds), *National Income and Nature Externalities, Growth and Steady State*. Kluwer, Dordrecht, pp.77-101.

Anderson, K. and McKibbin, W., 1997. *Reducing Coal Subsidies and Trade Barriers: Their Contribution to Greenhouse Gas Abatement*, Paper 97-07. Centre for International Economic Studies, University of Adelaide, Adelaide.

Austrian Economic Chamber, 1996. *Ecomanagement Pays off: Evaluation of a Subsidised Programme for the Introduction of Environmental Management and Audit Systems (EMAS) in Austria.* Commissioned by the Federal Ministry of Science, Transport and Arts and the Federal Ministry of Environment, Youth and Family (Vienna: State Government of Upper Austria, Austrian Economic Chamber), June.

Balogh, Z. and Lehoczki, Z. , 1997. *Product Charge on Packaging in Hungary*. UNEP, Nairobi.

Bizer, K., 1999. 'Voluntary agreements: cost-effective or just flexible to fail?' *Environmental Economics and Policy Studies*. Forthcoming.

Cambridge Econometrics, 1997. *Environmental Policy and the Competitiveness of British Industry, Ecological Tax Reform, Policy Briefing No. 1*. Forum for the Future.

Coopers & Lybrand, CSERGE and EFTEC, 1997. *Cost-Benefit Analysis of the Different Solid Waste Management Systems: Objectives and Instruments for the Year 2000*, European Commission, Brussels.

ECMT (European Conference of Ministers of Transport), 1998. *Efficient Transport for Europe: Policies for Internalisation of External Costs*. OECD, Paris.

EEA:
1998. *Europe's Environment: The Second Assessment.* European Environment Agency, Copenhagen, Denmark.

1997. *Environmental Agreements, Environmental Effectiveness*. European Environment Agency, Copenhagen, Denmark.

1996. *Environmental Taxes: Implementation and Environmental Effectiveness*, European Environment Agency, Copenhagen, Denmark.

Eiderstrom, E., 1998. 'Ecolabels in EU environmental policy'. In Golub, J. (ed.) *New Instruments for Environmental Policy in the EU*. Routledge, London, UK.

ENDS Environment Daily, 21/10/98. 'EU Parliament 'shocked' by nitrate law delays'.

ERM (forthcoming), unpublished material on EIAs.

European Commission:
1993a. *Report from Commission on the Implementation of Directive 85/337/EEC*. COM (93), 28 Volume 12.

1993b. *White paper on Growth, Competitiveness and Employment*. COM (93) 700. Eurostat, 1995.

1996a. *Communication from the European Commission on Environmental Agreements*. COM (96) 561.

1996b. *First Cohesion Report*. 6.11.1996.

1996c. *Communication from the European Commission, Implementing Community Environmental Law*. 22 October 1996. COM (96) 500 final.

1996d *Progress Report on Implementation of the European Community Programme of Policy and Action in relation to the environment and sustainable development 'Toward Sustainability'* COM (95) 624, January 1996.

1997a. *Study of Voluntary Agreements Concluded Between Industry and Public Authorities in the Filed of Environment*. European Commission, DGIII, January.

1997b. *Fifth Survey of State Aid.* Brussels.

1997c. *Environmental Taxes and Charges in the Single Market.* Communication from the Commission, COM (97) 9.

1997d. *Energy for the Future- renewable sources of energy: White Paper*. COM(97)599 final.

1997e. *Towards Sustainability*. Office for Official Publications of the European Communities, Luxembourg.

1998a. *Partnership for Integration. A Strategy for Integrating Environment Into EU Policies. Cardiff, June 1998.* Communication from the Commission to the European Council.

1998b. *Annual Report of Cohesion Fund 1997.*

1998c. Accession strategies for Environment: Meeting the Challenge of Enlargement with the Candidate Countries in Central and Eastern Europe. Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee, the committee for the Regions and the Candidate countries in Central and Eastern Europe. COM(98)294final.

1998d. *Agricultural Situation and Perspectives in the Central and Eastern European Countries: Summary report*

1998e. *ExternE: Externalities of Energy.* European Commission, Brussels.

1998f. *Fair Payment for Infrastructure Use: a Phased Approach to a common transport infrastructure charging framework across Europe.* White Paper, COM (1998) 466 final.

1998g. *Integrated Product policy. A study for the European Commission: DGXI.1998h.*

Federal Environmental Agency, 1997. *Nachhaltiges Deutschland. Wege zu einer dauerhaft-umweltgerechten Entwicklung* [Sustainable Germany. Routes to Sustainable Development]. Erich Schmidt Verlag, Berlin.

Goodwin, P.B., 1992. 'A Review of New Demand Elasticities with Special Reference to Short and Long Run Effects of Price Changes'. *Journal of Transport Economics and Policy*, **26**, pp. 155-169.

Goulder, L., 1995. 'Environmental Taxation and the 'Double Dividend': a reader's guide'. *International taxation and public finance*, **2**, 2, pp.157-183.

Haigh N., 1998. *Manual of Environmental Policy in the EC and Britain*. In association with the Institute for European Environmental Policy, London.

Hillary, R.:
1998a. *An assessment of the Implementation status of Council Regulation (No 1836/93) Eco-management and Audit scheme (EMAS) in the European Union Member States*. ICCET, Imperial College, London.

1998b. 'Pan European Union Assessment of EMAS Implementation', *European Environment*, **8**, pp. 184-192.

Hotte, M.H.H., van der Vlies, J. and Hafkamp, W.A., 1995. 'Levy on surface water pollution in the Netherlands', in Gale, R., Barg, S.,and Gillies, A. (eds) *Green Budget Reform*. Earthscan, London, UK.

IEA:
1999. *Energy Policies of IEA Countries: 1998 Review*. International Energy Agency, OECD, Paris.

1998. *Energy Polices of IEA Countries: 1997 Review*. OECD, Paris.

1997. *Indicators of Energy Use and Efficiency: Understanding the Link Between Energy and Human Activity*. International Energy Agency, OECD, Paris.

IWW/INFRAS, 1995. *External Effects of Transport*. Published by UIC, Paris.

IVM and EFTEC, 1998. *External Economic Benefits and Costs in Water and Solid Waste Investments: Methodology, Guidelines and Case Studies*. Institute for Environmental Studies, Amsterdam, the Netherlands.

Jarass, L., 1997. *More Jobs, Less Tax Evasion, Cleaner Environment: Options for Compensating Reductions in the Taxation of Labour – Taxation of Other Factors of Production*. European Commission.

Koplow, D., 1996. 'Energy subsidies and the environment', in OECD, *Subsidies and Environment: Exploring the Linkages*. OECD, Paris, 201-218.

Larson, O.I., 1988. The Toll Ring in Bergen, Norway. – The First Year in Operation, in *Traffic Engineeriung and Control*. 29, pp.216-222.

Lehoczki, Z. and Sleszynski, J., 1997. *SO_2 Emission Charge in Poland*. UNEP, Nairobi.

Maddison, D., Pearce, D .W., Johansson, O., Calthrop, E., Litman, T. and Verhoef, E., 1995. *Blueprint 5: The True Costs of Road Transport*. Earthscan, London.

Moe, T., 1996. *Work of the Norwegian Green Tax Commission: Some Main Elements*. Norwegian Ministry of Finance, Oslo.

National Audit Office, 1997. *The Ministry of Agriculture, Fisheries and Food: Protecting Environmentally Sensitive Areas.* Report by the Comptroller and Auditor General, HC 120 1997/98.

NOVEM, 1992. *Transport Policy, Traffic Management, Energy and Environment.* Consultants Report to the IEA by Netherlands Agency for Energy and Environment, Ultrecht, Netherlands.

OECD:
1989. *Economic Instruments for Environmental Protection.* OECD, Paris.

1996a. *Integrating Environment and Economy. Progress in the 1990's.* OECD, Paris.

1996b. *Public Support to Industry: report by the industry committee to the Council at Ministerial level.* OECD, Paris.

1997a. *Environmental Benefits from Agriculture: Issues and Policies*, OECD, Paris.

1997b. *Evaluating Economic Instruments for Environmental Policy.* OECD, Paris.

1997c. *Environmental Indicators for Agriculture.* OECD, Paris.

1997d. *Reforming Energy and Transport Subsidies: Environmental and Economic Implication.* OECD, Paris.

1997e. *Trends in the Transport Sector*. OECD, Paris.

1997f. *Ecolabelling: Actual Effects of Selected Programmes.* OECD, Paris.

1997g. Water subsidies and the Environment, OECD, Paris.

1998a. *Agricultural Policies in OECD Countries.* 2 volumes and diskette set on Producer and Consumer Subsidy Equivalents, OECD, Paris.

1998b. *Producer and Consumer Subsidy Equivalents Database 1998.* OECD, Electronic Data Products.

1998c. *Special Issue on Public Support to Industry. Science Technology Industry* Review No. 21, Paris.

1998d. *Improving the Environment Through Reducing Subsidies.* Parts I and II, OECD, Paris.

1998e. *Towards Sustainable Consumption Patterns: A Progress Report on Member Country Initiatives.* OECD: Paris.

forthcoming 1999. Domestic tradable permits for environmental management. OECD, Paris.

1994. *Managing the Environment: The Role of Economic Instruments.* OECD, Paris.

Pearce, D.W., 1998. *Environmental Appraisal and Environmental Policy in the European Union, Environmental and Resource Economics*, 11 (3-4) pp. 489-501.

Pretty, J., Brett, C., Gee, D., *et al.*, 1999. *An assessment of the External Costs of UK agriculture.* University of Essex (forthcoming).

Sadler, B. and Baxter, M., 1997. 'Taking Stock of SEA'. *Environmental Assessment*, **5**(3).

Schmelzer, D. 1996. *Voluntary Agreements in Environmental Policy.* Europa University Viadrina, Frankfurt, mimeo.

Segerson, K. and Miceli, T., 1996. *Voluntary Approaches to Environmental Protection: The Role of Legislative Effects.* Department of Economics, University of Connecticut, mimeo.

Seják, J. 1997. Theory and practice of economic instruments for environmental protection: experience of the Czech Republic, *European Environment*, 7, 187-193.

Steele, P., Hett, T. and Pearce D.W., 1999. *Environmentally Damaging Subsidies*. Technical background document for the European Environment Agency.

