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Proceedings of the Technical Workshop on Indicators for Soil Sealing

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Prepared by:
Simon Turner

Project manager:
Anna Rita Gentile
European Environment Agency

European Environment Agency

Layout: Folkmann Design A/S

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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

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Abbreviations

CEE	Central and eastern Europe
Corine LC	Corine land cover
COST	European cooperation in the field of scientific research
DG	Directorate-General
DPSIR	Driving forces-pressures-state-impacts-responses
EC	European Commission
EEA	European Environment Agency
EIONET	European environmental information and observation network
EMEP	Cooperative programme for monitoring and evaluation of the long-rangetransmission of air pollution in Europe
EPA	Environment Protection Agency
ESB	European Soil Bureau
ESDP	European spatial development perspective
ETC/S	European Topic Centre on Soil
ETC/TE	European Topic Centre on Terrestrial Environment
ETC/W	European Topic Centre on Water
EU	European Union
GIS	Geographical information system
GVA	Gross value added
IGBP-GCTE	International geosphere-biosphere programme global change and terrestrial ecosystems project
JRC	Joint Research Centre
JRC-EI	JRC Environment Institute
JRC-SAI	JRC Space Applications Institute
MF/MI	Multi-function/multi-impact
Moland	Monitoring land use/landcover dynamics
Murbandy	Monitoring urban dynamics
NFP	EEA national focal points
UNEP	United Nations Environment Programme
WFD	EC water framework directive

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Participants

The mix of delegates was broad providing an opportunity for wide-ranging discussion. Delegates represented environmental statistics and reporting, environmental monitoring (remote sensing and GIS), land and soil policy analysis, environmental (soil) policy development. Delegates represented the European Commission, national and regional government, the private sector and the newly established ETC on terrestrial environment (ETC/TE).

EEA	Anna Rita Gentile	European Environment Agency
Consultant (ADAS)	Hester Lyons	ADAS Consulting Ltd
Consultant (ADAS)	Simon Turner	ADAS Consulting Ltd
ETC/TE	Philipp Schmidt-Thomé	Geological Survey of Finland
DG ENV	Luis Carazo-Jimenez	European Commission, Environment DG
JRC	Robert Jones	European Commission, JRC, Environment Institute
JRC	Luca Demicheli	European Commission, JRC, Space Applications Institute
DE	Fabian Dosch	Federal Office for Building and Regional Planning
DE	Olaf Düwel	Federal Institute for Geosciences and Natural Resouces
IT	Pierpaolo Napolitano	National Institute of Statistics
NL	Cors van den Brink	Iwaco Groningen
ES	Inés Irjibarren Campaña	Ministry of Environment
UK	Liz Mills	Ove Arup
UK	Judith Lowe	Consultant
UK	Andrew Harrison	Consultant, national land-use database (NLUD)

Executive summary

In 2001, the EEA carried out a peer review of its work on soil, with particular reference to the development of policy-relevant indicators and the identification of probable problem areas for soil degradation (the so-called 'hot spots'). The review was, in particular, focused on work on indicators for soil erosion and soil sealing and two associated technical workshops were held in March 2001 to facilitate this review.

This report summarises the conclusions of the workshop on indicators for soil sealing, held in Copenhagen on 26 to 27 March 2001, and the results of the Eionet review of the EEA 'hot spot' work, undertaken in the first half of 2001 (see Annex E).

The purpose of the workshop was to identify a set of recommendations concerning reporting on soil sealing (as part of the wider theme of soil degradation), that could then be considered for inclusion in the work programme for the new ETC on terrestrial environment.

The EEA has defined soil sealing as the covering of soil due to urbanisation and infrastructure construction, such that soil is no longer able to perform the range of functions associated with it. Soil sealing is not adverse *per se*, rather it is the irreversibility in practical terms of sealing the soil and the consequent loss of soil functions.

Expectations from the presentations were to ascertain the extent to which monitoring of soil sealing is undertaken by the member countries. In addition, the JRC (SAI and EI) ([1]) has developed a number of databases and techniques that may support soil sealing monitoring and assessment, and their relevance to EEA soil-sealing monitoring was also assessed. The workshop, therefore, provided an opportunity to gauge the scope for comparing national data, to define key data sets for future data collections, and to indicate whether these data can be used to set up models or estimation schemes.

Although there are no explicit policy objectives at the EU level concerning soil sealing, there are relevant policies, strategies and actions that affect soil sealing. For example, the work under the European Commission sustainable cities initiative might be considered an implicit response to the problem of soil sealing. Furthermore, some member countries have implemented policies and strategies designed to address soil degradation and sustainable land use, and some of these are likely to implicitly address soil sealing.

The development of spatial indicators, and the use of maps for reporting and assessment of soil sealing, is considered a powerful way of communicating to policy-makers, and should be part of the indicator tools used by the EEA. There continues, though, to be a shortage of comparable and contemporary data at the European level.

Possible data sources are European databases (i.e. GISCO, Corine land cover, Eurostat statistical databases, Lacoast, Murbandy/Moland databases) on the one hand and data which needs to be directly collected from the member countries on the other hand.

It is likely that only some of the countries will be able to provide complete data sets, whereas others will only be able to provide incomplete data sets. In these cases, estimates and modelled data will be used to fill the gaps (JRC-SAI has developed a

([1]) The JRC has recently carried out a major reorganisation of its institutes. The JRC activities mentioned in this report are now undertaken by the Institute for Environment and Sustainability (IES).

model under the Murbandy project that estimates land-use change based on future scenarios). Estimates or modelled data can also be based on expert judgement.

During the workshop the participants split into two groups to identify policy issues and questions associated with soil sealing. Having agreed on these, sets of indicators were proposed and appropriate data sets identified that could be used to assess progress in policy impact. The results of the working groups are captured in Table 1 on page 8.

Table 1. **Tentative list of feasible indicators according to the DPSIR framework**

DPSIR element	Indicator description	Data sources
Driving forces	Population density; population density per urban area (physical area as opposed to administrative area)	Existing information from European statistical databases; commercially available datasets (e.g. road networks); supplemented by questionnaire
	Master plans; suitability maps; land-use maps	
	Policies in place to address soil sealing or to encourage it	
Pressures	GVA/geographical unit	Eurobarometer
	Public perception	Corine land cover; Murbandy/Moland databases
	Increase of decrease in urban sprawl	
State/impacts	Rate of increase/decrease in artificial areas; type of land use/soil type lost; fragmentation of habitat/protected area/land use due to urbanisation or transport infrastructure; green or free space not fragmented; ratio of sealed to unsealed area	Data requests at regional basis Estimates and modelled data for data gaps
Responses	Change in building land prices	
	Policy objectives; legislation; economic and financial instruments in place to address soil sealing	
	Public perception of the problem	

Until there is a more explicit EU policy covering soil protection, it will be challenging for the EEA to identity policy-relevant indicators. Nonetheless, there are policies that are implicitly linked to soil sealing (positive and negative) and the EEA should use these to guide it in the development of indicators. Some suggestions were made at the workshop, addressing the question of what we are trying to measure, and why. The DPSIR and the multi-function/multi-impact (MF/MI) approach are useful tools for constructing a framework around which indicators can be identified (EEA, 1999a). In essence, the overall objective of the EEA could be to provide signals to policy-makers that highlight the loss of soil functionality due to soil sealing. In particular, there is a need to identify where 'hot spots' of soil sealing are occurring and, in particular, whether there is a transnational impact on the environment that requires a European Community response.

The workshop also highlighted the paucity of data at the EU level that can be used to assess soil sealing and its impact on the environment. There is a potential role here for the EEA, via the ETC/TE and Eionet, to promote further research to develop improved data sets and identify the causal relationships described in the DPSIR framework.

1. Introduction

1.1. Background

The overall objective of the European Environment Agency (EEA) is 'to provide the Community and its Member States with objective, reliable and comparable information at European level enabling them to take the requisite measures to protect the environment, to assess the results of such measures and to ensure that the public is properly informed about the state of the environment'.

The main tasks of the EEA include:

- to report on the state, trends and outlook of Europe's environment;
- to establish, develop and make use of the European environmental informa tion and observation network (EIONET);
- to facilitate access to data and informa tion supplied to, maintained and emanating from the EEA and EIONET, together with access to other relevant environmental information developed by other national and international sources.

The role of the EEA, as defined by its mission and mandate, is to provide policy-makers and the public with quality information, and to do so through a range of products and services. The agency works as a facilitator or bridge between member countries, EU institutions and other environmental organisations and programmes to bring together, use, make available and thereby improve the quality of information on the environment relevant at the European level for policy-making and assessment.

This is done through basic activities, including: support to national monitoring; the gathering and storage of existing information and currently-accessible and reliable data; the analysis and assessment of data to produce policy-relevant information and indicators; the reporting of results to policy-makers; and the dissemination of information to the general public (Envision model, monitor to reporting — MDIAR— core activities) (Gentile, 1999).

The European Topic Centre on Soil (ETC/S) was established by the EEA in 1996. It had the objective of providing and developing information and data on soil aspects, covering all EEA member countries, in order to increase the understanding of soil as a natural resource, document soil degradation processes and improve the level of reliable and comparable information about contaminated sites, thus contributing to the development of the EEA work programme.

The ETC/S operated until December 1999. A new Topic Centre on Terrestrial Environment (ETC/TE) started operations in July 2001. The ETC/TE is carrying out the work initiated by the ETC/S on soil, land cover and the marine and coastal environment (terrestrial part of coastal environment).

1.2. The context of the soil sealing workshop

In 2000, the EEA established a working group on soil contamination (by local and diffuse sources), with the objective of making progress in the development of indicators for soil contamination in the interim period before the ETC/TE was started. The results of the work were discussed at the EIONET workshop that took place in Vienna in January 2001 (EEA, 2002).

As a complimentary activity, the EEA carried out a peer review of recent work on soil, with particular reference to the development of policy-relevant indicators and the identification of probable problem areas for soil degradation (the so-called 'hot spots'). The review is focused on work on soil erosion and soil sealing.

In order to facilitate the contribution of external experts and produce recommendations for further work, the EEA organised two workshops on the assessment and reporting of soil erosion

and soil sealing, respectively. The workshops took place in Copenhagen in March 2001, and this report is the proceedings and recommendations arising from the soil sealing workshop. The purpose of the workshop was to identify a set of recommendations concerning reporting on soil sealing (as part of the wider theme of soil degradation), that could then be considered for inclusion in the work programme for the new ETC/ terrestrial environment.

The objective of the soil sealing workshop was to technically review the work to date by the EEA (including the ETC/soil) concerning the loss of the soil resource due to urbanisation and transport infrastructure, i.e. soil sealing.

1.3. Enabling the process

A background report was prepared summarising the main results from EEA recent work on indicators for soil sealing and relevant hot spots work. The report presents the major problems/drawbacks and issues to be considered, and proposes a series of options for future development (see Annex D).

Besides the background report, and in order to facilitate experts' access to these results and the underlying data, a GIS application based on ESRI freeware was produced, which included digital projects of the three soil hot spot themes (soil sealing, soil erosion and soil contamination) and with support files documenting methodology and data sources (EEA, 2001).

The CD-ROM application and associated reports provide a good overview of the work to date by the EEA. It was against this that the workshop took place. A synopsis of the EEA approach to the assessment and monitoring of soil is included below.

1.4. European framework for the assessment and monitoring of soil

Indicators have increasingly been used at EU level (integration) and in countries (headlines, sustainable development) as tools to get across key messages to policy-makers and others interested in environmental policy developments. The EEA has chosen an indicator approach for its environmental reporting, since it facilitates the process of transforming data into suitable information.

The EEA has defined tools to support the development of indicators, including the DPSIR (driving forces, pressures, state, impact and responses) assessment framework and a typology of environmental indicators, which classifies indicators into four simple groups (descriptive, performance, ecoefficiency and overall welfare indicators).

A conceptual framework for the assessment of condition of soils and its multiple effects on the environment has been presented in the report *Environment in the European Union at the turn of the century*. This includes the DPSIR framework applied to soil and the multi-function/multi-impact approach, based on the concept of multiple soil functions (ecological and socioeconomic) and competition between these functions. This conceptual framework and approach represent the basis for a quantitative assessment of the condition of soils.

In order to implement these concepts, the EEA, together with its EIONET partners, is building an operational framework 'from national monitoring to European reporting'. The purpose of this framework is to provide policy-relevant information on soil, making use of existing activities and capabilities within member countries, including monitoring, data collection and storage.

The development of the framework started in 1999 (work on indicators on contaminated sites had started in 1996), with the preparation of a tentative list of policy-relevant indicators, the assessment of data needs and data gaps and the development of a restricted number of indicators on local contamination, soil erosion and soil sealing. Work included the organisation of an ongoing data collection and update, and the setting-up of a data flow between the national level and the European level, using Internet tools.

The EEA, with the support of the ETC/soil, organised a workshop in Vienna on 12 to 14 October 1999. A proposal for a common framework for the assessment and monitoring of soil in Europe was presented, with the aim of attaining a common understanding and agreement on the way of proceeding towards the development of policy-relevant indicators on soil.

The proposal contained an initial list of indicators to support soil protection policies across the environmental spectrum. Furthermore, it set out a basic set of soil data that should be considered for monitoring at the European level, in order to feed these indicators.

Representatives from 13 EEA countries and the JRC participated in the workshop. The participants recognised the importance of developing the proposed framework and in principle said they would support such a development, although they underlined the need to provide adequate funding of national activities. It was agreed to proceed with the work on soil, and to develop indicators in four priority areas: soil sealing, soil erosion, diffuse and local contamination.

1.5. The EEA concept of soil

In order to provide some context to this workshop report, reference is made here to the EEA concept of soil, and this is more fully elucidated in the EEA/UNEP joint message *Down to earth: soil degradation and sustainable development in Europe* (EEA, 2000a). The EEA has developed a comprehensive approach to soil and the environment, where soil is considered to have a fundamental role in the environment, because it performs multiple ecological and economic functions. Soils are one of the fundamental systems for agricultural food production, life and the environment, and therefore their functions and quality must be maintained in a sustainable condition.

1.6. The EEA definition of soil

Soil is a three-dimensional body performing a wide range of socioeconomic and ecological functions. It is a complex media formed by a porous matrix, in which air, water and biota occur together with the fluxes of substances and fluids between these elements. Alteration of soil processes leads to changes in the functioning of ecosystems, and many environmental problems which become apparent in other media actually originate within the soil (for further details on soil functions see the chapter on soil degradation in the reports (EEA, 1999a; EEA, 2000a).

1.7. Soil sealing — what do we mean?

The term soil sealing has been interpreted in different ways. A common use of the term soil sealing refers to changing the nature of the soil such that it behaves as an impermeable medium (for example, compaction by agricultural machinery). Soil sealing is also used to describe the covering or **sealing of** the soil surface by impervious materials by, for example, concrete, metal, glass, tarmac and plastic.

The EEA has defined soil sealing as the covering of soil due to urbanisation and infrastructure construction, such that soil is no longer able to perform the range of functions associated with it. Soil sealing is not adverse *per se*, rather it is the irreversibility in practical terms of sealing the soil and the consequent loss of soil functions. A discussion of the EEA approach and definitions of soil sealing and related terms is reported in Appendix C.

Soil multi-functionality should be considered in its environmental, social, economic and time dimensions. Some soil functions are mutually exclusive and are often in competition (for example, soil used for waste treatment in a landfill cannot be used for food production). This competition between functions may lead to an unbalanced use of soil resources and finally to soil degradation (EEA, 1999a; EEA, 2000a). In particular, the major issue at the moment (and in the foreseeable future) in Europe, and in most industrialised countries, is represented by the continuous increase of built-up areas. This usually leads to irreversible losses of soil resources (soil sealing), which means that the soil cannot perform a wider range

of functions. Moreover, soil issues are complicated by the fact that most soils are under private ownership and those private interests can often conflict with national public interests (EEA, 2001c).

The 'Down to earth' report (EEA, 2000b) describes many of these issues. The working paper 'Short review of the EEA work on assessment and reporting on soil sealing' prepared for this workshop also elaborates on the issues associated with soil sealing. A summary of the paper is provided in Annex D.

1.8. Past achievements

A variety of activities related to soil sealing preceded the workshop and were used as a basis for the discussion.

1. Joint EEA/UNEP publication *Down to earth: soil degradation and sustainable development in Europe.*
2. Analysis and mapping of soil problem areas (hot spots) in Europe. Final report to EEA, prepared by Turner, S., Lyons, H. and Favis-Mortlock, D. In *Where are the 'hot spots' of soil degradation in Europe?*, CD-ROM distributed to EIONET for review. European Environ ment Agency.
3. A review of soil issues in central and eastern Europe, including soil sealing, undertaken by Ruben Mnatsakanian on behalf of the EEA.
4. EEA publications, such as the chapters on soil degradation in the EEA report *Europe's environment: the second assessment*, published in 1998, and *Environment in the European Union at the turn of the century*, published in 1999.
5. Contribution to the *Proposal for a European soil monitoring and assessment framework*, including a list of relevant indicators for soil sealing.

1.9. Expectations

The general expectations of the EEA were to help in the review of work on soil indicators and to obtain some practical advice on how to carry this work forward. In particular, the workshop should provide advice on how to proceed with the establishment of a monitoring and assessment framework for soil sealing and the development of policy-relevant indicators. The development of such a framework is an integral part of the wider European framework for the monitoring and assessment of soil.