Storey, M., 1996. *Voluntary agreements with industry*. OECD, Paris

Taschner, K., 1998. 'Environmental management systems: the European regulation'. In Golub, J. (ed.) *New Instruments for Environmental Policy in the EU.* Routledge, London, UK.

Tuddenham, M., 1995. 'The system of water charges in France', in Gale, R., Barg, S.,and Gillies, A. (eds) *Green Budget Reform*. Earthscan, London, UK.

UNEP, 1997. *Compendium of Case Study Analysis on the Use and Application of Economic Instruments in Central Eastern European Countries*. UNEP, Nairobi, draft.

World Bank, 1997. *Expanding the Measure of Wealth: Indicators of Environmental Sustainable Development*. Environmentally Sustainable Development, Monograph 17, World Bank, Washington DC.

Country codes used in the tables in this chapter:

A:	Austria
B:	Belgium
D:	Germany
DK:	Denmark
E:	Spain
F:	France
FIN:	Finland
Gr:	Greece
I:	Italy
IRL:	Ireland
L:	Luxembourg
NL:	The Netherlands
P:	Portugal
S:	Sweden
UK:	United Kingdom
CZE:	Czech Republic
HUN:	Hungary
POL:	Poland
IS:	Iceland
N:	Norway
Ch:	Switzerland

4.2. Environmental information: needs and gaps

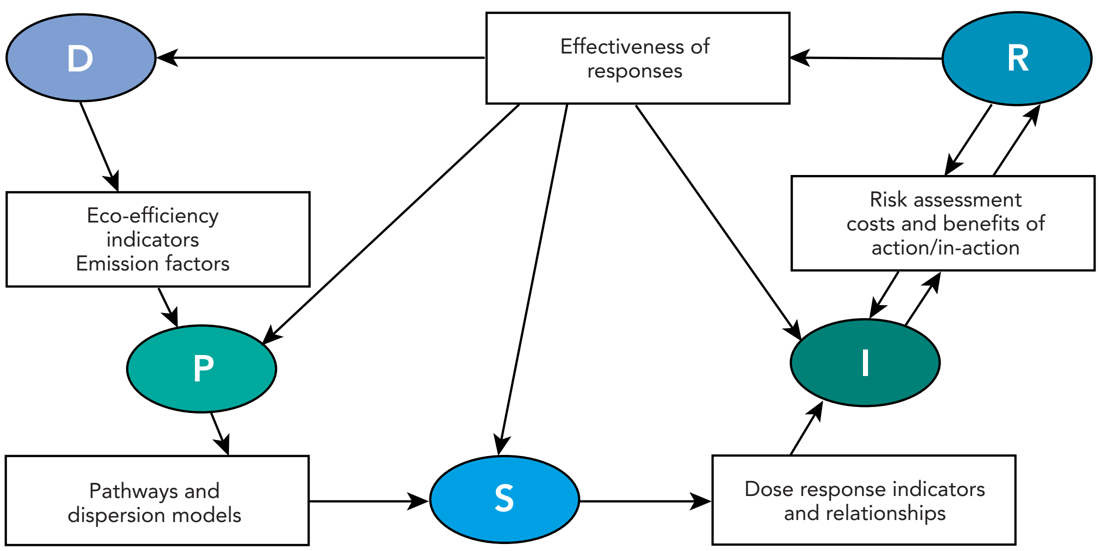
1. The issue

The preceding chapters in this report describe the current and foreseeable state of the environment in Europe as required under Article 3 of the EEA Regulation. In doing so, the report embraces methodologies for integrated environmental assessment (IEA) as encapsulated in the DPSIR framework where there is a chain of causal links from Driving forces to policy Responses, and which covers both the current and future state of environment quality, and resources, each considered on appropriate spatial and temporal scales.

The DPSIR framework is useful in describing the relationships between the origins and consequences of environmental problems, but in order to understand their dynamics and to develop tools to make environmental outlooks it is also useful to focus on the links between DPSIR elements. Figure 4.2.1 presents examples of the concepts which link the different elements of the causal chain. For instance, the relationship between the Driving forces and the Pressures by economic activities is a function of the eco-efficiency of the technology and related systems in use, with reduced pressure coming from the same amount or more of economic activity if eco-efficiency is improving. Similarly, the relationship between the Impacts on humans or eco-systems and the State depends on the carrying capacities and thresholds for these systems. Whether society 'Responds' to impacts depend on how these impacts are perceived and evaluated; and the results of 'R' on the problem depends on the effectiveness of the Response, and to which link in the causal chain the Response is mainly directed.

In this report, particular focus on IEA is given to key environmental issues and to the integration of environment-economic considerations. In doing so, information is presented within the framework of the DPSIR chain. Particular emphasis is given to the DPSIR interlinkages, to future outlooks and scenarios and where appropriate to analysis on a spatial scale. This reflects the increasing importance that policy makers and others now put on good-quality information and analysis in these areas. It is no coincidence that these areas are also where the report most lacks complete and consistent information on trends, since many of the needs have only been identified relatively recently and the frameworks for data collection are either not in place or have yet to be identified and implemented. Even in areas where monitoring activities have been in place for the past 20 years or so, such as for aspects of air quality and water quality, the right information on past trends is not always available, partly because new monitoring systems for important recently identified

Concepts linking Driving Forces-Pressures-State-Impacts-Responses (DPSIR) elements Figure 4.2.1



pollutants are not fully operational across Europe, but also because the balance of monitoring effort in many countries is still sometimes skewed in favour of the traditional pollutants which are not the only relevant pollutants.

This potential for inefficiencies in monitoring activities together with the need for new information to address new environmental paradigms was recognised at the 'Bridging the Gap' Conference (UK/EA, 1998) on new needs and perspectives for information, which concluded that:

> *'At present some of the systems for monitoring and gathering information about the environment in European countries are inefficient and wasteful. They generate excessive amounts of data on subjects which do not need it; and they fail to provide timely and relevant information on other subjects where there is an urgent policy need for better focused information, and for consistent environmental assessment and reporting.'*

The conference recognised the need for a concerted pan-European movement involving the EEA, the European Commission and Member States:

- to streamline environmental monitoring and practices,
- to focus new information gathering on key issues and perspectives; and
- to develop indicators, which would need to be widely agreed, illuminating the significance of environmental change and the progress of sustainability.

An important part of the work concerns harmonisation of definitions, data collection methods and agreement on good reference units for reporting such as watersheds and biogeographic regions. Having the right information, however, is not only important for helping to frame and monitor policies required for improving the state of the European environment. Information is also important for changing societal behaviour and influencing in a positive way the impact society as a whole has on the environment. Getting the right information to the right people is also important for enhancing public participation in environmental activities and decision making.

This chapter presents examples of some of the most important needs and gaps in current information provision for reporting and policy making and on the current and proposed initiatives to improve information systems. The chapter also summarises the needs and provisions for public information and its role in changing consumer behaviour and facilitating participation in environmental decision making.

2. Existing information and new needs

The European Environment Agency (EEA) report in 1995 *Europe's Environment: The Dobris Assessment* (EEA, 1995) included an overview of strengths and weaknesses in environmental and related information. There has been some progress since the 1995 review but much remains to be done to achieve the EEA mandate and the goals of the 'Bridging the Gap' Conference. Nevertheless, as shown in the present report, in *Europe's Environment: The Second Assessment* (EEA, 1998), and in the OECD (Organization for Economic Co-operation and Development) and UNECE (United Nations Economic Commission for Europe) country environmental performance reviews, more use is being made of the information currently available to highlight the state of knowledge and the remaining gaps and inconsistencies.

The following paragraphs summarise the current situation on the main information strengths, weaknesses and gaps and what is being done to address some of the major deficiencies. It is not the intention to be exhaustive in this analysis rather to highlight where are the main areas where action is either underway already or should be considered in the future.

2.1. Environmental monitoring and reporting

- There have been improvements in the consistency and comparability of **atmospheric emission inventories** through continuing co-operation between the EEA, the European Commission (EU Monitoring Mechanism for greenhouse gases), EMEP under CLRTAP, the Intergovernmental Panel for Climate Change (IPCC – under UN Framework Climate Change Convention), and member countries. There still remains substantial scope, however, for countries to report these emissions data in a more consistent and timely way. Complete and timely responses from only about half of EEA countries are still common under international conventions and EU legislation. This constrains the ability of the EEA and others to produce complete assessments and reports in support of policy developments. The issue of reporting will become more important in the next decade for greenhouse gases under the terms of the Kyoto Protocol and for acidifying gases and ozone precursors in view of the proposed EU National Emission Ceilings Directive. Data on past trends for air emissions is best for totals but limited for sectors. The situation is less well developed for the 'newer' pollutants such as heavy metals and persistent organic pollutants. Data at the more detailed level – e.g. splits within sectors – is less well developed for emissions of all pollutants. However, the recent initiatives following on from the Cardiff Council in June 1998, to develop sectoral indicators is expected to provide the stimulus for data gathering and estimations at these more detailed levels. These sectoral initiatives will also in time deliver indicators of sectoral eco-efficiency in terms of the emissions generated per unit of desired output (vehicles kms, energy consumption).

- EU Directive (96/62/EC) on **ambient air quality** assessment and management and the third EU Decision (97/101/EEC) on exchange of air quality information have been adopted. EEA has established EuroAirNet and Airbase to complement and support this legislation. The aims, in co-operation with the Commission, member countries of the European Environment Agency (EEA) and the EMEP Programme (under the Convention on Long Range Transboundary Air Pollution), are to improve the quality, consistency and timeliness of air quality data and information available at the European level. Reporting of data by countries continues to be a problem here also with again only 50% of EU countries providing complete and timely data. As for air emissions, Europe is data rich for the more traditional air pollutants e.g. sulphur dioxide, but much less so for arguably more important pollut ants for human health, such as benzene and PAHs. The information systems for these pollutants are being developed in some countries but there is still some way to go. There has also been little progress in detailed monitoring of non-methane volatile organic compounds. A substantial programme of work has been undertaken over the past 20 years to develop critical loads for acidifying compounds (sulphur, nitrogen and ammonia) to soil and water ecosystems. More information is needed, however, on dose (deposition) /response (relationships for impacts on ecosystems).

- Little is known about **chemicals** and their impact on human health and the environment. In the past, much of the monitoring effort and work on risk assessment has been focused on the *toxicity* of chemicals in the environment. Since 1981, all new chemicals put on the market in the EU have been required to undergo some pre-market toxicity testing. By the end of 1997, of the over 100 000 existing chemicals in the EU that have little or no eco-toxicity data, risk assessments had been completed for 10 of them. Overall, there is still inadequate toxicity data for about 75% of the chemical substances in use in Europe, and inadequate eco-toxicity data for 50-75% for the 2 500 priority high production volume chemicals (HPVCs) – those chemicals whose production exceeds 1 000 tonnes per year. In recent years there has been an increasing recognition of the need to shift towards monitoring and assessment of the risk of *exposure* of people and nature to chemicals. However, there is also a major lack of human health and exposure data for these HPVCs. Other information deficiencies for chemicals include: the pathways, fate and concentrations of many chemicals in the environment; the use of chemical substances and their presence in consumer products; the costs of the impacts on people and nature of exposure to chemicals including mixtures of chemicals (EEA/UNEP, 1998). Some progress is being made at EU level to develop indicators of the eco-efficiency ratios for the production/use of chemicals.

- There has been little progress in the quality of **waste** information**.** Detailed analysis is hampered by the lack of comparable statistical information across Europe. Even for municipal waste and household waste, which are normally thought of as areas with good statistics, confusion prevails. Reliable time-series of data can only be obtained with a great effort in collecting supplementary information and interpretations of the definitions used in the countries. These problems can only be overcome by harmonisation of the use of definitions and collection of data on a common platform. Current work on a Community Regulation on waste statistics is a first step in this direction. For Life-Cycle Analysis of products there is a lack of systematic knowledge of the connection between the composition of individual products and resulting emissions from different treatment types when they end up in the waste stream. There is also a need for better transfers of information between product developers and producers and the waste management sector in order to develop a system where products and waste management fit better together.

- There is an improved culture with regard to **industrial accident** reporting and sharing the lessons learnt. The European Commission's major industrial accidents database MARS, only for EU countries, is now complemented by SPIRS (Seveso Plants Information Retrieval Systems) which will cover information related to location and amount of substances handled in each 'Seveso plant' in the EU. Under the new Seveso Directive 96/82/EEC, such information has to be included in the safety report of each 'Seveso plant'. An enormous amount of accident monitoring and environmental **radioactivity** data is now being collected across Europe which now needs to be better linked and used. There is a serious lack of information on the extent and impacts of **radio active waste** on human health and on the environment. Information about the risks and environmental impacts of **natural hazards** and interactions with human activities is not widely available.

- Information on regional **freshwater** resources and on water abstractions has improved. Methodological differences make it difficult to produce comparable data at European level on the uses of freshwater. Some progress has been made on gathering data for assessing the efficiency of water use but more needs to be done to develop comparable efficiency ratios and to understand the dynamics which contribute to efficiency improvements. There is much improved information on discharges to freshwater bodies from point sources, in part as a result of the EU IPPC Directive. There is relatively little known about the diffuse discharges to freshwater bodies from agricultural activities and their impacts on the state and quality of European freshwater bodies. There is more data available on the quality of European rivers and lakes than for groundwaters. An initial report presenting available information on groundwater quality and quantity has been made by the EEA. In collaboration with member countries and several Accession Countries, EEA is also developing EuroWaterNet/Waterbase to help improve data comparability and provide the information relevant to the proposed Water Framework Directive. However, there is still little data on small rivers and lakes, organic micro-pollutants and metals. Information on discharges to the **marine environment** from point sources on the quality of Europe's seas remains limited but the EEA has brought together the various **marine** conventions and programmes in an Interregional Marine Forum to help improve the comparability and timeliness of information for future assessment and reporting.

- An overall framework for monitoring, assessing and reporting on **soil** issues in Europe has not been implemented, despite the multi-functional aspects of soil and the multi-impacts on this limited resource from human activities and the environment. An adequate assessment of the current state or potential risk of soil degradation in Europe is still missing, as well as comparable data on the loss of the soil resource to erosion and sealing. Basic data, such as detailed European soil maps, is still unavailable for assessment and there has been no progress in the quality and comparability of data available at the European level. There is no European-wide monitoring network for soil, although some progress has been made in some areas, such as the monitoring of forest soils. Statutory soil monitoring is carried out in a number of Member States, but rarely for the purposes of soil protection per se. There is large diversity in the design of soil monitoring schemes, the frequency of sampling, the range of parameters determined, and the methods of analysis used. There are also increasing problems of data ownership and transfer. As a result of this diversity, there is lack of harmonisation of the data derived from soil monitoring, and there is no pan-European quality control of the existing soil monitoring networks. A European inventory of contaminated sites is still lacking but requirements are being developed. Nevertheless, the importance of the soil medium and the need for European comparable data are being recognised.

- Though **biodiversity** in Europe is better known than in many other parts of the world, many gaps in knowledge and understanding remain and require co-ordination and a multi-disciplinary approach, drawing on biologists, geneticists, agronomists, foresters, ecologists, biologists and social scientists. In particular, long-term harmonised monitoring results for natural biodiversity are lacking. For species and some habitats much data has been collected for a long time at local and national levels but a harmonised synthesis at the European level remains difficult. Inventories and mapping of species and habitats have been enhanced, notably through projects under the EU LIFE and CORINE Biotopes programmes. Through the biogeographic regions approach, future assessments of common problems and effectiveness of nature protection will cross individual borders. Access to datasets and information held by countries is improving and should do so further when the Internet-based EU Clearing House Mechanism related to the Convention on Biological Diversity is established. There has been progress in compiling information on species and habitats for Natura 2000 (the Birds and the Habitats Directives) for the EU countries and for non-EU European countries in the related Emerald Net work of the Bern Convention. Data is being used by EEA through the European Nature Information System (EUNIS) in co-operation with the Commission, the Council of Europe and international nature-conservation organisations. The best data still concerns vertebrates and vascular plants, but datasets for several invertebrate groups such as butterflies and lower plants are improving. Red lists for the same species groups now exist in most countries. So far the focus has been on state and distribution of species and habitats, but there is a need to identify bio-markers for environmental change and to monitor these to provide indications of how environmental phenomena and their interactions impact on biodiversity and on how changes in biodiversity affect the environment and society, production of biomass, CO_2 sink functions, etc.

- **For genetically modified organisms** (GMOs) there is a need for much more monitoring and research into both risk assessment approaches and scientific studies on issues such as gene flow from GM crops to wild relatives. For example, large field experiments are needed to assess the fitness of the hybrid plants over time, the spatial and temporal dispersion of the crop and weeds, and the effect of different agronomic practices on gene flow. There is also a need for studies into cumulative impacts, invasiveness of multiple releases, and herbicide intolerance in weeds, as well as monitoring for delayed and indirect impacts such as on beneficial insects.

- For **human health** issues, there are long established monitoring systems for example for urban air quality and drinking water quality. Little progress has been made in relating these monitoring data to the consequences for human health. An attempt to relate water quality to human health has been jointly undertaken by the EEA and WHO (EEA/ WHO, in press). Some progress has been seen for exposure assessment, in particular population exposure to air pollution (both indoor and outdoor). However, little is known about doseresponse relationships and about the impacts on human health from exposure to mixtures of pollutants from multiple exposure routes. Some research and modelling has been undertaken in limited communities to understand better the relationships between human health and the low levels of chemicals and pollution many people are exposed to on a daily basis. These studies have shown some indication of impacts on human health and behaviour, e.g. lower sperm counts and neuro-toxic effects, but the links between multiple, low-level exposures to chemicals (including pharmaceuticals) in food, water, air and consumer products and impacts on people remain largely unexplored. Data and information is particularly needed on the cumulative chemical exposures, and related biologically effective doses, of sensitive sub-groups, such as the foetus, children, the elderly, pregnant women, and those with depressed immune systems; on the antagonistic and synergistic interactions between these exposures; and on bio-markers of exposure, of early effects and of susceptibilities, which together can help identify potential threats to sensitive communities so that adverse impacts can be avoided or minimised.

- On environmental **noise**, there has been little progress in establishing monitoring and assessment frameworks for Europe. Little data is available and what exists is not comparable between countries. The Community Noise Strategy which will consider requirements and methodologies for such information was established only in September 1998. Several technical groups started working on various issues including the harmonisation of noise indicators and noise mapping in Member States, and the development of common prediction models. More research and information is needed on the impacts of noise on both human health and well-being. Adverse physiological, biochemical, psychological, sociological and economic consequences of exposure to noise must be critically evaluated for relevant aspects of human behaviour such as work, communication, social interaction, sleep, etc., and environmental monitoring standards and targets developed. Methods are needed to define exposure limits for different community environments and for noise impact and abatement assessment.

2.2 Environment-Economy Integration

The integration of environmental considerations into economic and sectoral decisions is a central objective of the 1992 EU Fifth Environmental Action Programme (5EAP) which gives priority to the principal economic sectors – industry, agriculture, energy, transport and tourism. The following paragraphs summarise the current situation on the main information strengths, gaps and weaknesses for integration in these sectors under four headings – environmental assessment of the sector, eco-efficiency indicators, market integration and management integration.

- For **transport**, there is relatively good information available on transport supply, demand, intensity, and prices. The main information weaknesses hampering a comprehensive *environmental assessment* of the sector are in the areas of transport noise, land use for infrastructure and settlements, access to basic services and habitat fragmentation. *Eco-efficiency* indicators have been identified under the EU Transport Environment Reporting Mechanism. Data is available for some of the indicators e.g. fuel efficiency, proportion of vehicle fleet meeting air emissions standards, but not always for all countries or on a comparable basis. Indicators of the eco-efficiency of transport by mode with respect to air emissions are being developed by Eurostat and the EEA. For *market integration*, data on the external costs to the environment of transport is available for most countries, but more information is needed on the contributions to overall costs of the different types of externalities – noise, air pollution, congestion etc. More consistency is needed on definitions and methodologies used by countries to compile estimates of external costs; also trends data is as yet not available. Some information is available on instruments such as taxes, subsidies and voluntary agreements, but little is known about the effectiveness of such instruments for alleviating the environmental impacts of the sector; trends data is also needed. For *management integration*, little is known about the extent and effectiveness of environmental impact assessments for transport projects.