Expectations from those presenting were to ascertain the extent to which monitoring of soil sealing is undertaken by the member countries. In addition, since the JRC has developed a number of databases and techniques that may support soil sealing monitoring and assessment, their relevance to EEA soil sealing monitoring was also assessed. The workshop therefore provided an opportunity to gauge the scope for comparing national data, to define key data sets for future data collections, and to indicate whether these data can be used to set up models or estimation schemes.

1.10. Scope of workshop report

This report sets out the key points arising from the workshop. It does not include the presentations in detail.

The report sets out a number of recommendations for the EEA concerning the development of soil sealing indicators, and identifies links to relevant work undertaken with the support of ETC/S and ongoing work by the European Commission.

The report also includes the results of the EIONET review of the EEA 'hot spot' work, undertaken in the first half on 2001 (see Annex E).

2. Workshop minutes

The workshop was preceded by a report summarising the work to date by the EEA on soil sealing (see Annex D).

An application was also produced, distributed on CD-ROM (EEA, 2001), to allow interactive query of the spatial data used to identify soil sealing (as well as soil erosion and soil contamination) hot spots. The application included a GIS browser and associated reports and documents describing the methodology and data used. The CD-ROM was distributed to all relevant Eionet ([2]) members during March 2001, namely the EEA national focal points and their nominated national soil sealing experts, and the participants of the soil sealing workshop.

The workshop was opened by Anna-Rita Gentile, who coordinates the EEA work on soil. The workshop was chaired by Simon Turner, who has supported the EEA in the geographical analyses and mapping of hot spots of soil degradation in Europe.

The morning session of the workshop focused on presentations from the EEA, the former ETC/S and consultants who undertook the work on soil hot spots. The afternoon session was dedicated to presentations from the JRC and selected member countries undertaking work on soil sealing.

The morning of the second day of the workshop was based on a brainstorming approach to identify indicators that the EEA may wish to develop for reporting on soil sealing. The full workshop agenda can be found in Annex A.

2.1. Soil sealing — background, overview and policy

The first presentation was given by Anna-Rita Gentile, explaining the EEA approach with regard to indicator-based reporting, in particular addressing the following issues:

- the EEA mandate;
- the EEA monitoring and assessment framework for soil;
- the EEA reporting context and EEA reporting activities;
- the DPSIR assessment framework applied to soil and the soil multi function/multi-impact approach;
- required indicators for soil sealing; and
- a summary of the assessment by the EEA of soil sealing.

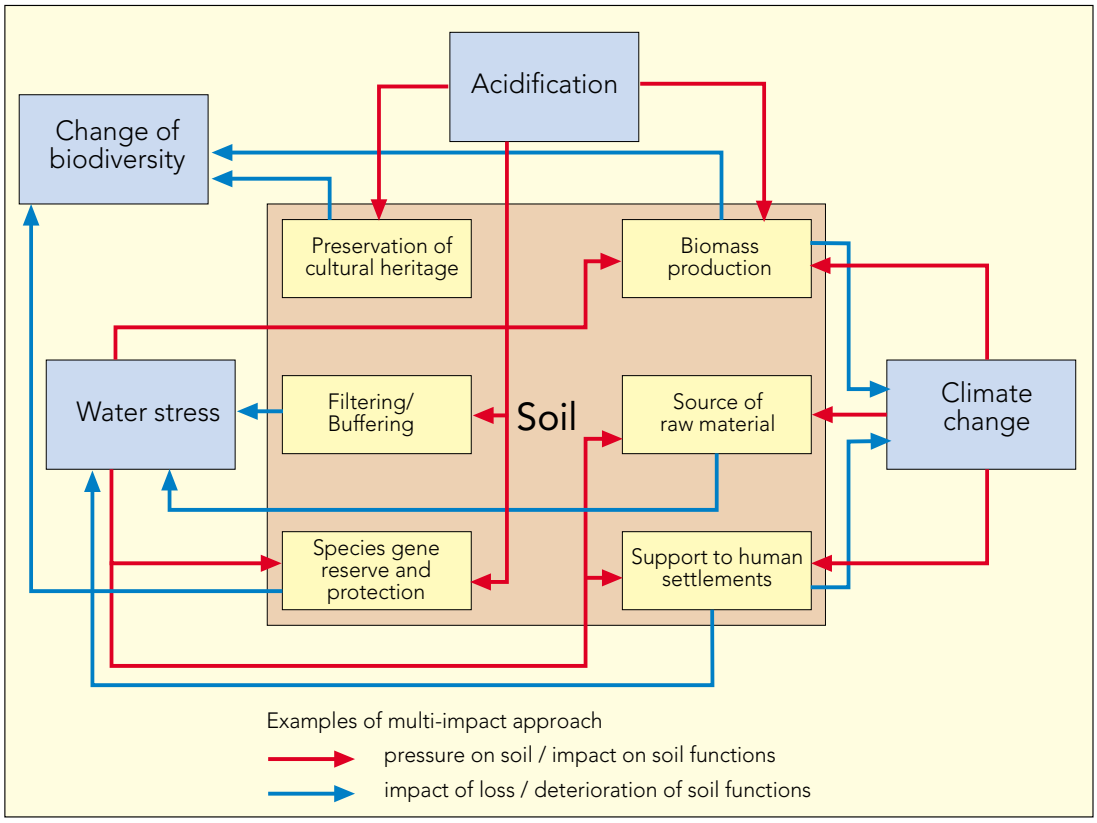
Soil is important not only in its own right, but it has links and impacts to other environmental compartments (air, water) and environmental issues (climate change, water stress). In order to show how the degradation of soil affects the environment and has impact on other environmental compartments, the EEA has developed a multi-function/multi-impact (MF/MI) approach (see EEA, 1999a), which identifies other, closely-interrelated key environmental issues with soil (Figure 1), such as:

- acidification: particularly affecting sensitive, poorly buffered soils;
- biodiversity: including gene reserves and protection, biomass production, protection of the landscape;
- climate change: leading to soil degra dation, but climate change is also influenced by soils and vegetation;
- dispersion of hazardous substances, due to run-off and/or leaching;
- water stress: soil has a filtering/ buffering capacity;
- soil erosion provokes off-site effects and can influence the material balance in coastal areas.

([2]) EIONET — the European environment information and observation network (EIONET), joins and builds on capacities of EEA member countries.

Figure 1. **The EEA multi-function/multi-impact model for soil (examples)**

Source: EEA



The EEA has adopted an indicator approach to reporting on the environment to make best use of limited resources available at the European and national level. Furthermore, such an approach, within the context of the DPSIR framework, described below, enables a linkage between environmental issues and socioeconomic aspects.

Indicators can either be a single measurement, or an aggregation of several measurements that provide information about a subject. Aggregated indicators have the advantage of simplifying and structuring the final data set, because they will contain fewer, more comprehensive data. The EEA has developed an iterative process for the development of indicators, the initial selection being based on the EEA modified framework for the assessment of environmental problems, DPSIR. The iterative process includes screening and review of DPSIR as applied to soil sealing in this case (Figure 2). Having developed a 'long' list of indicators a list of 'priority' indicators is then selected, based on their policy relevance and data availability.

To be of practical use, soil indicators must fulfil three basic requirements:

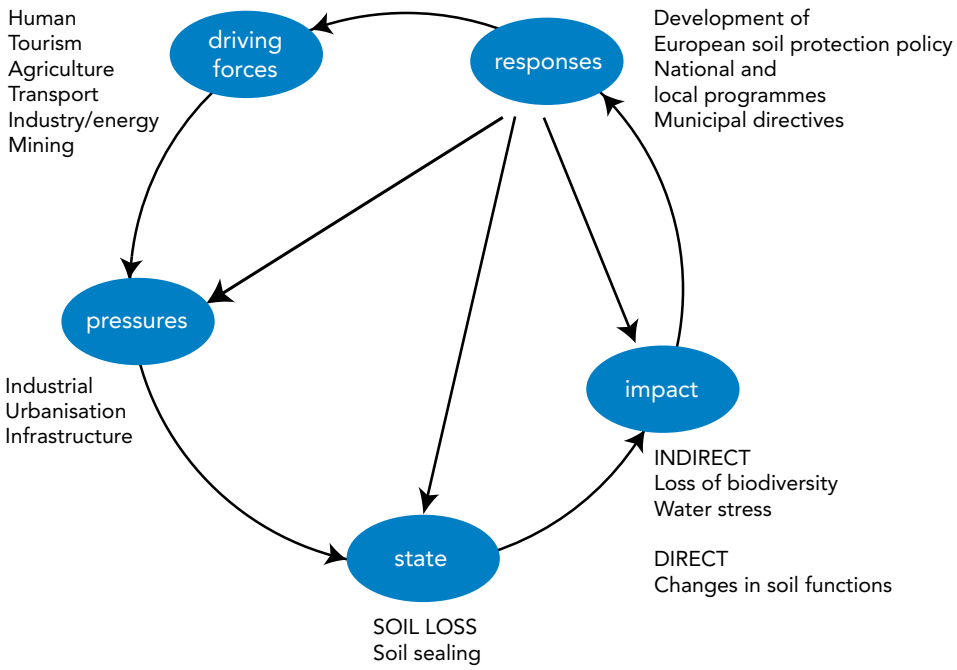
- sensitivity to management and abity to respond to changes in a relatively short time;
- accessibility, i.e. measurement method ologies or data sets must be easily available;
- if not directly measurable, it must be possible to define them using pedo-transfer functions or models.

The second presentation was given by Simon Turner, who summarised the key areas of work undertaken by the EEA on soil sealing. The following topics were explained.

- The EEA DPSIR indicator approach applied to soil; namely the DPSIR approach referring to the driving forces, pressures, state, impacts and responses related to the soil environ ment. Furthermore the EEA indicator typology, which is based on descriptive indicators (type A), performance indicators (type B), efficiency

indicators (type C), and total welfare indicators (type D) (EEA, 1999c).
- A first tentative list of draft indicators prepared by ETC/S (EEA, 2001b). For each indicator a reference to the addressed DPSIR element and to the type of indicator was given.
- The lack of a legal framework addressing soil protection including soil sealing problems at EU level and the resulting challenge to establish a framework for data collection and assessment, and in particular the development of type B and C indicators.

DPSIR framework for soil sealing Figure 2.



Source: EEA

The third presentation was given by Liz Mills, a member of the Working Group on Sustainable Land Use that is steered by Environment DG's Expert Group on the Urban Environment. The presentation gave an overview of existing policies and policies in the pipeline which, although they have no explicit remit to protect the soil resource, nonetheless will influence soil sealing. In addition, the presentation referred to the draft copy of the final report of the Working Group on Sustainable Land Use. The report, available on the web site of the European sustainable cities and towns campaign (http://www.sustainable-cities.org) summarises the activities of this working group and reviews the current EU policy context and relevant EC-level instruments helping or hindering prevention of urban sprawl and reuse of brownfield land.

Key points

The key points arising from these presentations and the discussion that followed are summarised below.

- Soil sealing is an important issue and a number of initiatives are in place at the national level that provide an estimate of the loss of soil.
- Some of these initiatives are at an early stage of development and do not pro vide a common overview at the European level.
- The scope to improve the reporting process at this level is significant.
- However, there is some ambiguity over what is meant by soil sealing and this may hinder the development of soil sealing indicators.
- An extended Corine land-cover typology could be adopted (i.e. 'artificial areas'). Artificial areas

are further subdivided in Corine LC so there would be sufficient scope to focus on particular elements (pres sures/states) giving rise to the loss of the soil resource to soil sealing. For example, under Corine LC nomencla ture level 2, land-cover classes include mines, construction, industrial, com mercial and transport units. These land-use categories could be explicitly adopted by the EEA to describe soil sealing. In this way the EEA will estab-lish a *de facto* standard that member countries could adopt to assess soil-sealing statistics. This would enable comparison of different national data, which is not often feasible, since differ-ent definitions and standards are used. The problem with national data on land-use statistics is that there are different definitions, so that the data are not directly and fully comparable. The EEA contribution should go towards making national data more comparable at the European level.

- The use of proxy indicators may not be relevant in some instances since they do not distinguish between sealed and non-sealed soils within cities (for example, pavements: some pedestrian pavements may be permeable and therefore 'semi-sealed'). Again, this supports the point that a clear set of definitions and standards need to be established and articulated to those collecting and analysing data to ensure comparisons can be made.
- What is the issue that needs to be addressed? Is it really soil sealing or something like 'urban growth management'? The wider policy con text needs to be addressed rather than the specificity of soil *per se* (the EEA multi-functional/multi-impact concept of soils helps in identifying some of the wider policy issues, and highlights the goal of developing a set of multi-purpose indicators).
- For example, there are several relevant policy areas, such as environmental protection, land use/spatial planning and urban regeneration.
- A more integrated approach is needed so that soil protection issues need to connect with urban and land policies.
- This raises the question as to whether the EEA monitoring and reporting, and consequently indicator development, should focus more on urban and land policy development, which will directly influence (negatively or positively) soil sealing.

In summary, the EEA has to address two parts of a complex process. Firstly, the loss of soil *per se*, and many of the functions it performs due to sealing, and, secondly, the force behind this, the competition for scarce land and frequent poor urban growth management. The risk of broadening the scope of the policy being addressed — such as environmental protection, land use/spatial planning and urban regeneration, rather than focusing on soil *per se* — is that the message the EEA wishes to put across becomes confused. There is a need, therefore, to ensure that these cross-policy issues do not get ignored when developing indicators for soil sealing, but at the same time clear distinction is made as to what part of the DPSIR framework these indicators are addressing.

Confounding this, is the lack of comparable land-use statistics, with the exception of Corine LC.

2.2. Soil sealing — indicators

Olaf Duwel, of the German Federal Institute for Geosciences and Natural Resources (BGR), presented a summary of work undertaken by the ECT/S in the development of soil sealing indicators.

- In line with EEA guidelines, the former ETC/S adopted a short and long-term approach to developing indicators for soil sealing, for which a range of indicators were proposed (see Annex D).
- Most of these indicators focus on pressures and states and are largely type 'A' indicators (i.e. descriptive) so that there is some scope for the EEA and ETC/TE to consider the development of type B and C indicators.
- Consideration was given to the development of indicators using land-cover data (e.g. Corine land-cover database), although there are problems associated with this including scale (low resolution: minimum mapping unit of 25 ha for polygons and 100 m width for linear features;

lack of time-series: Corine LC is only updated every 10 years and therefore would not provide a regular update).

The final presentation of the morning was given by Hester Lyons of ADAS, who was responsible for the geographical analyses and mapping of soil degradation hot spots in Europe (see EEA, 2001). This presentation focused on spatial data that could be used to identify soil-sealing hot spots.

- The use of spatial indicators (hotspots) is considered highly relevant for policy-makers.
- However, there is considerable scope for the wrong signal to be sent, since the representation of maps at such a small scale, whilst maintaining scientific credibility, remains a challenge. Nonetheless, this is an area of work that should be further developed by the EEA.
- New technologies such as embedding GIS functionality in web browsers presents new opportunities for the EEA to inform policy-makers and to disseminate spatial indicators in a more meaningful way.
- A significant constraint at the moment, though, is the lack of availability of spatial data and comparability at the EU level.

Key points
The key points arising from the discussion following these presentations is summarised below.

- There is a need to identify a clear objective/policy issue concerning soil sealing. This will help identify the indicator(s) required then to monitor and report on that issue.
- A headline indicator is desirable since it could summarise a large number of issues. However, it was felt that more detailed, specific indicators, would also be a requirement of policy-makers. Within this context, a headline indicator means information or data that describes a broad set of issues and could be supplemented by sub-indicators that add detail or explanation to the message given by the headline indicator.
- The (hot spots) maps were deemed very useful for policy-makers particularly in terms of conveying a message and where the problems were occurring.
- Technical issues such as scale, representation and significance were discussed — no clear guidelines were identified other then careful thought needed to be given concerning producing a map(s) that gave the right message.

Interestingly, feedback from Finland indicated how the maps had 'forced' policy-makers to consider whether the problem of soil sealing was significant — the perception was that it was not (low population density, few large cities, etc). However, on reflection, Helsinki is a 'sprawling' city ('one of the worst in Europe') and consequently the Finnish Government is considering putting in place a research programme to address the issue.

2.3. Soil sealing — monitoring and assessment

Luca Demicheli of the JRC (Space Applications Institute) gave the first afternoon session. The presentation summarised the project of Lacoast and then focused in more detail on the Murbandy/Moland projects. The Murbandy/Moland project aims at measuring progress towards sustainability in urban and regional areas. Both projects have investigated the use of remotely sensed and historical data (a range of about 50 years is considered) integrated in a GIS to derive land-cover and use-change statistics. The EEA has already made use of this type of information in reporting on soil sealing.

- The Lacoast (monitoring land-use change in coastal areas) and Murbandy/Moland databases could be used to derive soil sealing indicators.
- The methodologies developed also demonstrate the utility of such data sources and technologies for monitoring soil sealing. The EEA, however, would need to assess the costs involved in maintaining such a database.
- The Murbandy/Moland project already includes 30 areas spread across Europe, including central and eastern Europe. However, the sample is not yet

considered representative of 'Europe' although it does serve to indicate the types and rates of land-use change.