- For **energy**, there is relatively good information available in most areas to support a comprehensive *environmental assessment* for the sector; the main area of weakness is waste generation. *Eco-efficiency* indicators have been developed for many years by the OECD-IEA and in various countries. A selection is to be included in the EU project on indicators for the integration of environment in energy policies, and data availability is generally good. To improve the use of market-based instruments, studies have been done on external costs of the energy sector, but no country comparison is readily available. As for transport, information will also be needed on the contributions to overall external costs of the different types of externality – climate change, air pollution, waste. On the use of taxes, subsidies and voluntary agreements some information is available, but little is known about the effectiveness of such instruments for alleviating the environmental impacts of the sector. For *management integration*, little is known about the extent and effectiveness of environmental impact assessments for energy projects.

- For **agriculture**, the available data on (positive and negative) impacts is gradually extending. It is often difficult to separate out the specific contribution of agriculture to changes in the environment, like water stress or changes in breeding birds. The OECD has been working for many years on a core set of agri-environmental indicators. In 1999 the EU will develop a set of indicators and a reporting mechanism to follow the integration of environment in European agricultural policies. In the meantime *eco-efficiency* indicators are available at the European level comparing agricultural outputs against inputs such as fertilisers and pesticides and also water used for irrigation purposes. For *market integration*, only partial estimates are available of external costs of agriculture. Some scattered information is available on instruments such as taxes, subsidies and voluntary agreements, but little is known about the effectiveness of these instruments.

- For **industry**, there is substantial data available for *environmental assessment* of air and water pollution. The main areas of weakness are waste generation and soil contamination. *Eco-efficiency* indicators for this sector are well developed, in particular comparing output against air emissions and also against contaminant loadings to freshwater bodies and to the sea. Some data is also available on recycling rates by key industries. For *market integration*, there are no data available on external costs. As for other sectors, data will be needed on the contributions made to overall external costs of the different types of externality – air pollution, water pollution, waste generation, soil contamination. There is some information available on expenditure by industry on environmental compliance. Eurostat has a work programme in place to develop this important area further. Current deficiencies include incomplete coverage of countries and expenditure categories, and lack of time series. Some information is available on the extent of use of instruments such as taxes, subsidies and voluntary agreements, but little is known about the effectiveness of such instruments for alleviating the environmental impacts of the sector. An exception is for water discharges where there are assessments available showing the impact of charging on minimising effluent discharges. For *management integration*, relatively good information is available on the extent of use of tools such as environmental impact assessments, environmental management systems and green procurement policies. However, little is known about their effectiveness in minimising environmental impacts.

- There is no agreed framework either globally or in Europe to develop indicators across the DPSIR framework which measure the positive and negative impacts of **tourism** on the environment and how these are being dealt with through policy responses, including the use of economic instruments. The main problem is measurement of tourism activity at the local level (NUTS V), where the bulk of tourism impacts occur. Some progress has been made to evalu ate the impacts of tourism on coastal areas through the LACOAST project, however, the absence of associated economic and pressures data at NUTS V level seriously constrains meaningful assessments. There are no agreed *eco-efficiency indicators* for tourism and data availability is likely to be a problem once such indicators have been defined. For *market integration*, there is no information available at the European level on the costs of the various externalities: water pollution, land and soil degradation, soil erosion, heritage loss, landscape loss. For *management integration*, there is no data available on EIAs for tourism projects or on green procurement strategies.

2.3. Spatial dimension

The geographic integration of environmental data is arguably as important as the integration of environmental considerations into sectoral activities, which has been also stressed in Chapter 2.3. There are increasing demands for spatial and territorial analyses to support policy development such as CAP reform, Strategic Environmental Assessment of Trans European Networks, the initiative to prepare a European Spatial Development Perspective, development of the Natura 2000 network, water management at the catchment area level and the enlargement process. Integrated policies can not exist without a territorial reference.

Within this report, a first attempt has been made to include information on the DPSIR and trends in the environment as seen from a spatial perspective (see Spatial Chapters 3.12 to 3.15). This analysis has highlighted the priority gaps and weaknesses in information needed to enable spatial environmental assessment:

- Much more needs to be done to improve the quality, geographic consistency and coverage of the information base. The scale of the input data required for spatial analysis will strongly depend on the type of application. Very often, applications at European level such as fragmentation of land, pressure on protected areas, are demanding detailed geo-referenced datasets. Examples of datasets which are still incomplete or missing are the boundaries of NATURA 2000 sites, physical structure of cities, contaminated sites and large combustion plants. For the European Polluting Emissions Register under the IPPC Directive geo-referenced datasets and a geographic information system will need to be developed.

- The CORINE Land Cover map is used as the reference layer of a territorial database, because of its cross-border thematic consistency and spatial resolution. However, this database has been created by the countries from satellite data acquired over a time span of more than 10 years (1985-1995), and therefore is becoming out of date. An update of this reference database for the year 2000, including all European countries, is urgently needed for better and more advanced assessment of ongoing territorial changes in Europe.

- Earth observation (EO), in spite of its potential, has so far played a limited role in environmental monitoring by national and international organisations. The use of EO should be accelerated as a unique tool for spatial analysis, filling in missing gaps, more timely information at European scale for change analysis and future outlooks. Recent developments in earth observation show optimistic prospects for monitoring of the terrestrial, atmospheric as well as marine environment. Although tremendous progress has been made by the Centre for Earth Observation on bridging between EO data providers and the user community, there is still a considerable gap between research and operational use for the environment. Collaboration with the Joint Research Centre on development of operational EO tools for support to environmental policies at European and regional level should focus on the information extraction from new high resolution data, change analysis, modelling and integration in GIS.

- Priority needs to be given to gathering data on socio-economic activities which lead to environmental pressures – such as population growth, sectoral activities, resource use – on a spatial level. Currently many of the statistics are only available at high levels of aggregation for administrative units such as country, regional or commune level within countries whereas data is required at a finer or different level of aggregation, for example at the water-catchment area level. Eurostat has a project underway to develop data in these areas, but there is some way to go in countries to obtain the data required.

- For the present reporting (spatial chapters), specific criteria were chosen for reporting on urban areas (> 100 inhabitants/km^2 NUTS5), rural areas (<100 inhabitants per km^2 NUTS5), coastal zones (10 km strip along the European coast) and mountain areas (over 1 000 m altitude, slope > 5°, excluding areas l<100km^2). Better understanding and harmonisation of definitions applied for stratification or zoning of the European territory is needed.

- There is a strong need for further improvement of analytical tools such as geo-statistics, spatial modelling (Turner II *et al.,* 1997) and networking. The present information technology allows fast information exchange as well as powerful processing and analysis of voluminous and complex geo-referenced environmental and socio-economic data. In most countries and international organisations, Geographic Information Systems – indispensable for spatial analysis – are part of the operational infrastructure at local, national or European level, but interoperability, including improved co-ordination and access to data, needs to be improved.

2.4. Scenarios and outlooks

The *Baseline Scenario* used in this report aims to provide a consistent set of trends forecasts for the key economic and societal driving forces, for the environmental issues on which they have an impact and for human health. The exercise, based on a consistent chain of models, was the first of its kind in Europe and involved close co-operation between the EEA and the European Commission Services. It has exposed the strengths and weaknesses of current modelling and scenario expertise available in

Europe for environmental assessment. In general, coordination of modelling activities should be given priority attention in the future to ensure further the internal consistency and robustness of the model input data, the assumptions used and the output results. This should include the treatment of uncertainties and model sensitivities. As shown in sections 2.1 – 2.3 above, there is a need for more complete and consistent temporal and spatial data for past trends which form the basis for inputs to the scenarios and outlooks models. Better coordination is also needed at the international level to ensure consistent data on societal trends feeds the different models used in the *Baseline Scenario.* For societal trends, the assumptions underpinning the models used need to be refined further and alternative scenarios produced to provide ranges around the central estimates and to support sensitivity analysis. Currently, there are good models available for forecasting economic activity, transport demand, etc. Particular attention in the future needs to be paid to developing scenarios for urban population, number of households, the constituents of private final consumption, materials intensities, energy prices, tourism. For environmental issues, the most developed models and scenarios exist for air pollution aspects (climate change and transboundary air pollution) but these can still be improved. Next comes water where there are established models for forecasting water resources but less so for water quality aspects. Most attention needs to focus on improving models and scenarios for biodiversity and ecosystem impacts, waste generation, soil erosion and sealing, exposure to noise and exposure to chemicals. Many of these activities should take account where appropriate of human health impacts.

3. Using information to improve public awareness and participation

3.1. Setting the scene

The important role of the public in helping to achieve sustainable development was recognised in the EU's Fifth Environmental Action Programme (5EAP) (Box 4.2.1)

The importance of public information has further increased since the 5EAP in 1992 as environmental policies shift from directing the actions of the few, via regulations, to encouraging the behaviour of the many via incentives and information provision (see Chapter 4.1). Other developments have also increased the importance of public information, such as the move from 'supply side ' measures in transport, energy and water (the provision of roads, power stations and reservoirs) to the 'demand side' measures of public transport and efficiency improvements, which require the willing co-operation of many more people than was ever needed for construction activity. In addition, as the focus of policies moves from point source, environmental pollution from factory chimneys to the diffuse sources of pollution, from cars and consumer goods, so the importance of public information and participation for 'sustainable production and consumption' increases (Box 4.2.2).

Box 4.2.1. Information and the public: the Fifth Environmental Action Programme (5EAP)

'The achievement of the desired balance between human activity and development and protection of the environment requires effective dialogue and concerted action among partners… . The success of this approach will rely heavily on the flow and quality of information both in relation to the environment and as between the various actors including the general public'

'The success of the drive towards sustainability will depend to a very considerable extent on the decisions, actions and influence of the general public. But while surveys show a high, and increasing, level of environmental awareness among the general public, the public is considerably lacking in essential information …'.

'In addition to having access to available environmental information under the respective directive, and right to involvement in the assessment of environmental effects of major projects, it is essential that the citizen be enabled to participate in the process of setting conditions for operating licenses and integrated pollution control, and be facilitated in judging the actual performance of public and private enterprises through access to inventories of emissions, discharges and wastes and to environmental audits'.