Key points

- Policy-makers are most likely to be interested in the rate of land-use change rather than whether soil has been sealed *per se* and on the type of land that has been changed.
- The Lacoast and Murbandy databases can provide these estimates and illustrate that the rate of change is occurring quickly.
- The EEA must consider the scale at which they wish to report on soil sealing. What is of interest to the policy-maker? (i.e. at the regional level the 'quality' of life is of interest; at the local level sprawl may be good for the individual as they may be close to green space).
- The projects demonstrate that whilst monitoring soil sealing at the European level is not feasible, a representative sample is a way of getting around the problem (although currently neither project is deemed to have a representative sample for Europe). Nonetheless, the databases would provide the EEA with useful case studies that could be used as part of the package of tools for indicator reporting.

2.4. Monitoring soil sealing — Member State examples

Three presentations were given that describe the work of member countries in assessing land-use change and in developing indicators to assess soil sealing (to be consistent the presentation for Spain, given on Tuesday morning, is also described here).

Italy

Pierpaolo Napolitano from the National Institute of Statistics (ISTAT) gave this presentation. The main points are summarised below.

- There is a lack of statistical data on land use and cover in Italy and this is confounded by the autonomous nature of the regions.
- A harmonised, multi-purpose database of land use and cover would address these issues, facilitating land-use change analyses and the development of indicators, for example, to assess soil sealing.
- A database was constructed, based on the Corine typology, using remotely sensed data and allied information. The database, for the Tuscany region, was then applied to derive environmental statistics. Problems arising included what thresholds to set between continuous and discontinuous urban fabric (different thresholds gave different results).

Germany

Fabian Dorsch of the Federal Office for Building and Regional Planning gave a presentation of soil sealing issues in Germany and the development of indicators to monitor the loss of the soil resource. The main points are summarised below.

- Soil sealing is related to land consumption and is an important issue in Germany.
- There is a national monitoring programme for land-use statistics (property land register/surveying). This data can be used to estimation rates of soil sealing: 15 m^2 per second is new urban fabric, about 7 m^2 of which is sealed.
- A total of 87 % of Germany is unbuilt but highly fragmented, due to a highly dispersed urban and transport infrastructure.
- Sprawl is promoted by cheap building land prices, land speculation and subsidies on 'green' land rather than on brownfield, but induces increasing costs for traffic and infrastructure.
- A total of 6 % of the Federal area is 'sealed'. There is a de-sealing potential of far less than 10 %; but an increasing potential for recycling of derelict land to reduce land consumption.

United Kingdom

Andrew Harrison, consultant to the Department of Environment, Transport and the Regions (DETR) working with the development of a national land-use database (NLUD), gave an overview of how land-use statistics could be used to derive soil-sealing estimates.

- NLUD will provide an important source for deriving environmental statistics including proxy indicators for soil sealing.
- National land-use statistics for the UK show that there has been a reduction in the loss of greenfield areas, but that the extent of agricultural land encroaching on semi-natural areas has increased. The net effect therefore is that semi-natural areas have declined, agricultural area has stayed the same and built up areas has increased. The amount of soil sealed therefore has increased.
- The development of NLUD is based on existing data and a government vision addressing 'joined-up government', a modernising agenda and sustainability. The development of NLUD is facilitated by the private sector.

Spain

Inés Iribarren Campaña of the Spanish Ministry of Environment described the increasing emphasis placed on soil sealing and how this is gaining status compared to more traditional soil degradation problems.

- Soil erosion, contamination and desertification have been the principal soil focus for the Spanish Ministry of Environment, but soil sealing is now recognised as an important issue.
- In fact, an indicator for soil sealing has been included in the Spanish proposal of environmental indicators for the area of soils, discussed in February 2001. This indicator, changes in land use, refers to the surface of agricultural land (traditional or intensive), scrub or woodland that is transformed into built land (urban, industrial and infrastructures).
- However, there is a lack of a uniform methodology to collect and treat basic information about soil sealing.

Key points

A number of points arose from these presentations that, by and large, are common to them all, and for this reason have been grouped together here to facilitate comparison.

- It is important to enhance comparability of data on a European scale.
- Problems resulting from soil sealing through urban sprawl, are mainly loss of soil functions, land dissection (i.e. land fragmentation, the process by which a type of land use becomes more heterogeneous within a landscape element) and derelict core/inner cities.
- In developing indicators for soil sealing, it is very important to identify the objectives first that are to be addressed (i.e. what do we want to achieve, a reduction of soil lost, an increase in the use of brownfield sites for development etc.?).
- In developing performance (type B) and efficiency (type C) indicators for soil sealing, it is very important to identify objectives first. This is because B indicators are linked to a reference value and C indicators are linked to production and consumption processes, requiring a baseline or target against which the indicators can be compared.
- Since soil is multi-functional, and the effects of soil sealing are diverse, a broad policy-mix is required to address the many issues associated with soil sealing, as captured in the earlier DPSIR diagram. A broad policy-mix could include efficient use of regulatory provisions, strengthening of regions as a level of competence, orientation of economic instruments like taxes, funds and subsidies towards land-saving, and development of public awareness.
- The reduction of land consumption and increasing GVA per sealed geographical unit could be considered as core indicators, and this would indicate an increasing return of productivity per area of land and a reduction in sprawl.
- There are a number of different approaches to measuring/quantifying urban sprawl which will lead to different results. For example, land consumption in urban areas would indicate change of land use and by definition loss of soil (although not all functions of the soil may be lost); increase in the network of roads would indicate increased land fragmentation, loss of soil and increased run-off of water.
- Using the Corine land-cover database would mean underestimating the

extent of the problem, since areas less than 25 ha in extent, and linear features less than 100 m wide, were not mapped. The nomenclature used in Corine LC was felt to be adequate to describe soil sealing.

- It would be important to define what is meant by agricultural and urban land (although the Corine land-cover typology could be used for this). Some agricultural land is not always desirable whilst some urban land is, and this could also determine, to some extent, how the extent of soil sealed is assessed. That is, some low-quality agricultural land may be lost to soil sealing, but because it is poor-quality land, the loss of the associated soil may not be considered and therefore not reported. Conversely, some urban land-use types may be considered desirable and the loss of soil due to this development may not be reported. The point is that a standard in reporting soil sealing needs to be established and rigorously applied to allow inter- com parisons of member counties' data and information when reporting on soil lost to soil sealing.
- In Austria, the calculations of percent increase in soil sealed exclude mountain and forest areas.
- Data provision is very much dependant on local authorities. In the UK, for example, software has been provided to local authorities to enable the process of data capture and maintenance.

2.5. Alternative aspects of soil sealing and data availability

Bob Jones, of the JRC Environment Institute (European Soil Bureau) gave the final afternoon presentation and outlined the available data concerning soils and held on behalf of countries by the JRC. An additional aspect of soil sealing due to compaction of soil surfaces by agricultural machinery was also presented.

- There are clearly two definitions of 'soil sealing': (a) 'covering (sealing) the soil surface by impervious materials (e.g. concrete, metal, glass, tarmac and plastic)'; (b) 'changing the nature of the soil such that it behaves as an impermeable medium (e.g. compaction)'.
- The first definition was adopted for the most recent OECD work on soil-quality indicators, the second is proposed here, as an extension, to fully take account of the effect of agriculture.
- Changing the nature of the soil such that it behaves as an impermeable medium (definition b) is an extension to include the potential effects of the passage of machinery (mostly agricultural) and the effects of heavy rainfall.
- The overall deterioration in soil struc ture that may result from subsoil compaction can also: (a) increase lateral seepage of excess water over and through the soil, accelerating potential pollution; (b) decrease the volume of the soil system available to act as a buffer and a filter for pollutants; (c) increase the risk of soil erosion and associated phosphorus losses on slopes; (d) accelerate effective run-off from and within catchments; (e) increase greenhouse gas production and nitrogen losses.
- Subsoil compaction probably affects a larger area in Europe than urbanisation (land consumption). In this respect it must be included as a process of soil sealing.
- Surface crusting is the most ephemeral and easily alleviated form of soil sealing but, because it can increase flood risk and cause soil erosion, it should also be included in the 'debate' on soil sealing.
- The main aspect of sealing is the complete covering of soil by other materials and structures such as tarmac, concrete, buildings, etc. This process is sometimes called 'land consumption'.
- To some extent, the status of soil sealed is well covered and it should be possible to identify the trends (Lacoast, Murbandy and national studies).
- However, the causes (drivers and pressures) and responses are probably less well understood. A more holistic approach to assessing soil sealing would be useful taking into account the effects of pollution and erosion.

Finally, the EEA must consider the objectives it is seeking to address in reporting on soil sealing:

- minimising sealing/consumption;
- stopping it;
- redirecting sealing e.g. restricting loss of 'best' agricultural land;
- alleviating or mitigating the problem.

These issues are reflected in the DPSIR framework and MF/MI model. However, the definition of policy objectives is not in the EEA mandate.

2.6. What policy-makers require from soil sealing indicators

The final presentation, by Judith Lowe, considered the needs of the policy-maker, and set the scene for the discussion and debate concerning the development of soil-sealing indicators. The presentation considered the following points.

- It may be useful to consider what policy-makers may want to know concerning soil sealing — this is particularly so since there are few principal policies concerning soil protection at the EU level.
- Spatial data (maps) are important for communicating the message.
- We need to be careful in our selection of indicators and the questions that we want answered since they will determine the message (signal) received.

3. Indicator development

The final sessions of the workshop on the second day focused on developing a set of indicators for soil sealing based on the experts' opinion and the presentations given earlier.

3.1. Approach

The workshop split into two groups to address and report back on the following.

1. What policy issues/objectives are relevant or in the pipeline concerning soil sealing?
2. What questions need to be framed to address these issues?
3. What indicators (using DPSIR) can be used to answer these questions?
4. For each indicator, what data is needed and what is available?

An approach, adopted from the EEA, was followed that set out to identify the policy issue(s) or objective(s) that the EEA needed to address when reporting on soil sealing. Having identified the policy issue(s) it is then possible to set about defining a set of indicators to report on these issue(s). Within this framework, consideration was also given to the previous work done by the EEA and the indicators that they had proposed.

The results of these two groups is summarised below and presented on the basis of the questions outlined above.

3.2. Policy issues

The two groups identified a number of policy issues, from which it was possible to group these into four 'headline' issues (listed below).

1. The management of urban sprawl

Related policy issues include:
- loss of agricultural, natural and semi-natural and forestry land;
- greater use of brownfield sites for development;
- reduction of land consumption;
- rehabilitation of old buildings.

2. Enhancement of land and quality of life

Related policy issues include:
- land value;
- loss of soil function;
- rehabilitation of the natural and cultural landscape;
- de-sealing and introduction of water-permeable coats/surfaces;
- rehabilitation of soil functions.

3. Soil resource is limited and must be integrated with land-use planning

4. Increase the extent of permeable areas

Cross-cutting issues include the impact on the hydrological cycle (link with the ETC on water).

3.3. Policy-relevant questions and indicators

Having agreed on a set of 'headline' policy issues, the groups identified policy questions that the EEA would seek to address in order to assess and monitor soil sealing. For each policy question(s) an appropriate indicator(s) was identified (Table 2). The indicators, to some extent, reflect the data that is currently available (e.g. Corine land cover, GISCO, JRC Murbandy/Moland project, Eurostat statistics), and these datasets would provide a good regional assessment of the situation. The expert groups recognise that much of the data that could be used to monitor soil sealing is collected or maintained by local or regional government and, given the nature of the problem that is being assessed, it would provide a more detailed assessment. However, it is arguable that this is excessive detail that would not concern the EU policy-makers. Moreover, obtaining these data sets and ensuring comparability may not be feasible for the EEA. However, collecting detailed data sets may enable a number of case studies to be developed.

The case studies could serve to illustrate the point, such as, for example, the effects of localised urban sprawl due to poor urban management, or conversely a reduction in urban sprawl because of more efficient and effective planning processes.

The policy questions identified are those reflected by the workshop groups and may not necessarily reflect the headline issues associated with soil sealing as seen by the EEA. Interestingly though, some of the policy questions deemed important by the workshop are similar or reflect those used by the EEA. Clearly this is an area that requires further development and refinement in consultation with relevant EC directorate-generals and national focal points.

For completeness, the 'headline' indicators identified by the ETC/S are presented in Annex D, Table 5.

Policy issues, questions and indicators relevant to soil sealing Table 2.

Policy issue	Policy question	Indicator
The management of urban sprawl	(1) What is the rate of urban expansion? (a suitable timeframe and spatial scale need to be agreed)	(1) Rate of land-use change (increase or decrease in artificial areas)
	(2) What type of land is being lost or changed?	(2) Land-use-change statistics
Enhancement of land and quality of life	(1) Where is building land available? (data could be provided from 'master' plans, that is, plans compiled by responsible regional or local government authorities; suitability maps ([1]); land-use maps)	(1) Type of land available for building development
	(2) How have building-land prices changed?	(2) Expressed as euro/area (NUTS2) over time; rate of change
	(3) What is the productivity (GVA) of geographical units?	(3) GVA/geographical unit
	(4) What is the perception of the local environment (could be collected by Eurobarometer)?	(4) Quality of local environment (this is rather qualitative and would need to be developed)
	(5) What is the settlement density?	(5) Population/urban area (*not* administrative area)
	(6) What is the infrastructure density?	(6) Length of linear feature/geographical unit; fragmentation of specific land-use/protected areas; free space not fragmented
	(7) What is the ratio of sealed to unsealed soil?	(7) Ratio of sealed area to unsealed area
Soil resource is limited and must be integrated with land-use planning	(1) Is urban sprawl increasing? (2) Is there a policy objective? (3) Can we identify the urban area? (4) What are the competing land uses? (5) Is the public aware of the problem? (6) How fragmented are land areas?	The workgroup did not have time to identify suitable indicators associated with these policy issues and questions.
Increase in extent of permeable areas	(1) Is there a policy objective?	See above comment

([3]) Master plans and suitability maps would give an indication of a planning authority's intention to develop land that could give rise to soil lost as a consequence of soil sealing. It is the authors' opinion that this information would be difficult to acquire and may be at an inappropriate scale for EEA purposes. However, it may be worth following up to develop a set of case studies based on this information that illustrate the pressure on the soil.

4. Conclusions

4.1. Data availability

Possible data-sources are European statistical databases (i.e. GISCO, Corine land cover, Eurostat statistics, Lacoast, Murbandy/Moland database) on the one hand and data which need to be directly collected from the member countries on the other hand.

It is likely that only some of the regions will be able to provide complete data sets, whereas others will only be able to provide incomplete data sets. In these cases estimates and modelled data (JRC-SAI has developed a model under the Murbandy project that estimates land-use change based on future scenarios) will be used to fill the gaps. Estimates or modelled data can be based on expert judgement. Although these pan-European databases will contribute to the monitoring of soil sealing, there is still a need to identify new sources of data and information. There can be no doubt that at national level some countries collect useful statistics explicitly for reporting on soil sealing (e.g. Germany) and there is a need for the EEA to explore this in a more comprehensive manner. A more systematic approach to monitoring and reporting on soil is recognised by the EEA as reflected in its publication *Proposal for a European monitoring and assessment framework* (EEA, 2001b). The EEA must ensure that the recommendations from this workshop contribute to the development and implementation of this monitoring and assessment framework.

4.2. Policy objectives

Although there are no explicit policy objectives at the EU level concerning soil sealing, there are relevant policies, strategies and actions that affect soil sealing. For example, the work under the EC sustainable cities initiative might be considered an implicit response to the problem of soil sealing. Furthermore, some member countries have implemented policies and strategies designed to address soil degradation and sustainable land use, and some of these are likely to implicitly address soil sealing.

The EEA should undertake a comprehensive review of EU polices and strategies to assess their influence as a driving force or response (positive or negative) to soil sealing. Ideally, this assessment should also cover member countries, some of whom have already developed and published soil strategies.

4.3. Spatial indicators

The development of spatial indicators, and the use of maps for reporting and assessment of soil sealing is considered a powerful way of communicating to policy-makers, and should be part of the indicator tools used by the EEA. There continues, though, to be a shortage of comparable and contemporary data at the European level. The EEA should continue to work closely with the JRC in developing spatial databases that can be used as part of indicator reporting.

4.4. Development of policy-relevant indicators

Table 3 provides a tentative list of indicators and a list of possible data sources. Until there is a more explicit EU policy covering soil protection, it will be challenging for the EEA to identity policy-relevant indicators. Nonetheless, there are policies that are implicitly linked to soil sealing (positive and negative) and the EEA should use these to guide it in the development of indicators. Some suggestions were made at the workshop, addressing the question of what we are trying to measure, and why. The DPSIR and MF/MI approach are useful assessment tools for constructing a framework around which indicators can be identified and the workshop referred to these as part of the process of

identifying and developing indicators during the breakout sessions. In essence, the overall objective of the EEA could be to provide signals for policy-makers that lead to the reduction of land consumption and soil sealing, thereby enhancing living conditions in the existing built-up area.

Tentative list of feasible indicators according to the DPSIR framework Table 3.

DPSIR element	Indicator description	Data sources
Driving forces	• Population density; population density per urban area (physical area as opposed to administrative area) • Master plans; suitability maps; land-use maps • Policies in place to address soil sealing or to encourage it	• Existing information from European statistical databases; commercially available datasets (e.g. roadnetworks), supplemented by questionnaire
Pressures	• GVA/geographical unit • Public perception • Increase of decrease in urban sprawl	• Eurostat statistics • Eurobarometer • Corine land cover
State/impacts	• Rate of increase / decrease in artificial areas • Type of land use/soil type lost • Fragmentation of habitat/ protected area/land use due to urbanisation or transport infrastructure • Green or free space not fragmented • Ratio of sealed to unsealed area	• Corine land cover, Murbandy/Moland database • Corine land cover and JRC–ESB soil databases • Corine land cover, commercial road network and Natura 2000 databases • Regional or local databases • Regional of local databases
Responses	• Change in building land prices • Policy objectives, legislation • Economic and financial instruments in place to address soil sealing • Public perception of the problem	• Data requests at regional basis; • Introduction of new policies/ strategies/legislation • Regional data and EC data • Eurobarometer

4.5. The need for a conceptual framework and definitions

The DSPIR assessment framework was generally considered a useful tool for assessing the relationship between different socioeconomic interactions on the environment and the consequence or outcomes in terms of soil sealing. The DPSIR also provides a means of organising and presenting different data or statistics and identifying suitable indicators to describe elements of the DPSIR.

However, many entities of the real world can be considered as belonging to different facets of the framework. For example, land use can be considered as a state: according to the inputs determined or received by the driving forces, the land assumes a given configuration able to answer to the consumption and production needs of the social and economic system. That land use also directly determines pressures on the environment (on air, water and the land itself). Climate change can be considered as a driving force, modifying the status of the land use, but it can also be considered as an impact determined by the economic and consumption activities.

The workshop considered the need to further specify the DSPIR framework, and the need to develop, especially for a network such as Eionet, a conceptual

framework that describes the facets of soil sealing and their linear and non-linear relationships. Soil sealing is a phenomenon that can be considered and analysed according to different points of view. During the discussion at least two possible definitions came out: (i) soil sealing as a measure of the loss of soil and its associated functions (in this sense soil sealing may be interpreted also as a measure of urban sprawl which is also a function of economic activity); and (ii) soil sealing as a measure of the part of the land which is rendered impermeable (of particular relevance to the hydrological cycle).

5. Recommendations to the EEA

The following recommendations were made by the workshop.

1. The workshop concluded that only some of the indicators selected by the previous ETC/soil are relevant to assessing soil sealing (for example, the extent of urban sprawl). Some initial suggestions for policy-relevant questions and indicators have been made during the workshop (see Table 3).

2. The MI/MF approach used by the EEA was considered appropriate as a frame work for assessing the impact of soil sealing on the environment and the functions and 'goods' that soil performs.

3. The DPSIR framework captures well the various issues associated with soil sealing and illustrates clearly the linkages to other sectors and aspects of the environment. There is a need for the EEA to have continued and more regular dialogue with policy-makers and scientists representing these different components of the DPSIR, since they may be able to offer alternative data for monitoring and assessment. This will require greater interaction between the EEA and relevant stakeholders. The EEA, although with an explicit remit to report on environmental policy, acknowledges the socioeconomic components and related issues associated with soil sealing. This is captured in the DPSIR framework, for the ESDP, land use and planning policies and how this influences soil sealing. This more holistic consideration poses a challenge in developing indicators since it demands a greater understanding between the interactions of the different elements of the DPSIR framework and requires greater coordination between other EEA themes and policy areas (such as transport and water).

4. A comprehensive policy assessment should be undertaken concerning soil sealing, at the EU and member country level. EIONET could facilitate this process and also enable the link to other soil issues such as soil erosion to be considered.

5. Consequently, there is a need to clearly identify the policy issues, concerning soil sealing, that the EEA wants to address — some suggestions have been made by the workshop (see Tables 1 and 2 of this report).

6. Having agreed a set of policy issues and associated questions, the ETC/TE should seek to gather a comprehensive set of contemporary data using a questionnaire (as undertaken by ETC/S). Although there are risks with this approach, useful lessons have been learnt from the previous exercise that would minimise these risks. Careful formulation of the questionnaire, and the involvement of the EIONET partners in its design, combined with sufficient time for the data to be collected, should ensure a useful set of contemporary indicator datasets.

7. ETC/TE should work closely with other relevant ETCs, such as ETC/W (for example, on soil-sealing impacts on local and regional hydrology) to develop suitable indicators for soil sealing.

8. The state of soil sealing can be esti mated based on national statistics or from Corine LC. However, this data base does not provide a regular time series, and may underestimate the problem due to scale limitations. National statistics are likely to give a more accurate assessment, however the EEA need to define more precisely the term 'soil sealing' and the exact data they require. Adequate time should be allowed to collect this data.

9. Projects such as Murbandy/Moland demonstrate the utility of remote sensing and provide a 'snap shot' of

the rate of land-use change — from this an estimate of soil sealed could be estimated. Such an approach, although not representative of Europe, can provide very useful case studies for the EEA to illustrate the issue. Value can be added to these case studies by collecting impact data associated with soil sealed. The EEA should consider establishing a repeatable set of case studies (cities/regions) that can be used to illustrate change and policy impact.

10. The EEA already has a memorandum of understanding with the JRC. Through this mechanism, the EEA and ETC/TE should seek to enhance the work of Moland to achieve a more representative sample across Europe, and to work on the development of soil-sealing indicators through the development of Moland methodologies and databases.
11. Spatial data, and identifying soil-sealing hot spots, should be progressed by the EEA. Whilst there are gaps and limitations in the available data, a framework should be established to enhance what is available and to facilitate spatial data collection. The utility of hot spot maps is significant in terms of communicating the message.
12. The EEA and ETC/TE should work with a wider group (drawn from the workshop to enable continuity) in developing objectives and soil-sealing indicators.

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UK Department of the Environment, Transport and the Regions, 1999b. *Quality of life counts*. Chapter 3, p. 43. http://www.environment.detr.gov.uk/sustainable/quality99/index.thm Indicator 'Net loss of soils to development' S1.

World wide web sites

http://eea.eu.int/ (EEA European Environmental Reference Centre web site)

http://reports.eea.eu.int/ (EEA publication source)

http://dataservice.eea.eu.int/dataservice (EEA data service)

http://glossary.eea.eu.int/EEAGlossary/ (EEA glossary of environmental terms)

http://www.sustainable-cities.org (European sustainable cities and towns campaign web site)

Annex A: Workshop agenda

Monday 26 March 2001

Time	Speaker	Subject
Soil sealing — background, overview & policy		
10.00–10.30	Anna Rita Gentile	Introduction to the workshop and EEA work on soil degradation (to include ETC soil work; EEA Envision; MDIAR–Soil)
10.30–11.00	Simon Turner	Summary of work to date on soil sealing (summary of published work on soil sealing including indicators, soil-sealing monitoring)
11.00–11.30	Liz Mills	The policy context for soil sealing
Soil sealing — indicators		
11.30–12.00	Olaf Düwel	Soil-sealing indicators — the experience of the former Environmental Topic Centre for Soil
12.00–12.45	Hester Lyons	Soil-sealing hot spots in Europe (description of the 'hot spots' of soil degradation in Europe; soil-sealing hot spots; data issues and limitations)
12.45–14.00	Lunch	
Soil sealing — monitoring and assessment		
14.00–14.45	Luca Demicheli	Monitoring of land-use changes in urban and coastal areas (Murbandy and Lacoast projects)
14.45–15.15	Pierpaolo Napolitano	Land-use statistics to monitor soil sealing — a case study from Arezzo province, Tuscany
15.15–15.45	Fabian Dosch	Land consumption and soil sealing in Germany — monitoring, measures, indicators
15.45–16.15	Andrew Harrison	Monitoring land-use change in the UK: the national land-use database and other data sources
16.15–17.15	Robert Jones	Data availability for soil sealing at the European level

Tuesday 27 March 2001

Time	Speaker	Subject
General discussion		
10.30–11.30	Chair: Simon Turner Judith Lowe	Soil sealing — what do we need to monitor to inform policy-makersDiscussion — soil-sealing indicators
11.30–12.30	Chair: Simon Turner	Discussion on data availability, data gaps and needs
12.30–13.00	Simon Turner Anna Rita Gentile	Recommendations and concluding remarks

Annex B: Address list of workshop participants

Name	Organisation/institute/company	Address
Luis Carazo Jimenez	Commission of the European Communities Environment DG, Unit B1, Water, Marine and Soil	BU–9 Office N0 3/137 Rue de La Loi 200 B-1049 Brussels Tel. (32-2) 296 00 66 Fax (32-2) 296 88 25 *Luis.Carazo_jimenez@cec.eu.int*
Luca Demicheli	Commission of the European Communities — Joint Research Centre Space Applications Institute Strategy and Systems for Space Applications SSSA	TP 261, Via E. Fermi Ispra (VA) I-21020 Tel. (39) 0332 78 5231 / 6286 Fax (39) 0332 78 5461 *Luca.demicheli@jrc.it*
Fabian Dosch	Bundesamt für Bauwesen und Raumordnung	Am Michaelshof 8 D-53177 Bonn Tel. (49-1888) 401 23 07 *Fabian.Dosch@bbr.bund.de*
Olaf Düwel	Bundesanstalt fur Geowissenschaften und Rohstoffe, Federal Institute for Geosciences and Natural Resources	Stilleweg 2 D-30655 Hannover Tel. (49-511) 643 28 41 Fax (49-511) 643 36 62 *Olaf.Duewel@bgr.de*
Andrew Harrison		36 Walsingham Road St Andrews Bristol, BS6 5BT United Kingdom Tel. (44-117) 924 60 42 Fax (44-7092) 37 88 03 *a.r.harrison@dial.pipex.com*
Ines Iribarren	Spanish NRC for soil at IGME	Rios Roas, 23 E-28003 Madrid Tel.(34) 913 49 57 84 Fax (34) 913 49 58 34 *CNRsuelos@igme.es*
Robert Jones	Commission of the European Communities — Joint Research Centre Environment Institute, European Soil Bureau	TP 262, Via E. Fermi Ispra (VA) I-21020 Tel. (39) 0332 78 63 30 Fax (39) 0332 78 99 36 *Robert.jones@jrc.it*
Judith Lowe		160 Trafalgar Street London SE17 2TP United Kingdom Tel.(44-20) 76 40 01 32 Fax (44-20) 79 67 97 40 *JudithLowe@cs.com*
Hester Lyons	ADAS	Wergs Road, Woodthorne, Wolverhampton WV6 8TQ United Kingdom *Hester.Lyons@adas.co.uk*
Liz Mills	Ove Arup	4 Albemarle Row Bristol BS8 4LY United Kingdom Tel. (44-117) 988 67 31 / 929 27 46 / 976 54 32 *liz.mills@arup.com*

Name	Organisation/institute/company	Address
Pierpaolo Napolitano	ISTAT DISS	Via A.Rava,150 I-00142 Roma Tel. (39) 06 59 52 43 47 Fax (39) 06 5 94 32 57 *napolita@istat.it*
Philipp Schmidt-Thomé	Geological Survey of Finland	PO Box 96 FIN-02151 Espoo Tel. mobile (358-40) 542 41 92 Tel. office (358-20) 550 21 63 Fax (358-20) 550 12 *philipp.schmidt-thome@gsf.fi*
Simon Turner	ADAS	Wergs Road, Woodthorne Wolverhampton WV6 8TQ United Kingdom *Simon.Turner@adas.co.uk*
Cors van den Brink	IWACO	PO Box 8064 9702 KB Groningen Netherlands Tel. (31-50) 521 42 57 *c.vandenbrink@grn.iwaco.nl*

Annex C: Urban sprawl, land uptake, soil sealing — what do we mean?

Urban sprawl

The physical pattern of low-density expansion of large urban areas under market conditions into the surrounding agricultural areas. Development is patchy, scattered and strung out, with a tendency to discontinuity because it leapfrogs over some areas, leaving agricultural enclaves. (summarised from GEMET, 2000 in http://glossary.eea.eu.int/EEAGlossary/)

Land uptake

Land uptake is the area of land that is 'taken' (consumed) by a certain land use, in particular the land consumed by urban and infrastructure development. It can be used as an indicator of the pressure of urban development on the environment.

Soil sealing

The term soil sealing has been interpreted in different ways. A common use of the term soil sealing among soil scientists refers to changing the nature of the soil such that it behaves as an impermeable medium (for example, compaction by agricultural machinery). Soil sealing is also used to describe the covering or *sealing* of the soil surface by impervious materials by, for example, concrete, metal, glass, tarmac and plastic.

In this report soil sealing is defined as the covering of soil due to urbanisation and infrastructure construction, such that soil is no longer able to perform the range of functions associated with it. Soil sealing is not adverse *per se*, rather it is the irreversibility in practical terms of sealing the soil and the consequent loss of soil functions.

The DPSIR framework applied to soil sealing

The use of the different terms can be illustrated through the application of the DPSIR assessment framework (see Figure 2 in the main text).

Changes in human population as well as changes in the activity of sectors such as transport and tourism may lead to urban expansion and infrastructure construction. This may not be uniquely the result of an increase in population but it can be the result of a change in behaviour (as with urban sprawl, more extensive urban patterns are preferred). As a consequence, a certain amount of land is consumed (land uptake) and built-up areas increase at the expense of other types of land use. This exerts pressures on soil as ground surfaces are impermeabilised and sealed. Soil sealing has direct impacts on the impairment of soil functions as well as indirect impacts on other media. Responses may involve the development of a European soil protection policy as well as legal initiatives at the local and/or municipal levels.

Indicators to describe soil sealing

Due to the lack of precise information, the increase of built-up areas has been used as a proxy indicator to account for the amount of soil being sealed and to quantify the land taken by urban expansion. It should be noticed that, by definition, built-up areas also include the portion of land which is not actually sealed (such as gardens, urban parks, etc.). In Germany, it is estimated that only about 50 % of the built-up areas are actually sealed. However, it should also be noticed that the impacts of soil sealing go beyond the sealed area and expand in its surroundings.

Annex D: Short review of the EEA work on assessment and reporting on soil sealing

Introduction

Scope of the review
This annex presents a summary of the background paper, 'Short review of the EEA work on assessment and reporting on soil sealing', prepared to stimulate and organise the experts' contribution to the technical workshop on indicators for soil sealing. The summary provides an overview of the work undertaken by the EEA with the support of the European Topic Centre for Soil (ETC/S) concerning soil sealing. In particular, it considers the needs for information relevant to the framing, assessment and implementation of environmental polices relevant to soil sealing and the EEA role in support of that objective. An assessment of soil sealing is also given, based on recent EEA publications.

The effects of soil sealing
Sealing soil surfaces negatively affects the ecosystem and human habitat, this condition arising when the soil is covered with an impervious layer. The greatest effects of surface sealing are found in urban and metropolitan areas where large portions of total areas are sealed. Continued development increase the degree of sealing, giving rise to the impacts described in Table 4.

Selection of indicators for soil sealing

Using this conceptual framework the EEA proposed a number of indicators that are described below (Table 5). In identifying the indicators based on the DPSIR framework (see Figure 2 in main text) the principle driving forces were considered to be the increase in population, and, allied to these, accompanying developments in infrastructure (principally road development). In addition, tourism, particularly in coastal areas in southern Europe, has resulted in significant urban and infrastructure development.

Table 6 shows a list of 'headline' indicators relating to the major soil-sealing issues, derived from the proposed indicators listed in Table 5.

The impacts of soil sealing Table 4.

Urban climate	Air is warmed by the high heat-storage capacity of buildings and asphalt streets, reducing cooling at night. Relative humidity is decreased because cooling surfaces such as vegetation are lacking.
Water balance	Ground water recharge is reduced, and surface run-off polluted by residues associated with urban surfaces.
Soil ecological functions	Water and oxygen recharge to soils, once sealed, is severely impaired or at worst prevented, and the buffering capacity of soils impaired. Surface run-off can increase significantly, giving rise to local flooding in heavy rain events.
Habitat loss	Flora and fauna associated with the soil can be lost and the habitat destroyed.
Human habitat	Soil sealing today is associated with the disparity between population size and availability of open spaces (although historically, reasons may have been more complex such as industrial development, proximity to markets etc.). There is a strong argument that highly built-up areas can have a harmful effect on human health.

Source: Environmental atlas, Berlin, 1996

Table 5. **Preliminary set of indicators**

Issue / question	Indicator	Dimension	DPSIR	Indicator type	Short term core indicators
Development of human population What is the extent of human population (during a specified time, within a given country)?			D	A	No
	Total amount of human population	No	D	A	No
	Population growth rate	%	D	A	No
	Increase in number of households	No	D	A	No
Urban expansion ([4]) What is the increase of urban expansion?	Increase in area covered by human settlements and transport network	%	P	A	(Yes)
	Total consumption of built-up material	t	P	A	No
What is the total amount of consumption of built-up material per Member State What is the state of urban expansion?	Area covered by human settlements and traffic routes	%	S	A	(Yes)
	Estimated sealed area (by area covered by human settlements and traffic routes) per inhabitant	Ha/person	S	A / B	(Yes)
	Classified regional settlement structures (presentation as circle diagrams): areas with large conurbation areas where conurbation is beginning to develop rural areas	%	S	A	No
	Portion of high quality and / or environmentally important soil lost (sealed)	%	S	A	Yes
What are the effects of soil sealing on the environment?	Number of serious floods / landslides in recent years	No	I	A / B	No
Do legal bases for the prevention of soil sealing exist?	Existing legislation to minimise soil sealing		R	A	No
To what extent shall soil sealing continue in the future?	Local activities in defining targets for future soil-sealing rates (increase in area covered by human settlements and traffic routes)	%	R	A / B	No
How much sealed soil could be restored (including returning the sealed area to permeable materials)?	Local assessments of de-sealing potentials (portion of de-sealable and changeable surface areas (increase or permeability) on the total area covered by human settlements and traffic routes)	%	R	A	No
Tourism Development of infrastructure in areas highly attractive for tourism	Area covered by human settlements and traffic routes in selected areas (highly attractive for tourism)	No	P	A	No

([4]) Urban expansion could be described by the total area covered by human settlements and traffic routes per Member State, perhaps related to the total amount of inhabitants of the Member State.