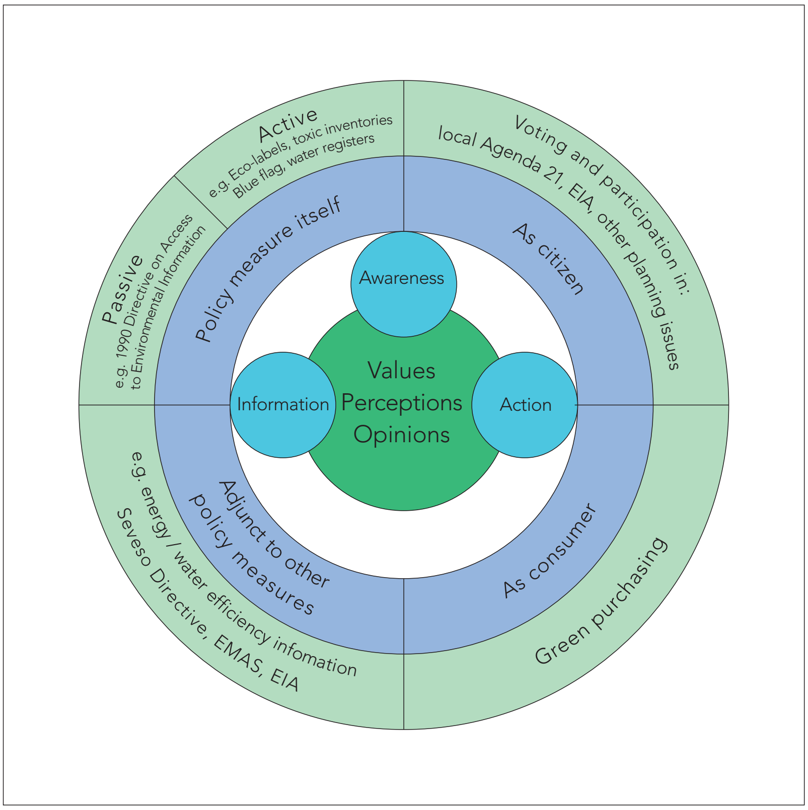
The key elements on public information provision identified in the 5EAP, such as the level of public awareness, access to information, rights to participation, and the associated actions of consumers and citizens, are linked together (Figure 4.2.2). However, there is no simple, one-way relationship between awareness, information and action – each can influence the others in complex and subtle ways.

Box 4.2.2. Sustainable production and consumption and public participation

The critical task is to create the conditions which improve the capacity of individual consumers and public authorities to choose, use and dispose of the goods and services they require in a sustainable way, in other words to move the sustainable alternatives from the margins to the mainstream… .

Open public participation is both a prerequisite and a way of stimulating public support for more radical alternatives. Ultimately lasting changes in consumption behaviour are only likely if those concerned understand their impacts, know about the alternatives, are motivated to change and gave the capacity to act.

Figure 4.2.2	**Key elements of public information and participation**



Source: EEA

3.2. States of minds

'Before Action comes Perception' — *Aristotle*

The level of awareness, or state of the public mind, on the environment has an influence on how information is received and used both by both the public and politicians. A simple and popular way of judging the state of the public mind is to do an opinion poll that asks how concerned people are about the environment compared to other issues, such as the economy or unemployment. However, the results rise and fall rapidly in response to how people perceive the way in which the issues are being addressed. If they think that governments are managing a serious problem fairly well then it is not of 'front-of-mind concern,' compared to the issues that they feel are not being managed well.

Since 1989-92 when the environment was a central concern for the public and politicians this 'front of mind' concern has been partly replaced by worries about unemployment and the economy, and many have interpreted this to mean that the public does not put a high priority on the environment. However, when asked about how worried they are about the environment as such, without having to rank it against other issues, Europeans indicate that they are more concerned about the environment now than in 1992 (Figure 4.2.3). The high level of concern about the environment, (which, at 80-90%, is similar to that in North America and Japan), was also noted in the Eurobarometer survey in 1995, which found that 87% of the EU public were very/quite worried about a range of global environmental threats.

Public opinion about environmental issues partly depends on people's *values*, or what they consider important in their lives. Moreover, it is often differences over values, rather than over information and its significance, that explains conflicts between scientists and the public over complex and uncertain environmental issues (Box 4.2.3).

The EU Ulysses focus group project (1997-99) is exploring one way of eliciting the values of the public about uncertain and complex issues such as energy and climate change, but there are other methods that governments and others in the EU are increasingly using. These include consensus conferences, (pioneered in the EU by the Board of Technology of the Danish Parliament), citizens' juries and deliberative polls. The effectiveness of these activities has not been systematically evaluated but an indication of their usefulness can be gauged by the contrasting experiences of food irradiation in the UK and Denmark. The Danish Parliament had available a very negative report by a lay panel and decided that irradiation of food should not be approved for general use. In the UK the Advisory Committee on Novel Foods and Processes decided that the process should be introduced. There was a hostile response from the public, and industry was unable to use plant it had installed. 'The outcome might well have been avoided if there had been appropriate public debate before the decision was taken.' (RCEP,1998).

An issue in the radiated foods episode was that of justification, or need, where the public's values about the need for irradiated food were in contrast to the scientists views about the risks of the process. This is an increasingly prevalent issue in environmental debates over complex problems, such as chemicals, radiation and GMOs, (see Chapter 3.9), where increasingly 'hard' (i.e. strongly held) public or consumer values need to be reconciled with increasingly 'soft' (i.e. uncertain) scientific facts. The Brent Spar episode (Box 4.2.4) seemed to be an example of this shift which involved the public in Germany, the Netherlands and other EU countries.

Controversy over large-scale transportation projects have been the focus of conflict between the public and authorities in the UK, the Netherlands and other countries, and efforts are underway to try and improve dialogue. In 1994 the Dutch Ministry of Transport and Communication established the 'Infralab' with a mission 'to overcome the gap between the authorities, experts and society' (van Zwaneberg *et al.*, 1998) by organising dialogue between the public and authorities at the early 'framing' stage of a project.

A failure to have timely public debate about controversial issues can widen the gap between the public and governments, which can then lead to mistrust. Trust in the sender of information is a key element in how it is received and used (Macnaughten, 1998). However, public authorities and industry are not considered by the European public to be very reliable sources of information, according to a Eurobarometer poll (Figure 4.2.4). Mistrust in public institutions, and in science, seems to vary widely between Member States, with low levels of trust being reported in some countries such as the UK and Italy, and high levels in Germany and the Netherlands (Jamison, 1998).

Trust, and the perceived reliability of the information provided, is partly related to how information fits in with local experiences: information that cannot be related to local circumstances is often ignored (Lancaster University, 1995). This is a particular challenge for European institutions who need to produce pan-European information that reflects regional and local diversity (Waterton, 1995).

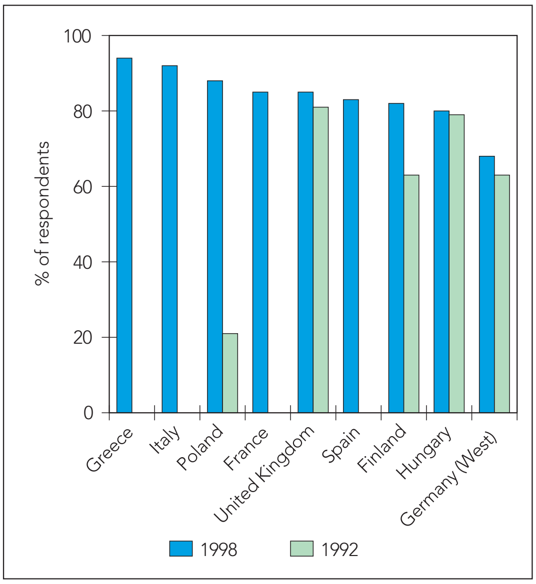
3.3. Access to information

The EU has taken several initiatives to provide public access to information (Box 4.2.5).

The Directive on Freedom of Access to Environmental Information is being revised and updated. Several reviews have identified the benefits and limitations of the Directive (EEA, 1997; REC, 1998).

Having access to information is a 'passive' right: the active provision of information to the public has also been encouraged at EU and Member State level. In addition to the

Respondents personally worried a great deal/fair amount about environmental problems in 1992 and 1998 — Figure 4.2.3



Source: International Environmental Monitor 1998; 1992 Gallup survey data

Box 4.2.3. The importance of values in environmental affairs

'A truly integrated assessment must take account of values, including those held by citizens…' (Ravetz, 1996)

'Conflicts of values in environmental policy turn up again and again… providing a continuing debate about moral choice… they oblige people to stike a balance between counting what can be quantified and caring for what cannot be quantified.' (Ashby,1977)

'The public's judgement about hazardous waste and global warming… is strikingly similar to the scientists' views. The few examples of divergence seem rooted more in value differences than in expertise.' (Doble, 1995)

'Results show that scientific uncertainty is not a hindrance to political action if it is communicated explicitly and discussed openly: talk with us, don't teach us, is the basic rule.' (Kasemir, 1999)

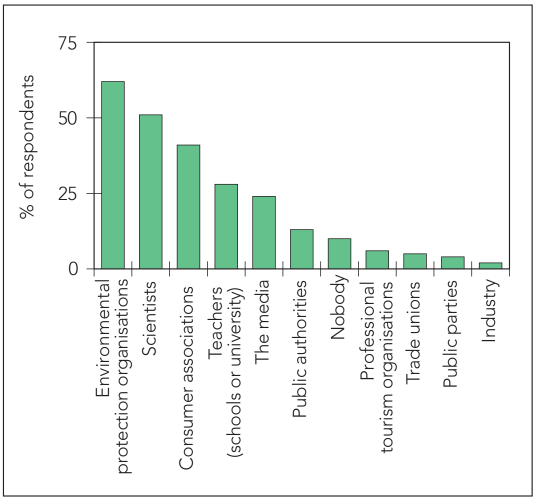
Box 4.2.4. Brent Spar: A case of 'soft' facts and 'hard' values?

Although the amount of hazardous materials involved in the proposed dumping of the Brent Spar oil platform in 1995 was not large, the disposal was of symbolic importance. Not only was the Spar the first of approximately 400 oil platforms in the North Sea due to be decommissioned in the coming decades, but the proposed method of disposal at sea was viewed as sending the wrong signals that the seas could be used as free dumping grounds for the waste products of industrial society. Although such a policy had been agreed by Shell as the Best Practical Environmental Option (BPEO), and subsequently endorsed by the UK government, Greenpeace were able to occupy the Brent Spar and use the moral argument about dumping to initiate a co-ordinated consumer boycott against Shell products, starting in Germany and spreading to other countries. The widespread media and public response to the boycott took even Greenpeace by surprise, and made a very substantial impact on Shell, resulting in a reversal of policy.

As the facts about the long-term impacts of deep-sea disposal were not certain, and the values of the public were strongly held, the conflict may be seen as part of a growing tendency towards such 'soft' facts and 'hard' values in environmental risk management.

Figure 4.2.4 **Which sources of information ‘tell the truth’ about the environment (several answers possible)**

Source: Eurobarometer,1995



general duty of the EEA to ‘ensure that the public is properly informed about the state of the environment’, and to ‘ensure the broad dissemination of reliable environmental information’, several other EU initiatives in Box 4.2.5 require the active provision of information, such as the eco-label.

3.4. Information provision and behaviour change

The links between information provision and associated changes in behaviour are complex and difficult to unravel (Williams, 1997). It is clear from the previous discussion on awareness and values that the receiver’s state of mind and general situation is critical to the successful communication of information that intends to change behaviour. The process has to be viewed in two directions, and the *efficient* communication of information does not necessarily mean it will be used effectively. The range of behaviour choices open to the receiver is crucial, as are other aspects of the ‘information use environment’ (Menou, 1993). More subtle indicators of effectiveness of information provision are needed that can identify impacts other than behaviour change itself and which are generated more by the receiver’s agenda than the sender’s.

Box 4.2.5. Public access to environmental information: some EU initiatives

- Major hazards from Industry (the ‘Seveso’ Directive, 1988);
- Radiation emergencies (Euratom Directive, 1989);
- Labelling and advertising of food (food labelling Directive, 1979 and 1989; nutritional labelling, 1990; novel food Regulation, 1997; GMOs, 1997/98);
- General information on the environment (freedom of access to environmental information, 1990);
- Eco-labelling of consumer goods (Community eco-label award scheme Regulation, 1992);
- Environmental management of companies (eco-management and audit voluntary scheme, 1998);
- Chemical emissions (Integrated Prevention and Pollution Control Directive 1996 – due in 2002);
- Environmental data (EEA regulation, 1990).

The use of eco-labels is an increasingly common way of trying to influence the market and consumer behaviour (see Chapter 4.1). A review (OECD, 1997) of several eco-label schemes, including those in the EU, concluded that, although data on environmental effectiveness was lacking, there was evidence of positive impacts on both consumers and producers (Box 4.2.6).

A recent Nordic Council review of product change management in Sweden and Finland focused on detergents, clothing and textiles, electrical and electronic appliances, home and office furniture, and paper products. It analysed information flows and eco-labels and found that although such information was not yet integrated into the actors’ normal decision-making routines, there was potential for improving the environmental impacts of products across the product chain via better information and communication flows (Nordic Council, 1998).

A specific study of the EU energy label on refrigerators and freezers found evidence that such environmental information provision lead to some behaviour change (Box 4.2.7).

Evidence of other effects of information on behaviour is scarce but where there is an authoritive report by a scientific body on a specific issue, such as the leukemia risk from the benzene in some unleaded fuels, and there is extensive coverage by the mass media, and different choices are readily available, without much financial cost, then behaviour can change dramatically (Figure 4.2.5; Fouquet, 1997).

The liberalisation of energy and other utility markets can provide opportunities for greater consumer choice, and pressure, which could be used, for example, to increase the market shares of renewable energy supplies (Fouquet, 1998). In addition, the experience in the US with the Toxic Release Inventory is that public information

Box 4.2.6. Effects of eco-labelling

The OECD studied eco-labelling schemes in several countries: the EU Eco-label Award Scheme, the Nordic Swan, the Swedish Environmental Choice Programme, the Canadian Environmental Choice Programme, the Blue Angel, the Green Seal, the Japanese Eco-Mark and the French NF Environment.

Transparency and consultation
Eco-labelling programmes all have mechanisms for transparency, ranging from publication of information to active dissemination to interested parties, to simply establishing inquiry points; and they have similar consultation processes. Decision-making on the final eco-label criteria is generally not open to outside participation.

Market impacts
Data concerning the market impact of eco-labelled products is very difficult to obtain. It is often confidential commercial information in the hands of industry. Some scattered anecdotal evidence shows that sales have increased when an eco-label has been obtained, but there is no statistical data in general to show the market power an eco-label may confer on a product. Producers however continue to apply for and pay for eco-labels, indicating they have some market value. It is difficult to separate out the market impact of the eco-label from other factors which influence a product's market share.

Eco-labelling programmes have been more successful in countries or regions which benefit from a higher level of consumer awareness of environmentally preferable products and therefore a consumer demand for eco-labelled products (e.g. Sweden). Environmental NGOs, consumer groups and the media have contributed to increasing consumer awareness of environmentally preferable products through consumer awareness-building campaigns of various kinds (e.g. the Swedish Society for Nature Conservation in Sweden, consumer organisations and the specialised press in Germany). In certain cases, eco-labels have had a significant impact on the market for specific product categories (e.g. detergents in Sweden).

Overall, eco-labelling has only been moderately successful with the individual consumer. However, eco-labels may have an important market impact when retailers specify they want to stock products with eco-labels (e.g. ICA retailers in Sweden) or when they become a tool in identifying environmentally preferable products for government procurement.

Trade concerns
Some eco-labelling programmes such as the EU Eco-label Award Scheme, the Nordic Swan, and NF Environment generally include production-related requirements in their eco-label criteria.

The eco-label for T-shirts and bed linen and the eco-labels for paper products developed by the EU have been the largest source of trade concerns because they include criteria related to the production stage of products which are largely imported into the EU.

Environmental effectiveness
Although data relating to the environmental benefit achieved through eco-labelling is lacking, a few estimates of the environmental effectiveness of eco-labelling programmes have been made in terms of pollution avoidance. Generally, however, due to the difficulty of isolating and measuring the environmental benefits of eco-labelled products, environmental effectiveness has instead been evaluated indirectly on the basis of consumer awareness and consumer demand for eco-labelled products, and changes in producer behaviour. Public awareness and attitudes to eco-labelled products vary significantly depending on the country. In some instances, the development of eco-labels has had an impact on the behaviour of manufacturers, strongly encouraging them to modify their products in order to qualify for an eco-label so as to maintain their products in retail chains, for example. Surveys have indicated that eco-labels are better known to women than men and to younger people than older people.

Source: OECD, 1997.

Box 4.2.7. Energy labelling

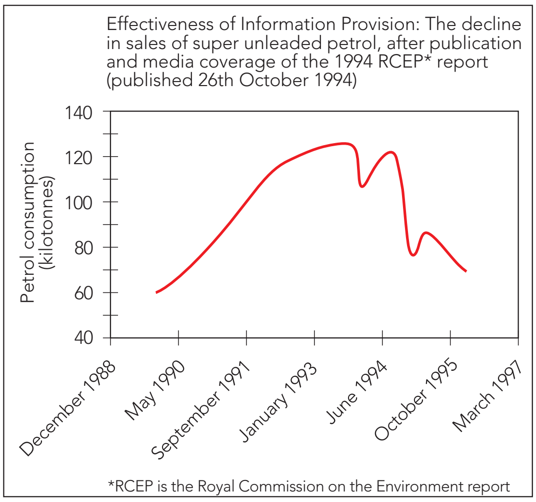
The impact of refrigerator and freezer energy labelling on purchase decisions has been studied in a cross-European survey of people buying cold appliances since the introduction of the energy label. They found that consumers use the Energy Label and they understand its message. The label is especially influential when the consumer is already concerned about energy use of appliances.
The study found large national differences in the importance attributed to energy use, and that this was not related to the relative price of electricity, but to environmental concern. Of those who said they recalled seeing the energy label, there was a similar degree of national variation over whether it had influenced purchase (61% in Denmark to 3% in Greece), with a strong relationship between the impact of the label and the expressed importance of energy use as a purchase criterion. The label was widely trusted as being accurate, but the variable rates of compliance with the labelling scheme between different countries also reflected the degree to which energy was considered an important factor, and the extent to which the labels influenced purchasing decisions. The label had little effect on purchasing patterns in the southern countries, even though the benefits of cold appliances would be greatest where the summer is hot. In northern countries, where there is a longer history of concern about energy use, the label has had a much greater influence. Across the EU, it is estimated that about a third of consumer purchases of cold appliances are now influenced by the Energy Label. The energy label can thus be considered to be successful where there is already a concern about energy use; it does not, of itself, appear to generate this concern.

Source: Winward et al., 1998

Figure 4.2.5

An example of the role of information provision: the sales of super unleaded petrol in the UK, 1988 - 1997

Source: Fouquet, 1997



*RCEP is the Royal Commission on the Environment report

can play a significant role in pollution reduction. 'Public disclosure of environmental information on emissions is a cornerstone of the regulatory process in the US. Experience has shown that the public disclosure of this data has had a major impact on compliance rates and has led to improved environmental management' (USEPA,1994). Several EU countries provide public access to chemical release data, and the IPPC directive will extend this practice across the EU.

There is little information available that could help determine the optimum investment in public information provision on pollution release and control. A review of economic analyses of information disclosure strategies for pollution control (Tietenberg, 1997) concluded that, whilst there is evidence that information strategies can be effective in motivating environmental improvement, there is no evidence about the cost effectiveness of such strategies compared to other methods of pollution control.

The public appears to be ready for further behaviour change on the environment, as indicated in Eurobarometer polls (Box 4.2.8), and from the rising demand for organic produce and green, or ethical, investments.