'Headline' indicators for soil sealing Table 6.

Issue / question	Indicator	Dimension	DPSIR	Indicator type
What is the state of urban expansion?	(increase of) area covered by human settlements and traffic routes	%	P / S (?)	A
	Estimated sealed area (by area covered by human settlements and traffic routes) per inhabitant	Ha / person	P / S	A / B
To what extent are soils of high quality / environmentally important soils affected by soil sealing?	Portion of high quality and / or environmentally important soil sealed	%	S	A

Although indicators are often used in connection with thresholds, it is very difficult to identify suitable threshold values for a Europe-wide analysis of soil sealing. This is evident in the EEA STAR database, an inventory of national and international sustainability reference values and policy targets. For example, brownfield redevelopment, (the re-use of abandoned industrial areas for new urban development) has been identified as a response to the increasing demand for land resources. Some EU countries — Germany, Italy, the Netherlands and the UK among them — have initiated such redevelopment projects and some have defined targets. In the UK, for example, between 1985 and 1988, 44 % of total land changed to urban uses was previously developed urban land. The recycling rate increased to nearly 50 % between 1990 and 1994. In 1997, about 55 % of new homes (including conversion of existing buildings) were built on previously developed land, against a target of 60 % to be achieved by 2008 (UK DETR, 1999a and b). Targets to reduce loss of soil to urban development have also been defined by Germany, where the increase of built-up areas should be reduced to 30 ha/day by 2020, and Belgium, where limitations to the increase of residential and industrial areas have to be met by 2007 (targets relate only to the region of Flanders) (EEA, 2000).

Notwithstanding these examples, there are few others concerning soil sealing. Consequently the approach adopted by the EEA has been to identity the direction of trends of the selected indicators.

EEA assessments of soil sealing

The assessment presented in Europe's environment at the turn of the century (EEA, 1999a) shows that damage to Europe's soils from modern human activities is increasing and leads to irreversible losses due to soil erosion, local and diffuse contamination and the sealing of soil surfaces.

Sealing of soil surfaces due to increased urbanisation and new (mainly transport) infrastructures is the main cause of soil degradation in the most industrialised and populated countries of western and northern Europe. Soil losses due to surface sealing, through urbanisation and infrastructure within the EU, are particularly high in Belgium, Germany and the Netherlands, and are increasing in Greece, Spain and Portugal. Soil sealing is also expected to increase within countries with relatively little urbanisation. These include Ireland, Portugal and Finland, where the rate of change of artificial areas within the main cities has also been high over the past 50 years, and central and eastern Europe, where the increase of artificial areas has not been high in the past decades, due to the intensive types of construction used.

Data on the rates of soil sealing are available only for a number of countries and are not consistent. Since countries use different methodologies to assess the extent of surface sealing, the comparability of the data poses a further problem. However, even within this margin of uncertainty, soil loss rates through land development and infrastructure may exceed those, due to soil erosion in many European countries.

The loss of soil to urbanisationand infrastructure

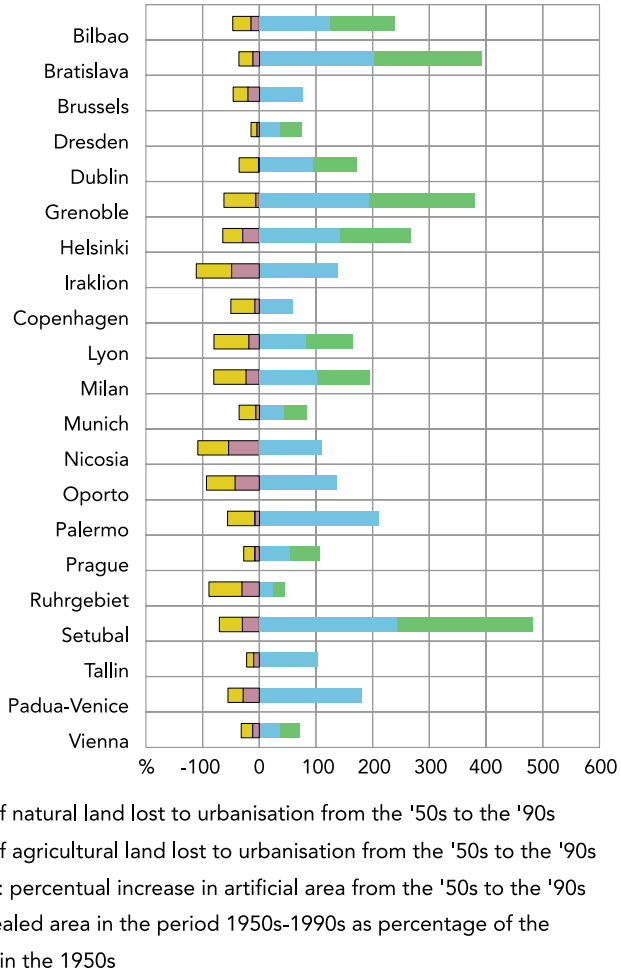
Rates of soil loss due to surface sealing through growth in urbanisation and transport infrastructure (roads, airports, railways, ports, etc.) are similar in several EU countries. Since 1970, the increase in the length of motorways has been significant in most of the EU countries. Occupation of land by transport infrastructures is high in Belgium, the Netherlands, Germany and Switzerland and is increasing in Greece, Spain and Portugal.

Since 1990 the growth of built-up areas has been similar in Belgium, France and Germany, where it reached about 50 and 70 ha/day over the period 1990–95 in Belgium and France respectively, and exceeded 120 ha/day over the period 1993–97 in Germany.

Built-up areas have grown at the expense of agricultural land in France, Germany, Iceland, the Netherlands and Poland, where forest areas have also decreased in the period 1990–95 (EEA, 1999a).

Figure 3. **Loss of natural and agricultural areas due to urbanisation in selected European cities from the mid-1950s to the late 1990s**

Source: European Commission-Joint Research Centre ([5]) — EEA data elaboration, 2000, published in EEA, 2000b.



Note
The tables and figures showed here only give an idea of the size of the problem of urban sprawling in selected European cities and should not be used to compare the situation in different cities. Each city has its own dynamics and more data would be necessary to make a full evaluation.

([5]) Data shown here are the results of the European Commission's Murbandy project (monitoring urban dynamics), which aims to study current and past land uses in cities, monitor urban dynamics, develop urban and environmental indicators and elaborate scenarios for urban growth.

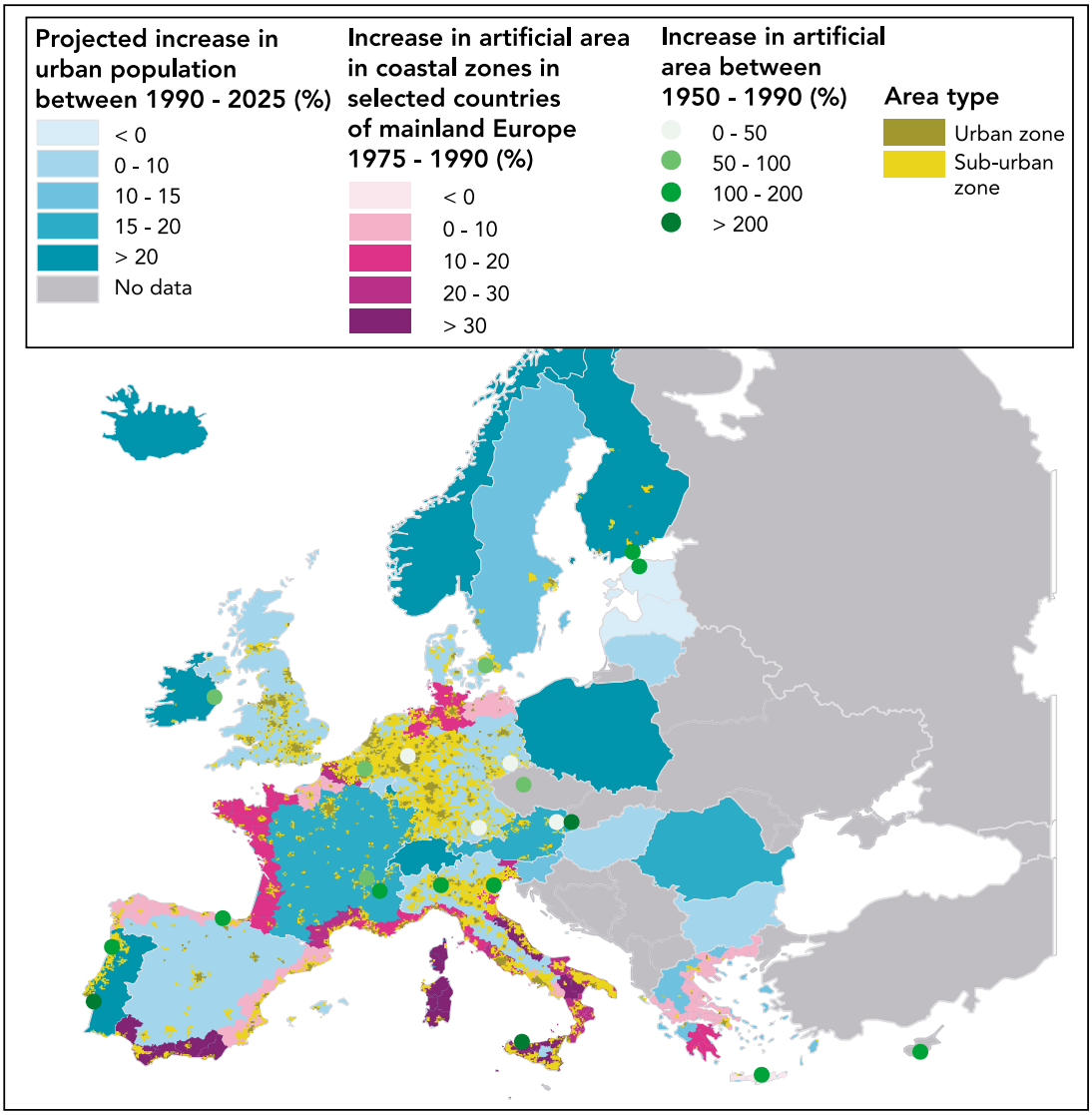
Loss of natural and agricultural areas due to urbanisation in selected European cities from the mid-1950s to the late 1990s — Table 7.

City	Period	Total area (without the sea): km² referred to 1950s	Percentage of natural land lost to urbanisation from the 1950s to the 1990s	Percentage of agri-cultural land lost to urbanisation from the to 1950s the 1990s	Urban sprawl: percentual increase in artificial area from the 1950s to the 1990s	Increase of sealed area from the 1950s to the 1990s as percentage of total area	Increase of sealed area from the 1950s to the 1990s as a percen-tage of the artificial area in the 1950s	Increase of artificial areas from the 1950s to the 1990s as percentage of total area	Total artificial area in the 1990s vs. total area: %	Total artificial area in the 1950s vs. total area: %
Bilbao	1956-97	168.6	14.5	32.3	124.2	18.9	116.2	20.2	36.2	16.2
Bratislava	1949-97	462.7	11.4	25.2	202.6	16.7	190.1	17.8	26.7	8.8
Brussels			20.2	26.6	75.9					
Dresden	1953-98	1256.7	4.0	11.1	36.0	7.2	39.1	6.6	25.0	18.4
Dublin	1956-98	691.9	1.3	34.4	95.8	17.9	75.8	22.6	46.1	23.6
Grenoble	1948-97	193.4	6.2	56.2	193.5	30.2	187.7	31.2	47.3	16.1
Helsinki	1950-98	798.8	29.1	36.0	141.5	21.6	127.6	23.9	40.7	16.9
Iraklion	1960-97	29.5	48.8	63.2	139.7	-	-	43.1	72.8	30.5
Copenhagen	1954-98	645.4	7.7	42.8	59.1	-	-	22.2	59.8	37.6
Lyon	1956-97	311.6	18.3	61.8	81.2	32.7	83.0	32.0	71.4	39.4
Milan	1955-97	325.2	22.8	57.5	103.8	32.8	93.2	36.6	71.8	35.2
Munich	1955-90	797.8	6.5	29.6	44.7	12.5	40.3	13.8	44.7	30.9
Nicosia	1957-97	75.9	54.0	54.5	109.6	-	-	35.8	68.5	32.7
Oporto			42.6	51.1	136.8					
Palermo	1955-97	221.9	7.9	47.8	210.9	-	-	26.4	38.7	12.5
Prague	1953-98	797.6	7.4	19.5	54.4	12.3	52.6	12.7	36.2	23.4
Ruhrgebiet	1952-98	352.6	30.4	58.8	24.6	13.0	20.8	15.3	77.7	62.3
Setubal	1958-97	22.2	29.7	41.1	243.3	35.1	239.7	35.6	49.3	14.6
Tallin			9.7	12.5	102.7					
Padua-Venice			28.6	26.9	181.6					
Vienna	1958-97	841.8	11.6	19.9	36.6	10.2	34.4	10.9	40.5	29.7

Source: European Commission, Joint Research Centre - EEA data elaboration, 2000 (included in EEA, 2000b).

Figure 4. **Probable problem areas of soil sealing in Europe**

Source: EEA, 2000b.



In the Mediterranean, soil sealing mainly affects coastal areas. In 1985, almost 90 % of urbanised land was located along the coasts of France, Greece, Italy, Spain and former Yugoslavia. This percentage is likely to increase by 2050, according to the UNEP/MAP blue plan. A study carried out by WWF-Italy shows that in 1996 nearly 43 % of the Italian coastal zones were completely occupied by intensive built-up areas, while 13 % were occupied by extensive buildings and infrastructures, and only 29 % were completely free from constructions (EEA, 1999 b).

Urban sprawl

Changes in land use leading to soil sealing are particularly relevant around urban areas. An assessment of changes in land use in 25 European cities from the 1950s to date has shown that in some cities, such as Iraklion, Milan, Nicosia, Oporto, Bilbao, Palermo, Lyon and Grenoble, total losses of agricultural and natural areas due to increase of artificial areas have been more than 35 %, with peaks of 41 % in Iraklion and roughly 37 % in Milan and Nicosia. Most of the losses took place during the 1970s and 1980s in most of the cities (Murbandy project,EC-DG JRC-SAI).

In the same period, artificial areas have more than doubled in Setubal (240 %); Palermo (210 %) and Bratislava (200 %). In four cities the percentage of artificial areas is currently very high, accounting for more than 70 % of the total area, with a peak of nearly 78 % in the Ruhr region,

although in this case the percent increase since 1952 has been relatively low (less than 25 %) in comparison to other cities, since this region was already highly urbanised (Figure 3 and Table 7).

A spatial perspective of soil sealing

A spatial assessment of soil sealing (Figure 4) was undertaken by the EEA for the joint EEA-UNEP message on soil degradation *Down to earth: soil degradation and sustainable development in Europe* (EEA, 2000b). A short summary is presented here.

Proxy datasets on pressures to soil have been used for the assessment, including the areas in the EU-15 classified as 'urban' and 'suburban', the rates of urban expansion that have occurred in the past 50 years in selected European cities and the increase in artificial areas in coastal zones in the period 1975-90.

Projected changes of urban population on a country basis are also shown. However, the relation between increase in population and soil sealing are complex. The increase in artificial areas in the last decades was not due to increase in population in most of the countries, but rather to changes in population behaviour (shift from an intensive to an extensive urban pattern: suburbanisation). Currently, problems of continued soil sealing are located in countries where the projected increase in urban population will be less than 10 % over the next 25 years, and are mainly caused by extensive suburbanisation.

The Benelux countries and western Germany already have a high degree of urbanisation and suburbanisation. Although the projected rate of urbanisation within these countries is quite small in percentage terms, the actual area needed for this change is likely to be substantial. Most of this growth is likely to be within or on the edge of the suburban areas, due both to logistic issues (that is, the lack of available space within cities, as indicated by the relatively low past rate of urbanisation of some of the cities within these areas) and socioeconomic factors (such as people's preference for living outside the city centre). On the other side, the highest projected percentage rates of change are seen within countries with still relatively little urbanisation such as Portugal, Finland and Ireland, where the rate of urbanisation over the past 50 years within the cities sampled has also been high. Although the actual area needed for the projected increases may not be very large, the impact on natural areas may actually be greater in relative terms than within those countries that are already highly (sub)urbanised.

Competition between different uses of soil, leading to soil contamination and consumption of the soil resource, is becoming more severe in the Mediterranean region, mainly as a result of increasing urbanisation and tourism. Indeed, in the Mediterranean countries, urbanisation has been especially rapid in the coastal zones of southern Spain, the Mediterranean islands, southern France and Italy, this process being linked with the development of tourism in these areas. In fact, the Mediterranean is the most popular tourist region in the world, accounting for 30 % of international tourist arrivals, while one third of its population is concentrated in coastal areas (EEA, 1999a,b). With the continuing increase in tourism within Europe, these pressures are likely to remain or increase in the coming years.

Soil sealing in central and eastern Europe (EEA, 2000a)

In past decades, loss of soils due to urbanisation and industrial development in most of the central and east European countries was not very high, due to the intensive type of construction used (EEA, 2000). In fact, although the population growth in most of the cities of the central and east European countries (CEECs) was high, actual growth of urban areas was relatively modest.

However, in recent years, soil loss due to urbanisation has increased in these countries, due to a shifting to more extensive urban developments. In Romania, for example, the built-up area increased, between 1989 and 1994, by about 100 000 ha or nearly 19 % (Ministry of Waters, Forests and Environmental Protection of Romania, 1996). Currently built-up areas occupy 630 000 ha, over 2.6 % of the total land area in Romania.

Soil sealing is extremely severe in some areas of the newly independent States (NIS), which are so heavily transformed by mining and heavy industry, as to give rise to the term 'industrial desertification'. In Ukraine, for example, this phenomenon extends to 3 % of total land area (national report on the state of environment in Ukraine in 1997, 1998).

Data needs, data gaps and institutional cooperation

Data collection, ETC/S recommendations
In preparing for the latest state of the environment report in the European Union (EEA, 1999a) a questionnaire, based on the questions outlined in Table 4, was sent to all EEA national reference centres for soil to obtain data to describe the associated indicators. The response was varied and in many cases incomplete, for a variety of reasons including data not being available and insufficient time to deal with the request.

Based on this experience, a more long-term approach to the collection of indicator data has been proposed by ETC/S (EEA-ETC/S, 1999b) based on the Corine land-cover database combined with information on the actual surface sealed for selected monitoring areas across Europe. Although such an approach may be feasible, there are limitations, including the minimum mapping unit of Corine LC (25 ha) and linear features greater than 100 m wide. Furthermore there is no explicit definition for sealing, rather the term 'artificial surfaces' is applied and includes the urban fabric, industrial, commercial and transport, mine, dump and construction sites. Finally, Corine LC currently is updated every 10 years, and for monitoring of soil sealing a more regular assessment is required of every two to five years.

Nevertheless, remote sensing of land cover could play an important role in monitoring soil sealing as demonstrated by the JRC Moland (monitoring land use/cover dynamics) project.

Table 8 summaries the approach recommended by ETC/S for the collection of State indicators in the short to long term.

Developing a monitoring system for soils
The EEA has proposed that any monitoring framework to collect indicator data should be based, as far as possible, on existing activities in EEA member countries. Soil monitoring and survey programmes are routinely undertaken by Member States at national and regional levels although there are differences between these existing networks (EEA-ETC/S, 1999a; Gentile, 2000).

A stratification scheme is used to separate monitoring sites into three classes, to coordinate national monitoring and to enable harmonisation across the many different monitoring activities. This scheme encompasses integration with the developing European network for water and monitoring of special sites with specific soil problems. A site selection procedure would place different classes of sites over many diverse soil categories within the EU, taking into account the soil region and land use.

The different requirements of monitoring systems concerning major soil degradation patterns are considered within this framework. This allows maximum extraction of soil information to assess and quantify effectively the direct/indirect impacts on soils. Data collected from the soil monitoring network (SMN) sites will be stored in the future EuroSoilBase (SoilBase). To enable this, a satisfactory data flow from the national monitoring networks to the proposed EuroSoilNet (SoilNet) has to be implemented. Hence, the development of suitable data exchange formats and a procedure to aggregate national collected 'raw' data are necessary. Finally, after assessment of the data and transformation of information presented in reports, the data and the information should be readily accessible to the users, for example to member countries.

SoilBase should contain the data sets that will be collected within the future SoilNet, supplemented with non-site data from other databases (such as statistical databases). SoilNet should consist of a restricted number of carefully chosen sites within comprehensive monitoring programmes, which would act as reference or control sites for harmonisation and quality control between disparate SMNs.

Indicators and data sources for soil sealing — Table 8.

	State indicators	Data sources	Data availability	Date reliability
Short-term approach	Built-up areas in Europe	Different statistical institutions	(✔)	?
	Increase of built-up areas	Questionnaires and data collection	(✔)	?
	Road density in Europe		✔	-
Long-term approach	Built-up areas in Europe and their increase	Periodical monitoring by remote sensing combined with ground validations in test areas	✔(?)	✔(?)

Relevance to soil sealing

Despite these proposals and developments, it is debatable as to the relevance of such a monitoring system for soil sealing. The indicators proposed for soil sealing are more concerned with land-use change that is, urbanisation and road construction. Once a soil has been sealed arguably there is little point in it being monitored *per se* since the soil resource is effectively lost for good. The proposed soil-monitoring framework should seek to encompass land-use-change statistics. The proposed set of headline indicators should be re-orientated to make better use of the anticipated soil monitoring framework.

Better information for policy-makers

Data on soil has been gathered by different organisations for different purposes (soil has many users). There are, however, important data gaps and access to relevant data and information is difficult. Little data can be directly used for policy purposes and most covers small geographical areas.

The specific situation about soil data in Europe is summarised below:

- a mass of data exists at the local level, but there are data gaps at the regional level;
- there is a lack of harmonisation of monitoring at the national and regional levels;
- data flows between data collectors and the organisations responsible for reporting have not been established at the national and European levels.

Data gathering is a costly process: a better balance between modelling and monitoring activities should be applied. Modelling is needed to cover current data gaps, provide information on future scenarios, assess the effects of policy in place, etc. Monitoring should provide information on the current state and trends and should only be applied when economically feasible. A full, dense and costly monitoring network covering the whole of Europe might not provide results which can be used in a wider policy context, while information entirely based on models cannot provide a full picture of the current situation.

Moreover, spatial aspects need to be taken into account: knowing what is happening and where will help to set priorities for policy development and assess the results of existing policies.

In more general terms, improving data and information on the state and trends of Europe's soils would require:

- a coherent framework for monitoring and assessment of Europe's soil, including the establishment of a data flow/reporting mechanism on Europe's soils, which will enable a greater knowledge of the policy-relevant issues at the EU level;
- streamlining of existing activities/collaboration of relevant stakeholders (who does what, how collaboration between existing institutions/organisations can

improve Europe's soils). This should include the development of a work programme for soil for the years to come.

Notwithstanding this, some progress has been made to close data gaps and to produce better information to support policy-making. A framework 'From national monitoring to European reporting' is being developed by the EEA, together with its Eionet partners and with the support of Commission services such as the Joint Research Centre and Eurostat (EEA, 2000).

The assessment of soil-related environmental issues is based on the identification of suitable, policy-relevant indicators, using the multi-function/multi-impact approach (MF/MI) and EEA assessment framework DPSIR.

Further development of the assessment system concerns the derivation of indicators using monitoring data and validation and comparison of the results achieved with defined reference values. However, for soil sealing there are no European thresholds defined, making any policy-relevant assessment difficult. Assessments have been made by the EEA concerning soil sealing, which has highlighted a range of data gaps.

Summary and conclusions

The assessment of soil-related environmental issues is based on the identification of suitable, policy-relevant indicators, using the multi-function/multi-impact approach (MF/MI) and EEA assessment models DPSIR.

Further development of the assessment system concerns the derivation of indicators using monitoring data and validation and comparison of the results achieved with defined reference values. However, for soil sealing there are no European thresholds defined, thus making any policy-relevant assessment difficult.

Assessments have been made by the EEA concerning soil sealing which have highlighted a range of data gaps.

An opportunity now exists to review the choice of soil-sealing indicators, and, if appropriate, to suggest new ones (for example indicators that may be classified as type C, performance indicators).

Annex E: Conclusions from the Eionet 'hot spots' review

For the workshop, and as part of the EEA review on soils, a CD-ROM application was developed that included all of the digital cartographic data compiled, analysed and published in the joint EEA-UNEP publication (EEA, 2000a) in the chapter 'Where are the hot spots of soil degradation in Europe'. The CD-ROM also included background papers and the methodology used to develop the published maps. A simple GIS browser was also included to allow the user to explore the data that made up the maps. The CD-ROM was distributed by the EEA to national focal points and nominated national experts, as well as to other soil experts, to solicit their opinion and comments concerning the 'hot spot maps'.

Due to current data limitation, this first attempt to derive hot spot maps had the objective of showing priority areas and identifying/visualising data gaps.

The Eionet reviewers were requested to answer the following questions.

- Are we using the best available data sources for your country on each theme in the hot spot maps?
- If not, which data sources should we be using?
- Did you find this method of reviewing the hot spot data useful?

In addressing these questions the reviewers were asked to consider the five maps published in the 'Down to earth' report, namely (i) soil acidification and eutrophication, (ii) diffuse contamination of soil, (iii) local contamination of soil, (iv) soil erosion and (v) soil sealing. A sixth map summarising all of the five maps was also made available for comment. The summary map is shown in Figure 5.

Table 9 on page 47 captures the main points received by the EEA, and conclusions concerning this work are drawn at the end of this Annex.