3.5. Public participation

The EU has taken a number of initiatives to encourage public participation (Box 4.2.9) and the success of such measures depends in part on the timing and quality of the information provided to the public. In particular, early involvement of the public at the scoping stage of a project, under Environmental Impact Assessment (EIA), or of a programme, plan or policy (Strategic Impact Assessment) seems to maximise the chances of dealing with value differences and of incorporating local knowledge (Sheate and Atkinson, 1995). The updated EIA directive, 1997, places greater emphasis on public consultation, requiring information to be provided that allows the public to express an opinion before development consent is granted, and which includes reasons for decisions and 'descriptions of the main measures needed to avoid, reduce and, if possible, offset any major adverse effects'. However, the treatment of such environmental mitigation steps in EIA can be problematic (DETR, 1997). The treatment of health impacts in EIA, which particularly affects the public, is also poor (BMA, 1998).

EU countries have national laws transposing the EIA Directives into their national practices, allowing for the public participation provisions described in the Directive. However, national differences in democratic and administrative traditions means that public participation in practice varies considerably (Garrett and Martins, 1996). Access to information, and to the Courts, are necessary for successful public participation, particularly where the objectives of economic development and environmental protection conflict (Box 4.2.10)

3.6. What's ahead

Both the review of the Directive on Freedom of Access to Environmental Information and ratification by the EU of the Aarhus Convention 1998 (Box 4.2.11) will provide further

Box 4.2.8. Some public actions on the environment

Most common actions

These actions were identified as being 'already done' and/or that people would 'be prepared to do more often/start doing to protect the environment'. The six highest scoring actions were:

- Avoid dropping paper or other waste on the ground (95%);
- Sort out certain types of household waste… for recycling (84%);
- Save tap water (82%);
- Save energy by using less hot water, by closing doors and windows to save heat (81%);
- Not make too much noise (79%);
- Buy an environmentally friendlier product, even if it is more expensive (67%).

Source: European Commission, 1995

opportunities for public information provision and participation. Meanwhile, the EEA's development of the European Reference Centre for European environmental data and information as a public information service could provide an information base for policy makers, non-governmental organisations and the public. As the focus of environmental activites widens to cover sustainability issues, so the need to inform and involve the public is likely to increase significantly.

Box 4.2.9. Rights to consultation or participation: some EU initiatives

- consumer participation in products standardisation (Council Recommendation, 1988);
- public consultation over release of GMOs (the GMOs Directive, 1990, suggests public may be consulted);
- participation in Environmental Impact Assessment (EIA Directives, 1985 and 1997);
- participation in the permitting procedure for new industrial installations (Integrated Pollution Prevention and Control Directive, 1996);
- public opinion on some major accidents or hazard installations (amended 'Seveso' Directive, 1996).

Box 4.2.10. The Acheloos river diversion project

Acheloos is the largest river flowing entirely in Greek soil. In Greek mythology, Acheloos was the God of all rivers.

The Acheloos river diversion project involves the major diversion of the river from its physical route to a totally different catchment basin, the Thessaly plain in Eastern Greece. The project involves the construction of three dams, three tunnels, extended irrigation works covering an area of 350 000 ha, drainage and anti-flooding networks and many kilometres of new roads. The aim was to increase the production of cotton which enjoyed the support by the Common Agricultural Policy (CAP).

The diversion is expected to cause severe alternations to the Messolongi wetland where the river flows. This wetland is one of the 11 RAMSAR sites in Greece. Due to critical point in which the wetland is now, it is believed that further reduction of the freshwater input to the wetland will be devastating for the system (Scoullos, 1996).

There is no detailed study for the available water resources in Thessaly and the real needs and alternative methods for meeting these needs.

The campaign against the project started in 1992 by four of the largest Greek NGOs. The objectives of the campaign are:

- to cancel the project and to protect important habitats and monuments;
- to provide information, raise awareness and promote dialogue and partnerships between stakeholders and the public.

The local authorities of the lower Acheloos area where the RAMSAR wetland is found asked the NGOs to support their opposition to the proposal and to confront jointly the Environmental Impact Aassessment prepared by the Ministry. However, the project is very popular in Thessaly, the largest cultivated plain of Greece which is intended to benefit from the diversion.

In 1994 the NGOs were successful in two legal cases against the Government for inadequacies in the IEA. It was the first time in Greece, and Europe, that a Higher Court had decided that an integrated EIA was required for large complex development schemes in order to assess whether the project is compatible with the notion of sustainability and the precautionary principle. The Greek Government refused to halt the construction works but ordered a new EIA. The NGOs and local authorities of the upper Acheloos district submitted an injunction to a Local Court asking for the immediate compliance of the Government with the Decisions of the Council of State. The case was lost.

A case was also taken in 1995 against the Government denial to allow the NGOs access to information related to the actual water flow of Acheloos, which is one of the most important questions of the case. The case was won and a decision of the Council of State was issued despite the fact that the relevant EU Directive was not at that moment integrated into the Greek law.

New environmental terms for the construction and operation of the diversion project, according to the conclusions of the new EIA have been inserted by the Government and the quantity of water to be diverted has been reduced to 6 000 million m^3/year, compared to 1.1 billion m^3/year.

The Campaign, and the construction, continue.

Source: Scoullos and Constantianos, 1999

References

Ashby, E., 1997. *On Reconociling Man with His Environment.* Oxford University Press, Oxford, pp. 85-86.

BMA, 1998. Health and Environmental Impact Assessment: an Integrated Approach. British Medical Association, London.

DETR, 1997. Mitigation Measures in Environmental Statements. Department of the Environment Transport and the Regions, London.

Doble, J., 1995. 'Public opinion about issues characterised by technological complexity and scientific uncertainty', in Public Understanding of Science, 4, 1995.

EEA, 1995. *Europe's Environment: The Dobris Assessment.* European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

EEA, 1997. Public Access to Environmental Information. Prepared by R.E. Hallo, Stitchting Natuur en Milieu (the Netherlands Society for Nature and Environment), May 1997. Experts' Corner No 1997/1, European Environment Agency, Copenhagen.

EEA, 1998. *Europe's Environment: The Second Assessment.* European Environment Agency, Copenhagen. Office for Official Publications of the European Communities, Luxembourg.

Box 4.2.11. The Aarhus Convention,1998

The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters was adopted in the Danish city of Aarhus at the Fourth Ministerial Conference in the 'Environment for Europe' process, in June 1998, and signed by 35 countries and the European Union.

The Aarhus Convention aims to strengthen:

- Rights of access to environmental information via a wide definition of information, a presumption in favour of access, and a public interest test for exempted information;
- Rights to participate in environmental decision-making, including an obligation on the decision-making body to take due account of the outcome of public participation, and to inform the public of the decision, and the reasons for it;
- Rights of access to justice in environmental matters, including access to administrative or judicial procedures to challenge acts and omissions by private and public bodies which breach environmental laws, subject to the standing of members of the public in national law.

EEA/UNEP, 1998. Chemicals in the European Environment: Low Doses, High Stakes? EEA and UNEP Annual Message 2 on the State of Europe's Environment European Environment Agency, Copenhagen, Denmark, and United Nations Environment Programme, Châtelaine Switzerland. UNEP, UNEP/ROE/97/16.

EEA/WHO. *Water and Health in Europe* (in press).

European Commission, 1995. *Europeans and the Environment in 1995: Eurobarometer 43.1* (Brussels: European Commission).

Fouquet R., 1997. Environmental Information and the Demand for Super Unleaded Petrol, Surrey Energy Economics Discussion Paper, no.90, University of Surrey, Guildford.

Fouquet R., 1998. 'The UK Demand for renewable electricity in a liberalised market', Energy Policy, 26(4), 281-293.

Garrett, C. & Martins, I., 1996. EIA and Administrative Management Models: a marriage of ineffectiveness? IAIA '96 Proceedings, Estoril.

International Environmental Monitor, 1998. Environics International Ltd. Toronto

Jamison, A., 1998. 'Technology Policy meets the public', Pesto Papers 2, p.164, Aalborg University Press, Aalborg.

Kasemir, B., 1999. 5th Ulysses workshop on 'Integrated Assessment Focus Groups: A new Approach to stakeholder involvement in Environmneta policy', March 1999.

Lancaster University, 1995. 'Public Perceptions and sustainability in Lancashire', by Macnaghten, P. Grove-White ,R.,Jacobs, M.,Wynne,B., Lancashire County Hall, Preston.

Macnaghten, P. and Urry, J., 1998. Contested Natures (London, Sage)

Menou, M.J., 1993. Measuring the impact of research information on practitioners, IDRC, Ottawa.

Nordic Council, 1998. Environmental Improvement in Product Chains, Temanord, Nordic Council of Ministers, Copenhagen.

Norwegian Ministry of the Environment, 1998. *Consumption in a Sustainable world,* Report of a Workshop, Kabelveg, Norway.

OECD, 1997. *Eco-labelling: Actual Effects of Selected Programmes.* Organisation for Economic Cooperation and Development.

Ravetz, J, 1996. Integrated environmental assessment: developing guidelines for good practice'. Research Methods Consultancy. London

RCEP, 1998. Setting Environmental Standards: 21st Report. The Stationery Office, London.

REC, 1998. Doors to democracy. Regional Environment Center for Central and Eastern Europe

Scoullos, M., 1996. Environmental impacts of the Acheloos river diversion. In 15th Congress of the International Association for Bridge and Structural Engineering (IABSE), Congress report. Copenhagen, 16-20 June 1996

Scoullos, M., Constantianos, E., 1999. Personal communication, Elliniki Etairia, The Hellenic Society for the Protection of the environment and the Cultural heritage. Athens

Sheate, W & N Atkinson, 1995. Public Participation in Environmental Decision-Making: The European Dimen- sion. Environmental Policy and Practice 5, 3, 119-129

Tietenberg, T. 1997. 'Disclosure strategies for pollution control'. Paper for conference on Environmental Implications of Market-Based Policy Instruments, Göteborg, November 1997.

Turner II, B.L. *et al.,* 1997. '"Socializing the Pixel" and "Pixelizing the Social" in Land-Use/Cover Change (LUCC) with reference to scalar themes'. IGBP-IHDP LUCC Newsletter No 1, February 1997.

UK/EA, 1998. Chairman's conclusions, Bridging the Gap Conference. UK Environment Agency, VROM (The Netherlands) and European Environment Agency. London, June 1998

USEPA, 1994. Changing Environmental behaviour in the USA through the use of Public Disclosure of Information. Environmental Protection Agency, Washington.

Van Zwanenberg, P., te Velde, R., Ostby, P., 1998. 'Roads to Sustainable Transport?', in 'Technology Policy Meets the Public', Pesto Papers 2, Aalborg University Press, Aalborg.

Waterton, C, Grove-White, R., Rodwell, J., and Wynne, B., 1995. CORINE: Databases and Nature Conservation – the new politics of information in the European Union. Centre for the Study of Environmental Change and Unit of Vegetation Science, Lancaster University.

Williams, W., Wilson, K. and McConnell, M., 1997. 'Is there any knowledge out there? The impact of research information on practitioners', British Library Research and Innovation report n°62. British Library.

Winward, J., Scheillerup, P., and Boardman, B., 1998. Cool Labels: the first three years of the European Energy Label (Energy and Environment Programme, Environmental Change Unit, Oxford).

Glossary

5EAP	Fifth Environmental Action Programme (EU)
AAE	average accumulated exceedance
AC	Accession Countries
AC10	ten central and eastern European Accession Countries
AFA	antibacterial feed additives
AOT	Accumulated Ozone exposure over a certain Threshold value (parameter used to express effects of ozone)
AQG	air quality guidelines
As	arsenic
BAT	best available technology
BOD	biochemical oxygen demand
BSE	bovine spongiform encephalopathy
BSS	basic safety standards
Bt	Bacillus thuringienis
CAP	Common Agricultural Policy (EU)
CBD	Convention on Biological Diversity (UN)
Cd	cadmium
CEC	Commission of the European Communities (or European Commission)
CEFIC	European chemical industry confederation
CET	Central European Time
CFC	chlorofluorocarbon
CFP	Common Fisheries Policy (EU)
CH_3Br	methyl bromide
CH_4	methane
CHP	combined heat and power
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CLRTAP	Convention on Long-Range Transboundary Air Pollution (UNECE)
CLRTAP-HM	Convention on Long-Range Transboundary Air Pollution by Heavy Metals
CLRTAP-POP	Convention on Long-Range Transboundary Air Pollution by Persistent Organic Pollutants
CO	carbon monoxide
Co	cobalt
CO_2	carbon dioxide
COD	chemical oxygen demand
COP3	Third Conference of the Parties to the UNFCCC, Kyoto, Dec. 1997
COP4	Fourth Conference of the Parties to the UNFCCC, Buenos Aires, Nov. 1998
COPs	cereals, oilseed and protein crops
Corinair	CooRdination of Information on the Environment AIR emissions (former EC programme), since 1995 a EEA/ETC-AE programme (CORe Inventory of AIR emissions)
Cu	copper
dB(A)	international sound pressure level unit meaning ‘decibel with an A frequency weighting’ which reflects the sensitivity of the human ear
DDD	1,1-dichloro-2,2-bis(4-chlorophenyl)ethane
DDT	1,1'-(2,2,2-Trichloroethylidene)bis(4-chlorobenzene)
DG XI	EC Directorate-General XI (Environment, Nuclear Safety and Civil Protection)
DPSIR	Driving forces, Pressures, State, Impact, Responses
dw	dry weight
EAP	Environmental Action Programme
EBRD	European Bank for Reconstruction and Development
EC	European Community
ECB	European Chemicals Bureau (Joint Research Centre, Ispra, Italy)
EDTA	EthylenDiaminTetraAcetic acid

EDS	Endocrine disrupting substances
EEA	European Environment Agency
EFTA	European Free Trade Association
EIA	environmental impact assessment
EINECS	European INventory of Existing Chemical Substances
EIONET	European Information and Observation Network
EMAS	Environment Management and Audit Scheme (EU)
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollution in Europe
EMSC	European Mediterranean Seismological Centre
Enterococci	Type of bacteria present in the intestines of animals and humans
EPE	Environmental Programme for Europe
EPOCH	European Programme on Climatology and natural Hazards
ERDF	European Regional Development Fund (EU)
ESDP	European Spatial Development Perspective
ETC/AE	European Topic Centre on Air Emissions (EEA)
ETC/AQ	European Topic Centre on Air Quality (EEA)
ETC/IW	European Topic Centre on Inland Waters (EEA)
ETC/LC	European Topic Centre on Land Cover (EEA)
ETC/MC	European Topic Centre on Marine and Coastal Environment (EEA)
ETC/NC	European Topic Centre on Nature Conservation (EEA)
ETC/S	European Topic Centre on Soil (EEA)
ETC/W	European Topic Centre on Waste (EEA)
EU	European Union
EU15	European Union (15 Member States)
EUNIS	European Nature Information System
EUR	euro
EURAM	European Union Risk RAnking Method
Eurostat	Statistical Office of the European Union (Luxembourg)
EUSES	European Uniform System for Evaluation of Substances
FAO	Food and Agriculture Organization (United Nations, Rome)
FCCC	Framework Convention on Climate Change (UN)
FYROM	Former Yugoslav Republic of Macedonia
GDP	gross domestic product
GEM-E3	General Equilibrium Model for Energy-Economy-Environment interactions
GEO	Global Environment Outlooks (UNEP report)
GHG	greenhouse gases
GJ	gigajoules
GM	genetically modified
GMO	genetically modified organism
Gt	gigatonnes
GVA	gross value added
GWP	global warming potential
HBFC	hydrobromofluorocarbon
HCB	hexachlorobenzene
HCFC	hydrochlorofluorocarbon
HCH	hexachlorocyclohexane (g-HCH = lindane)
HELCOM	Helsinki Commission
HFC	hydrofluorocarbon
Hg	mercury
HM	heavy metal
HPVC	high production volume chemicals
HSRN	high-speed rail netork
I-TEQ	International Toxicity EQuivalents with respect to 2,3,7,8-TCDD
IAEA	International Atomic Energy Agency (UN)
IC	internal combustion (engine)
ICAO	International Civil Aviation Organisation
ICES	International Council for Exploration of the Seas
ICP	International Co-operation Programme (UNECE)
ICRP	International Commission on Radiological Protection
ICZM	integrated coastal zone management

IEA	integrated environmental assessment
IIASA	International Institute for Applied Systems Analysis
INES	International Nuclear Event Scale
IPCC	Intergovernmental Panel on Climate Change (UN)
IPPC	Integrated Pollution Prevention and Control (EU Directive)
IRS	Incident Reporting System
ISSA	Information Society Services and Applications
IUCLID	International Uniform Chemical Information Database (Joint Research Centre, Ispra, Italy)
km	kilometers
ktonnes	thousand tonnes
LCA	life-cycle assessment
Ldn	Day-Night Level, a descriptor of noise level which is based on the energy-equivalent noise level (Leq) over the whole day with a 10 dB(A) penalty to noise levels experienced during night time (22.00 - 07.00 hrs)
Leq	equivalent sound pressure level
LFA	less favoured area
LIFE	financial instrument for the environment (EU)
LOIS	Land-Ocean Interaction Study (funded by UK Government and CEC)
LRTAP	Convention on Long-Range Transboundary Air Pollution (UNECE)
MAC	maximum admissible concentration
MAP	Mediterranean Action Plan (Barcelona Convention)
MARS	Major Accident Reporting System
MEDPOL	Mediterranean Pollution Monitoring and Research Programme
MIRABEL	Models for Integrated Review and Assessment of Biodiversity in European Landscapes (see Chapter 3.11)
MJ	million joules
MMM	Multi-Media Model
MS	Member State (of EU)
mSv	millisievert (radiation exposure unit)
Mt	million tonnes
N_2O	nitrous oxide
NGO	non-governmental organisation
NH_3	ammonia
Ni	nickel
NMVOC	non-methane volatile organic compound
NO	nitric oxide
NO_2	nitrogen dioxide
NO_3	nitrate
NO_x	nitrogen oxides
NRC	National Reference Centre (EEA)
NTA	nitrilotriacetic acid
NUTS	nomenclature of territorial units for statistics (Eurostat)
O_3	ozone
ODP	ozone depletion potential
ODS	ozone-depleting substance
OECD	Organisation for Economic Cooperation and Development
OSPARCOM	Oslo and Paris Commission
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCT	polychlorinated triphenyl
PEEP	prominent European environmental problem
PFCs	perfluorcarbons
PHARE	Poland, Hungary – EU Assistance for the Reforms of the Economies (currently extended to 13 central and eastern European countries)
PIC	prior informed consent (procedure)
PIPP	policies in place and in the pipeline (baseline scenario, August 1997)
PM	Particulate Matter

PM10	respirable Particulate Matter with aerodynamic diameter between 2.5 and 10 μm (see Ch. 3.3)
POP	persistent organic pollutant
ppb	parts per billion
ppm	parts per million
PPP	polluter pays principle
PPS	purchasing power standard
ppt	part per trillion
PSC	polar stratospheric cloud
pSCI	potential site of community interest (EU)
Pt	platinum
PVC	polyvinylchloride
RIVM	National Institute of Public Health and Environmental Protection, the Netherlands
SAC	special area of conservation
SAVE	specific actions for vigorous energy efficiency (EU)
SCI	site of community interest (EU)
SEA	strategic environmental assessment
SFA	substance flow assessment
SME	small and medium-size enterprises
SO_2	sulphur dioxide
SPA	special protection area
SPIRS	Seveso Plants Information Retrieval System (EU)
t	tonnes
TACIS	technical assistance to the Commonwealth of Independent States (EC)
TBT	tributyl tin
TCDD	tetrachlorodibenzodioxin
TEN	Trans-European Network
TERM	Transport-Environment reporting Mechanism (EU)
TEU	twenty-feet equivalent
toe	tonnes of oil equivalent
TRI	trichloroethen
UAA	usable agricultural area
UN	United Nations
UNCED	United Nations Convention on Environment and Development
UNCDD	United Nations Convention to Combat Desertification
UNECE	United Nations Economic Commission for Europe (Geneva, Switzerland)
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USEPA	United States Environmental Protection Agency
UV	ultraviolet radiation
VC	vinylchloride
VOC	volatile organic compound
VRE	vancomycin resistant enterococci
VVER	pressurised water reactor
WHO	World Health Organisation
WTO	World Tourism Organisation
ww	wet weight
WWT	waste water treatment
Zn	zinc