Figure 5. **Probable problem areas of soil degradation in Europe**

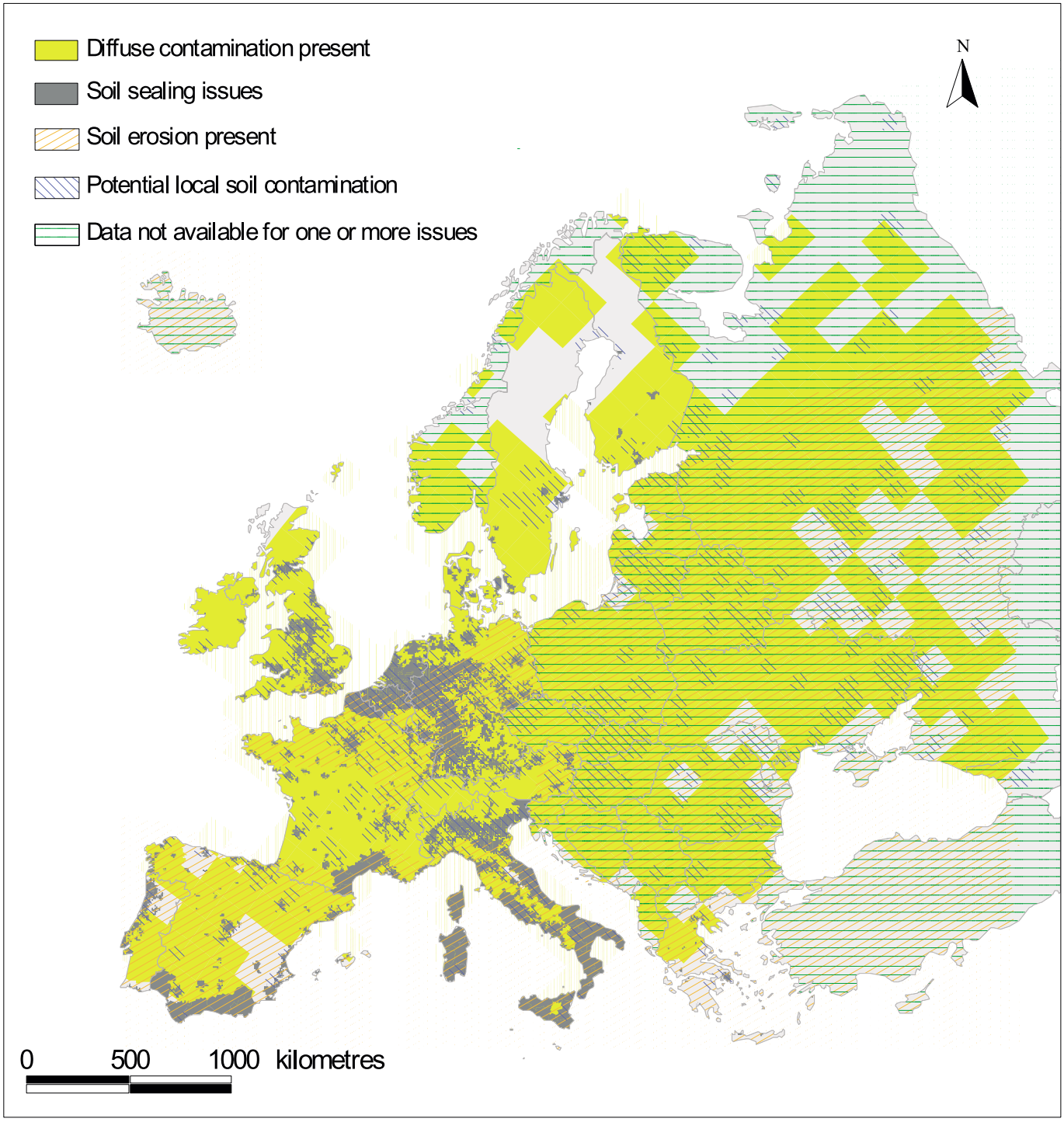


Table 9

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
Austria	20/04/2001 25/04/2001 04/05/2001	Completed	**Local contamination** In general, the EEA approach in focusing on hot spot areas is considered to be suitable for spatial prioritising and delimitation of local soil contamination at the European level, as well as for priority-setting for EEA future activities. However, the methodology for deriving hot spot maps is complex and requires stepwise improvement by including gained experiences. Are we using the best available data sources for your country on each theme in the hot spots map? If not, which data sources should we be using? For Austria, derivation of hot spot areas is based on the localisation of eight steelworks. The picture given in the map can be seen as information about several single industrial locations (steel works) — so far it is not significant for indicating hot spot areas at the national level. Location of the sites is correct. Information about locations of sites assigned to further industrial branches such as chemical industry, gas works or the mineral oil industry would help to give a better picture of the spatial dimension of the contaminated sites problems. In Austria, there exist several databases providing information on the existence and location of industries, assigned to determined industrial sectors — at a national level. As waste sites are also an important source of local contamination, information on locations of waste sites are missing. However, a national inventory on (potentially) contaminated sited is the most important source of information for derivation of hot spot areas. The national inventory includes an interpretation of the above-mentioned databases on industries, as well as information on waste sites. Information from this data source is missing (reasons for this are given in the explanation). Locations of large industries are considered to be a suitable indicator for identification of hot spot areas. However, it is suggested to broaden the interest from only steelworks to all industrial sectors where hazardous substances are handled in considerable quantities and local contamination can be expected. Interest should be redirected from the location of single industrial sites to the frequency of locations causing local contamination in a certain area (density of sites per area). Buffer zones around the locations of sites suppose a spatial dimension of single sites. However, representativeness for causing risks for human health of a single site depends very much on local site conditions. So, indication of buffer zones is considered to mislead the actual situation by supposing spatial information. The opinion, that an industrial area is likely to be concentrated within a certain radius of a particular industry, is not shared — above all, information is based just on eight locations (steelworks). In the description of the methodology for elaborating hot spot areas for local contamination, it is mentioned that the presence of air pollution by industrial substances within cities has been considered too. But it is not obvious why air pollution should be considered as a factor for causing local soil contamination. There should be a distinction between local and diffuse contamination which should be respected. Further, it is mentioned that forest degradation due to emissions was taken account of on the map. Again, it is not obvious why forest degradation is considered as a local soil aspect. The same can be applied to radioactive contamination (emission, or local contamination?) and pesticide pollution!	The definition of hot spots should be explicit and a set of suitable indicators developed. The work published is a useful start but requires further development and refinement. In addition, there is a need to develop more robust data sets and to make better use of data collected by member countries.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
Finland	12/04/2001	Completed	**Soil sealing** This map is interesting and is basically correct for Finland. Growth, especially of the Helsinki area, is more or less out of control, described either by the increase in urban population or the growth of artificial areas during the last decades. Significant soil-sealing problems in Finland are, however, restricted to very few cities. **Soil erosion** The soil erosion map is acceptable. It shows an actually measured situation in a couple of areas in south-western Finland. In general, there has been only little measurements of this kind in Finland and these river areas are known to be among the worst in Finland when erosion in concerned. **Local contamination** Usually, contaminated sites are point features and situated scattered all over the country, though more dense in the areas of the biggest population centres. The overall impression given by the map is satisfactory when international lines are drawn. However, the data used is not necessarily related to local soil contamination. Also some major (also heavy metal) polluted areas are clearly missing. This map cannot, therefore, be used in Finland for pinpointing the Finnish hot spots of local contamination. **Diffuse contamination** The data sets used to produce this map are not comparable. Either two separate maps are needed or a different approach must be developed. The presented map states that there are no major diffuse soil contamination problems on Finnish agricultural soils because of agricultural practices. However, there is a serious industrial heavy metal deposition problem that also concerns arable land in Harjavalta, south-western Finland. **Acidification** Summarising three critical load maps does not really explain what the problems are in different grid cells. Acidifying and eutrophying deposition are different problems. Two or three separate maps are needed.	The results are generally satisfactory, but, in some examples, too much is portrayed in one or map, or combining different map layers is not appropriate.
France	25/04/2001	Completed	In general, there is a need to generate new 'mapped' information, focusing on the role of soil in the environment, although it is a very difficult exercise to talk about soil in a simple way. However, this approach is at too early a stage to meet the expectations of the public. General remarks on the maps: • high heterogeneity of the quality of data; • maps are too little and too dense, and difficult to understand; • some legends are inconsistent, mixing dissimilar data (reflecting the lack of data on a European scale). **Soil sealing** This map is very difficult to interpret: local and national data overlap each other. Problems of the coastal areas should be separated from the other data. Several smaller, generalised maps would have been better. **Soil erosion** Semiology: all the Mediterranean sea is covered by an erosion zone. Legend is inconsistent, mixing geographic (Iceland) with pedogeological definitions (loess belt) or erosion processes (wind, water). Two maps would be more readable: one showing degradations and another one showing causes. How do you interpret areas where two zones are overlapping? (i.e. eastern and southern Europe?). For France, there are a lot of	Hot-spot mapping is a good idea, however the methodology requires development, as do the associated data sets. Publishing such complex maps on such large scales poses additional problems.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			mistakes: erosion in Brittany is very exaggerated. Erosion problems are not 'mappable' by this method and it would be more convenient to wait for the results of the Pesera programme in progress at ISPRA (JRC). **Local contamination** There is too much information on this map. The use of the metal bulletin books seems to be an interesting method (buffer size of 40 km is difficult to justify). Data exists, but an effort to harmonise the definition of contaminated sites between the European countries should be done. For France, reference can be made to the database BASOL on the site of the Ministry of the Environment: http://www.environnement.gouv.fr/dossiers/sols/default.htm **Diffuse contamination** Nitrogen production is more a problem of water quality than a problem of soil, even if this one is playing an important role as a filter. The calculation for the amount of pesticides and fertilisers is satisfactory, but it could be possible to select other zones of high-pesticide use, using some items from the Corine LC nomenclature: 221, 222 (vineyards, fruit trees, etc.). Data from eastern countries is not compatible with the other information in the map. **Acidification** This is ok.	
Germany	21/05/2001; 12/06/2001; 13/06/2001; 18/06/2001	Completed	**Soil sealing** There is neither a European- or an EU-wide statistic on land consumption nor on soil sealing. As a substitution for lack of data the authors combine proxy data sets. For Germany, an estimation of soil sealing based on land-use statistics for 1993 showing that 49 % of the settlement and traffic area are sealed, that means approximately 2.1 million ha or nearly 6 % of the Fe deral area. The sealing degree depends on the regional situation and on building land prices. The sealing degree is the highest in the core cities of agglomerations and the lowest in rural regions. On average, the plots are built up with nearly 25 % of buildings. Time series indicate an increase of the sealing degree of existing building land.[3] There are estimations for soil sealing in Germany derived from land-use statistics, for the whole country and for cities and regions. But there are no similar data sets or model calculations available on a European scale. There is no simple correlation between the increase in (urban) population and soil sealing as indicated by the map. Increase in soil sealing and land consumption is a result of population behaviour and welfare as explained in the text related to the map, for example: the higher the gross value added, the higher the sealing degree, • problem 1: lack of force of expression; • problem 2: mixture of measured and projected data (time varies); • problem 3: a lot of data is only shown for selected countries; • problem 4: it is difficult to identify hot spots, to distinguish their increase in artificial surface. Alternatively, the following may provide a more accurate assessment of soil-sealing hot spots: • areas with high increase in urban fabric (e.g. 20 % in 15 years); • areas with high increase in building land prices are one reason for high soil sealing;	Many of the issues identified here were identified and debated in the development of the hot-spot maps, and are common to the other maps, not just soil sealing. In the absence of soil sealing data proxy data sets were used and these were selected on the basis that they illustrated some of the issues associated with soil sealing. However, there is a need to develop these indicators and explore the use of new ones.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			• highly urbanised areas (sealing degree > 80 %); • areas with extreme warming (urban heat island effect due to soil sealing) cause climate effects; • areas with rapid decrease of free space (green areas in urban fabric); • areas with surface compaction and puddling. **Acidification and eutrophication** Exceedances of critical loads were estimated on the basis of critical loads for several ecosystems, with respect to the actual deposition values. A problem is to combine the exceedances of critical loads for acidification and of eutrophication in one summarised map, unless the critical load function is used for acidification and eutrophication for every grid cell. Otherwise, some more information is needed for the qualification of this chapter. With respect to that, it should be remarked consequently, in the data description and the report itself, that the map is based on critical loads from CCE and their exceedances caused by deposition (EMEP data). We would like to stress to the fact that CCE is reviewing the critical load data on the base of a call for data at the end of 2000. It is recommended to use the new data set for further publications. **Usage of data sources and form of appearance of the map** As mentioned above, in principle it is possible to summarise the exceedances of critical loads for acidification and eutrophication in such a way as shown in Figure 3. Assuming that you considered the critical load function for that, a short description on the critical load function itself has to be added. However, it should be explained how the map was produced and, additionally, some explanation should be given on what the classification system 1–3 means. Furthermore, it is assumed that you involved the data set on critical loads from CCE to estimate the exceedances. This should be mentioned in this chapter in the same way as it is written on the deposition values from EMEP. As a result from that in Annex II — data sets used in project — mention that the data sources on critical loads from CCE were used is also missing. Otherwise, it is not clear how the exceedances were derived. **Local contamination** Having had a look at the CD-ROM nothing appeared to be really wrong. However, it must be stated that it appears to be lacking additional information and not representing the countrywide situation. Generally, the German comments on the datasets in the EU-98 report are still valid for the principle comments on the CD-ROM. Germany has compiled various datasets on local contamination. Countrywide datasets are exclusively based on information from the responsible authorities on the lower administration level. On this level, authorities do collect and compile data according to their own principles. Therefore, direct comparison between each of them is difficult. Originally, the data are published in tables which seems to be more appropriate, since this format allows commenting by footnotes. Mapping the data on a countrywide level implies a countrywide validity which is actually not the case. For instance, the information on iron and steelworks that are included in the CD-ROM are based on various publications from the early 1990s. The validity of these data has not been checked. Also, it is surprising that no data on military-based contamination are mapped. Germany has plenty of them and a report about military contamination is cited in the references	

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			for data sources. Furthermore, Germany has provided very specific local contamination data for the test region 'Regierungsbezirk Leipzig'. Identification of these data on the CD-ROM was not possible. **Diffuse contamination** **General remark — balance of problems shown in the map** The hot spot map on diffuse contamination focuses in the EU-15 area on inputs from agricultural use and on the pollution by nitrogen and phosphorus input. The parallel presentation of the agricultural theme in the western part and the heavy metal and radioactive contamination in central and eastern Europe gives the false impression that the problems are restricted to the areas shown in the map. In fact, with respect to the data not used, such as the heavy metal deposition, it is more a question of data availability. The concept of showing different figures, area as well as point data in one map is in principle a good one, even if it could be criticised from a cartographic point of view. **Points of diffuse contamination in eastern Europe** The locations of serious diffuse contamination in eastern Europe for which the extent of the affected area was not available are very special examples of diffuse contamination. With some deeper research, it should have been possible to find some similar points in the western area of Europe. The focus on these two references (Denisov and Mnatsakanian) implement the risk of a wrong balance. **Agricultural impacts** In the area of western Europe, the well-known areas of high agricultural intensity are shown well in this European scale. But this picture gives just a hint to the general problem. To foster the discussion about links to political responses and possible measurements, a more detailed information would be necessary. In a suitable time frame, and in cooperation with Agriculture DG and the agricultural departments of the EU Member States, some more detailed data should be available, such as for Germany. **Summary map** Looking on the summary map, it has to be noticed that the whole area of Europe is somehow affected. This map is more a figure than a map. And despite the 'problems' it is useful. However, we advise against a further attempt of any summary map. **Method of reviewing the hot spots data** This method gives a good overview about data and data sources used. The CD-ROM is a very good way to inform the user about data sources and availability.	
Greece	21/05/2001	Completed	A general remark is that there are generalisations in the documents included in the methodology, e.g. other countries' data have been considered — to some extent — for Greece too. It seems that there is a need for the elaboration of specific projects for more reliable data collection, processing and interpretation to achieve a much-improved validity level of the conclusion derived. But it is worth mentioning that the structure of the data collection, manipulation and presentation offers a common tool and therefore this effort is really important. **Soil erosion** The map indicates erosion on mountainous land, which is acceptable, but steep sloped mountains are presented together with nearby flat valleys. Nevertheless, significant erosion also takes place in hilly cultivated land that is not indicated on the map. Long-term erosion data from the Cesio-	The maps are a useful start but there is a need to develop the methodology and the associated data. A lot of additional information and data is available for Greece. Common definitions of hot spots must be developed.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments

137 erosion technique can be considered. Also, water and wind erosion takes place in the Aegean islands, which is not indicated on the map. Concerning the measurement points included, more erosion measurement plots have been established by the Agricultural University of Athens, Forest Research Institute and Soil Institute of Athens. Some erosion data from Greece seem to be missing. The erosion rates recorded deviate in some cases significantly from those reported in the review data spreadsheet. Due to lack of accurate data on soil erosion rates and the inefficiency of the existing erosion models to predict rates at regional levels, the approach used may be accepted as one of several possible. The results may be considered as preliminary, with the possibility of large deviations. The results expressed numerically (tonnes/ha/yr) could be strongly disputed. The Pesera programme has so far shown that it may produce more accurate results but it needs further development. Another programme, which may be considered, is the Spanish Impelero model.

Diffuse contamination
Fertilisers – Pesticides
The map indicates average fertiliser values for region areas between 108 and 141 Kg/ha which are not the actual spreading rates. Considering that the wheat and cotton actual spreading fertiliser rates, two crops that cover in some agricultural areas more than 90 % of the cultivated land, are almost of the same magnitude as the ones on the map, the values seem too high. A better approach to estimate pesticides and fertiliser application rates would be to stratify the agricultural areas to various crops used. The area covered by each major crop is known and recorded annually and the recommended amount of each fertiliser is also known. Using these data, the fertiliser and pesticide amounts in each particular region can be estimated rather accurately. The area covered by the main crops can also be derived from satellite images.

Nitrogen production by livestock
The map indicates quite significant nitrogen production in the Epirus region. In Greece, the manure is not used to meet the fertiliser recommendation rates of cash crops. Chemical fertilisers are used to cover the N-needs of the crops and the livestock inputs is not significant. The livestock system does not favour point manure production. So the figure in the map shows considerable nutrient input as it happens in some parts of northern Europe, which is not the case for Greece and not comparable.

Local contamination
This map could include some more specific information, for example in the cases of:
- coal mines: indications in the areas of Ptolemais (western Macedonia) and Megalopolis (central Peloponnissos);
- metal mines (mainly): Kassandra mines (Chalkidiki), Lavreotiki area (Attica);
- also, the asbestos mine in Zidani (Kozani, western Macedonia) could be included in contaminated mining areas.

Soil sealing
The Corine land-cover data could be used to estimate the areas where urban expansion takes place. Air photos of test sites at various time intervals may be used to calculate rates of change. Some could be achieved from urban planning authorities, which keep records of urban expansion in various areas. Of course the aforementioned approach might be more time consuming and expensive. Conclusions based on population density require a more thorough analysis, since there is a tendency – as the living

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			standards of the population are improved - for lower building density in new residential areas.	
Ireland	19/04/2001; 29/05/2001; 18/06/2001	Completed	**Map 1 — Probable problem areas of soil sealing in Europe** The LaCoast data presented has been completed for Ireland showing an urban increase of 10 %, however, the map does not show this. **Map 2 — Probable problem areas of soil erosion in Europe** There is no information included in the data sets on Ireland in relation to soil erosion. Information on soil erosion in Ireland is limited, however there are areas, particularly in the west of Ireland, where soil erosion is occurring. Some details follow: increases in sheep numbers grazing on the upland peatlands particularly in the west and north-west of Ireland has lead to overgrazing of natural vegetation making these soils more susceptible to erosion. Soil erosion from blanket peats in upland areas which experience high rainfall (ca. 2 500mm/annum) and windy conditions is a natural phenomenon, however the rate of erosion is exacerbated by overgrazing of the natural vegetation, leading to increased risk of soil erosion. The amount of soil loss in tonnes/ha/yr has not been quantified in detail, however some research undertaken in Ireland would indicate soil losses ranging from 0.37 mm average annual loss to 2.628 mm of peat over the sub-catchment used in the research. Where severe overgrazing has occurred, the natural blanket peat has totally disappeared, exposing the underlying geological material. **Map 3 — Probable problem areas of local contamination in Europe. Areas with high probability (location of areas of heavy industry)** Large-scale steel works were used as the indicator for areas of heavy industry. For Ireland, this map therefore represents one steel manufacturing plant which is located in the south of Ireland. As this represents only one plant in Ireland, the EPA feel that this is not a good indicator for use for Ireland. **Evidence of contamination (industry/contamination type)** No areas have been identified in Ireland in this map. Certain industrial activities which occur in Ireland have been identified as probable causes of soil and/or water contamination. Of the activities listed in Map 3, the following occur in Ireland: • metal mines, • chemical industry, • mixed industry, • power generation, • waste disposal, • heavy metals. A more explicit description of the thresholds (i.e. scale of activity) used to select activities for inclusion in Map 3 should have been provided. In addition, the evidence used to quantify contamination should have been described. **Map 4 — Probable areas of diffuse contamination in Europe** The term 'diffuse pollution' used in relation to the over-application of plant nutrients to soils was not deemed appropriate since an excess of nitrogen, phosphorus or potassium in soil will not require these lands to be taken out of production or require a change in use. In contrast, soils contaminated by heavy metals or organic pollutants may require a change of landuse and could potentially pose a risk to human and animal health. Areas of high pesticide use: the values used are averages for regional areas and not actual application rates. Can hot spots be identified when data presented at a regional or country level is used, and is it more likely that hot spots will occur within these regions?	There is a need to more explicitly describe the methods and calculations used in the analyses of the statistics and the development of the maps. In the case of Ireland, more up-to-date data is available. However, it is important that a common timeframe be applied to all countries to ensure comparability. This should be made explicit and, if appropriate, references given to more up-to-date sources of data. However, the issue of using contemporary data is difficult since some countries will have more contemporary (and comprehensive) data sets than others.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			Areas of high fertiliser use: the term fertiliser should be clearly described i.e. chemical nitrogen fertiliser and /or chemical phosphorous and potassium. Utilised agricultural area would give a more accurate representation rather than total land area. Chemical fertiliser usage for Ireland is available. Area of high nitrogen production: detailed examples of calculations should have been presented. **Map 5 — Probable problem areas of acidification in Europe** For information in relation to acidifying and eutrophying deposition please contact Ms. Annmarie Tuohy, EPA, Johnstown Castle (e-mail address a.tuohy@epa.ie).	
Italy	15/05/2001; 26/042001	Completed	**Acidification and eutrophication** The data sources used for this theme are the best available for Italy. Consideration should be given to using the RIVM approach of calculating and mapping of critical loads in Europe (1995, 1997 and 1999). **Diffuse pollution** As a general comment on the methodology used for the project, normalising the data to the total land area within the NUTS2 region is not appropriate for mountain regions (such as Liguria and Valle d'Aosta) where the agricultural area is usually small, but the chemical use may be locally intense. **Pesticide** Using a national average rate based on ISTAT statistics (1996, 1997) and following the methodology adopted in the project, we would add the Basilicata region to the Italian hot spots in Figure 3. However, the estimated intensity use of pesticide is greater than 2 kg/ha in almost all Italian NUTS2. Using a regional average rate (ISTAT 1996), we would identify as hot spots the following NUTS2: Piemonte, Veneto, Emilia Romagna, Campania, Puglia and Sicilia, obtaining a rather different map from that of Figure 3. **Fertilisers** The data used in the project agree with those published by ISTAT (1996, 1997), and, using a national average, no region seems to use more than 100 kg/ha of fertilisers. Again, different results are obtained when using regional data: in this case we would estimate more than 100 kg/ha for Veneto, while the value is not far from 100 kg/ha in Lombardia and Emilia Romagna. **Soil erosion** The European Soil Bureau (JRC, Ispra) published the report **Soil erosion risk assessment in Italy** (Johan M. van der Knijff and Robert J.A. Jones, Interim report, August 1999). The erosion was computed through the universal soil loss equation (USLE). **Local contamination** The assessment of local contamination in Italy will be available when the national inventory of contaminated sites, after the decree DM 471/99, has been completed. In the meantime, preliminary information can be obtained through the so-called 'Piani regionali di bonifica' (regional remediation plans), that are prepared according to decree DM 185/89. In those plans both contaminated sites and potentially contaminated sites (including those with a high probability of soil contamination) are included. Although the location of steelworks can be used as a proxy indicator for this kind of industrial contamination, the buffer zones of 40 km around the cities are misleading. In fact, in Italy, the buffer zones identify all the Po river valley, part of Marche and of Abruzzo Regions	A very comprehensive report was submitted for this assessment including maps. The maps and data could be considered for updating future hot-spot maps.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			as potentially contaminated areas. This picture does not represent the reality and the resulting risk seems too high as well. It would be more appropriate to keep point sources as such. **Soil sealing** Referring to the map of Figure 4 'Problem areas of soil sealing through urbanisation in Europe', our feeling is that mapping the LaCoast data at NUTS5 level would allow an understanding of whether the soil-sealing process in coastal zone is linked with the development of tourism or with the expansion of 'urban' and 'suburban' areas. **Other comments** We all have found the way of distributing the documents and the data very striking. We had no problems using the navigation tool and the GIS software. However, for future reviewing, it would be useful not to have the GIS data projected in GISCO format, but rather in latitude and longitude. This would make it easier to compare the project results with Italian data, because data representation in our national map projection was somehow not satisfactory.	
Latvia	16/05/2001	Completed	The overall picture about the evaluation and reflection of the Baltic States, including Latvia, is that out-of-date information has been used in the report. This does not show the current and real situation in Latvia. The latest official information is available in the publications: • *Second Baltic state of the environment report based on environmental indicators,* produced by the Baltic Environmental Forum, Riga, 2000; • regular Latvian state of the environment reports (1996-98). **Local contamination** The situation in Latvia has been changed. There is no presently observed pollution around Ventspils city. Heavy industry (metallurgy) developed in Liepaja city causes soil pollution problems in the vicinity of Liepaja. **Diffuse contamination — agriculture** It is not possible to agree with the statement of Mr. Denisov et al., that there is medium-level diffuse contamination of soils in Latvia. As the soil investigations show, the pollution of soils in Latvia generally is very low, in some isolated cases — medium level. It is not known what is meant by 'other components' in the map. **Soil sealing** This map also needs to be corrected concerning the Latvian situation. The suburban zone has been expanded around Riga city. **Soil erosion** There are no precise calculations of the intensity of soil erosion in Latvia. Nevertheless, it is obvious that wind erosion in the coastal zone, and water erosion of soils in upland areas, is developing. Those areas, as has been done in the case of Poland, should be reflected on the map.	There is a need to update the data collected (this seems a common problem for CEE countries).
Liechten-stein	16/03/2001	Declined	Do not have the capacity	
Lithuania	29/05/2001	Completed	Contemporary data on soil pollution is available, although that presented in the maps generally reflects the Lithuanian situation. However, some information, especially concerning diffused pollution, is slightly misleading. For example,	More contemporary data should be used.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			pollution in rivers has decreased in recent years. After broad consultations with the experts, we came to the conclusion that this information can be used since it is not wrong, although it is out of date.	
Luxem-bourg	10/04/2001	Declined	Do not have the capacity.	
Nether-lands	5/06/2001	Partial	**General comments on diffuse contamination.** Map 4 was deemed acceptable, based on the important data sets and is a useful first step. To include data on actual contents of contaminants in the soil would have required much more time but is nonetheless important. The results for eastern Europe are felt to be less reliable. With respect to diffuse contamination, a definition of 'contamination' would be useful. The way in which diffuse contamination in western Europe is estimated (excluding atmospheric deposition of heavy metals) restricts the contamination to agricultural soils. Heavy metal contamination of nature areas affecting biodiversity is not considered. In many European countries, soil quality monitoring networks of some kind do exist. In many countries, the actual contents of pesticides, heavy metals, nutrients, PAHs etc, are well known. It is absolutely necessary to include the actual contents of contaminants in the soil in a future review on diffuse soil contamination. Only by combining actual contents with actual accumulation rates, can a real assessment of diffuse soil contamination risk be made. There was strong disagreement with Section 2.2.1 of the report 'Analysis and mapping of soil problem areas in Europe' where the rejection of the heavy metal deposition rates is justified. Firstly, for nature areas, with very vulnerable ecosystems, heavy metal deposition is the main (and often only) source of diffuse contamination. Secondly, for some metals (e.g. Pb, Cd), atmospheric deposition is often more important than supply via fertiliser or manure. Thus, if the latter two are included in the estimation of diffuse soil contamination risk, so should atmospheric deposition. The cited background values in Berlin are very likely not natural background values, but caused by atmospheric deposition during the last decades/century. Therefore, the high background values for Pb and Cd are proof that atmospheric deposition is important. With the cited maximum deposition rates, the Cd content values for Berlin may be doubled in the relatively short time-span of some 25 years.	Terminology needs to be carefully described and set out in the report to avoid confusion. There is a need to collect data for natural areas as well as agricultural land.
Norway	06/06/2001; 16/05/2001: 06/06/2001	Completed	**Local contamination** The map 'Problem areas of local contamination in Europe' is based on the ironwork dataset, which is considered to be of acceptable quality for the purpose of the report. A more precise definition of 'hot spots' should have been worked out in order to increase the relevance of maps. **Diffuse contamination** Pesticides and fertiliser use and nitrogen production. No data from Norway is presented in the report. Fertiliser and pesticide use at national level are reported to FAO, Eurostat and the OECD. There is no reporting from Norway on nitrogen production by livestock. (It is not clear whether the nitrogen production is the total nitrogen produced, including volatile ammonia, or the net nitrogen spread as manure.) The national databases at Statistics Norway have rather detailed statistics about fertilisation and livestock. Sale statistic for fertiliser is available for county level (NUTS3) and can be aggregated to NUTS2. The sale statistic for pesticides is only available at	The definition of 'hot spot' should be explicit and the general methodology developed. Scale and the time frame are important elements.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments

national level but should be calculated for regions with a method similar to that presented in the report as described in pp. 10-11. It should be taken into account that most of the pesticides are spread to cash crops like grain and vegetables, which are cultivated in certain regions in south-east and mid-Norway, while grass for harvesting, where use of pesticides is negligible, is the predominant crop for the remaining part of the country. Therefore, the calculation method should need some modification in order to reveal hot spot areas in Norway. The nitrogen production by livestock can be calculated at any geographical level based on the agricultural statistic (number of animal species and coefficients for nitrogen production). Both total nitrogen produced and nitrogen spread as manure can be calculated.

Acidification and eutrophication
The map 'Acidifying and eutrophying deposition' is based on the EMEP 150 km grid. In Norway, a more detailed grid (50 km) is developed by the Norwegian Institute for Air Research and the Norwegian Institute for Water Research. The original data set, which is equivalent to the meteorological observation net, includes 800 plots.

Soil erosion
No erosion data for Norway is presented in the 'hot spot' map. In general, erosion can be considered to be moderate in Norway compared to central and southern Europe, mainly because of the vegetation cover, high soil organic-matter content and low rain intensity. However, in some areas with grain production, silt and silty clay soils and hilly landscape, water erosion is a serious problem and a source of water pollution. Erosion in Scandinavia is also influenced by autumn/winter rain, freezing/thawing periods in the winter and snow melting in winter and spring. There are different programmes for soil erosion assessment in Norway:

- the soil survey programme includes cultivated land and areas prone to water erosion have been given the highest priority. From the detailed soil maps risk maps for sheet erosion are derived;
- the agricultural environmental monitoring programme that has completed its seventh year of analysing soil loss (water erosion) and nutrient balance. The monitoring programme includes 10 catchments in different regions in Norway.
- a total of 20 years' data series for soil loss measurement in selected plots near Oslo.

There are still needs for monitoring, data analysis and data management in order to reveal hot spots of soil erosion in Norway.

Soil sealing
Predicted rate of population increase in urban areas is used as an indicator on soil sealing. The map presented on page 22 shows a predicted increase in urban population for Norway of >20 % between 1990 and 2025. Statistics Norway, which is responsible for Norwegian population statistics, is unacquainted with this figure and could therefore not approve it. It is our opinion that the predicted rate of population increase in urban areas is a rather poor indicator on soil sealing caused by urbanisation. This is because the real soil sealing depends highly on the number of inhabitants in a certain area, the population density, policy etc., in addition to the percentage increase of the urban population. As an example from the map, Iceland (where soil sealing can hardly be considered as a serious soil degradation problem) seems to have a higher increase of urban population than, for example, Austria.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
Poland	5/06/2001	Completed	**Local contamination** There are no nuclear power stations in Poland. Therefore, we find the location of radioactive 'hot spots' on Polish territory illegitimate. Including this kind of hazardous waste into overall waste group is very controversial and could be mistaken. Thus, it may be better to display radioactive waste as a separate waste group. **Diffuse contamination — agriculture** The most relevant and reliable source of data on the use of fertilisers in Poland is the Polish Central Statistical Office (CSO). They are available in the latest *Statistical Book — Environment 2000* and on the CSO web site at: http://www.stat.gov.pl. **Soil sealing** The data concerning the projected increase in urban population between 1990 and 2025, which have been presented for Poland, seem to be unreal and overestimated (>20 %). The relevant statistical data can be found in the annual statistical books on demography (e.g. in the decade 1990–2000 the percentage of change in urban population was approximately 0.2 %). **Soil erosion** The most relevant data source in this scope, are studies performed by the Institute for Soil Science and Plant Cultivation in Pu³awy. Some of them were published by the Chief Inspectorate for Environmental Protection in the publication series entitled *Environmental Monitoring Library*: *Erosions and anti-erosion land improvements*, *Environmental Monitoring Library*,1996 (available only in the Polish version) *Agro-ecosystem erosions — Environmental Monitoring Library*, 1995 (available only in the Polish version).	More precise and up-to-date data should be used, much of which is available from government departments.
Spain	21/052001	Completed	**Acidification and eutrophication** Because there is not a separate representation of acidifying N, acidifying S and eutrophying N, it is not possible to distinguish which critical load is represented. Northern areas of Spain such as Galicia and Asturias should probably be included as regions where critical loads of acidifying N and S are exceeded. **Diffuse contamination** We do not agree with the consideration of Spain as an area of low agricultural chemical use. According to our data, there are high consumption rates of pesticides at least in the south and southeast area of Spain. For example, in Murcia region, there was a consumption of approximately 110.7 kg/ha of pesticides in irrigated areas during the year 2000. We are also considering Asturias along with Galicia, and perhaps some other regions, such as the Basque Country, should be included as areas of high N production by livestock. **Soil erosion** It would be more accurate to divide Spain into two different erosion zones: the Mediterranean zone and the Atlantic zone that, according to their water balance, have significant differences in their erosion rates. As an example, we enclose the climatic diagrams of Malaga and Santander in Spain and of Plymouth in the UK (see the enclosed file 'Climatic diagrams.cdr'). As it is observed, the climatic conditions of the last two regions are much more similar between them than the ones of Malaga and Santander. For data compilation at a national level, there is a series of maps, published by the former ICONA (Instituto para la Conservación de la Naturaleza), about the erosion state for all the Spanish territory detached by river basins.	Common data sets should be applied to all the countries represented in the maps. Additional and more detailed data is available.

Country	Received	Status	Summarised comments received	Conclusions drawn from comments
			There are also two interesting data sources at a regional level: the Andalusian Regional Ministry of Environment (http://www.cma.junta-andalucia.es/) and the Navarra Soil Service (http://www.cfnavarra.es/) **Local contamination** It would be very interesting to include, as has been done for central and eastern Europe, the industry/contamination type. This would allow a more accurate image of the environmental risk for these sites, which is, at the same time, associated with the specific chemical compounds that are likely to be present. It would be necessary to define what is considered as 'heavy industry'. **Soil sealing** We consider that two separate maps representing population growth and changes in land use would be more useful for assessment and policy-making as well as easier to interpret for non-specialist groups. **Summary map** More coordination is needed between thematic maps and the summary map. For example, in the diffuse contamination map, Spain is an area of low agricultural chemical use whilst in the summary map it is considered as an area where diffuse contamination is present. **Other comments** We recommend the use of the CLC 2000 to elaborate future maps and reports, at least for some topics, as it is a reliable and objective tool that provides homogeneous data at a European level. For example, agricultural areas in CLC 2000 are expected to be areas where diffuse contamination is present.	

The following comments were received and added separately here since they do not represent the official comment of the Belgium EIONET.

Belgium	25/07/2001	Completed only for soil erosion	Comments were based on a recent publication (Steegen A., Govers, G., Takken, I., Nachtergaele, J., Poesen, J. and Merckx, R., 2001), which describes factors controlling sediment and phosphorous export from two Belgian agricultural catchments. Some more recent information is published. Observed erosion rates are: 10.0 tonnes per ha per year for a 250 ha catchment (in this catchment an extreme event may have skewed the results) over a period of 30 months. 6.75 tonnes per ha per year in a 117 ha catchment (with not such an extreme event) over a period of 18 months. These erosion rates are based on the area of arable land in the catchment. Data on phosphorous is also available. The catchments are in loess areas, and land use is mainly arable (80-90 % with wheat, potatoes, maize and sugarbeets as the main crops). Measured phosphorous export from the catchments is equivalent to 5.45 kg per ha per year for the 250 ha catchment and 1.38 kg per ha per year for the 100 ha catchment if only arable land is considered as a P source and 4.4 kg per ha per year for the 250 ha catchment and 0.75 kg per ha per year for the 117 ha catchment if total area is considered.	Illustrates the ongoing work at the small catchment level and the need for the EEA to ensure that it is regularly updated of such work. This data could be incorporated as point data into the hot-spot erosion map.

Conclusions and recommendations of the review

The comments received from the EIONET review concerning hot spot mapping and geographical analyses is varied and, in some cases, contradictory. Nevertheless, it is possible to draw out some common conclusions and recommendations for the EEA.

1. The CD-ROM application was gener ally well received and enabled the EIONET reviewers to access and visualise the data used to produce the final map. Some reviewers had problems with using the GIS browser, but because the GIS data was in acommonly-used format (i.e. ESRI shapefiles), they were able to visualise the data using their own GIS. The EEA should continue to explore the development of such applications such as the use of CD-ROM and HTML hyperlinked documents and embedded GIS software to facilitate data reviews.
2. All reviewers pointed out that better or more up-to-date data was available for their country. However, this may pose problems for the EEA in (i) accessing this data; (ii) ensuring that all data sets used are of a common time frame; (iii) that the data provided by each country is 'harmonised' and therefore comparable. Whilst countries undertake to collect data and statistics that may be suitable for hot spot mapping, it is the authors' opinion that the use of published international data sets should be used for this type of exercise. However, reference can be made to more contemporary data sets identified by EIONET countries.
3. There is a need to develop the concept of the term hot spot to avoid any ambiguity in what is trying to be portrayed. Hot spots could portray issues associated with human health or environmental health and there needs to be a clear distinction between this. EEA should seek to clearly define what is meant by 'hot spot'.
4. The issue of scale is important and, in some instances, too much information is portrayed on one map, thereby making it difficult to interpret or even meaningless. Consideration should be given to giving greater space in publications to maps or reducing the amount of information portrayed.
5. The EEA has invested some resources in hot spot mapping (EEA, 1999a and EEA, 2000a) and, in general, there seems to be a consensus that hot spot maps are useful in conveying information. However, there is considerable need to develop a consistent methodology and data set(s) for hot spot mapping. In addition, greater time should be allocated to undertaking this and the review process before EEA publish follow-ups to these maps.
6. For central and eastern Europe (and in some cases the EU) the maps indicate more a lack of data rather than hot spots per se. Where data is not available for the whole of pan-Europe, different data sets have been used, thereby making comparisons across continental Europe impossible - in effect the maps are portraying different issues. It is important to use consistent and homogeneous data sets for all countries mapped.
7. The maps generate debate and are a useful way to solicit opinion and identify where additional data sets may be obtained.
8. The integration of spatial data with administrative data sets should be developed in addition to indicators that can be reported spatially. The EEA, in consultation with other Commission services, is undertaking work (EEA, 2001a) in this area and this should be incorporated into any further hot spot mapping and geographical analyses.

The following comments refer to the feasibility and potential to develop the maps further and are based on feedback from the EIONET review, discussions with workshop delegates and the authors' own judgement. The comments are made without any reference to the costs or associated resources that may be necessary to undertake the tasks.

Soil erosion: the EC fifth framework project Pesera (see workshop report on soil erosion for a full description and progress in monitoring soil erosion in Europe; EEA, 2002) is currently developing a methodology for assessing

and mapping soil erosion risk at the European scale, based on empirical models. The results generated from this work would be a useful source of information for future hot spot mapping of soil erosion and would enable the EEA to identify and prioritise areas for monitoring and assessment. However, the results will only indicate the potential soil erosion risk. Actual soil erosion will require field-based monitoring data. A number of member countries have reported that data is being collected quantifying soil lost for some catchments. This data could also be usefully incorporated into the hot spot map for soil erosion. Issues of data harmonisation would need to be considered. Additional sources of data or information may become available once the water framework directive (WFD) had been implemented. The LUCAS project, managed by Eurostat and Agriculture DG and undertaken by all EU Member States may be a useful source of information and is based on field surveys.

Nonetheless, soil erosion is a serious problem in Europe, yet the availability of measured data is very poor. Thus, effort should be put into:

- the establishment of appropriate monitoring schemes to assess current rates of erosion;
- the creation of schemes to bring together existing measured data, including information regarding collection methodologies;
- the production of a more detailed map based upon this data.

There has been some recent progress on the second point. The establishment of international groups such as the IGBP-GCTE soil erosion network (Ingram et al., 1996) and EU Cost Action 623 'Soil erosion and global change' (see http://www.cost623.leeds.ac.uk/cost623/) have enabled erosion researchers to begin to establish dialogues which will eventually lead to a better-harmonised and more freely-available pool of data on erosion.

Diffuse pollution: diffuse pollution of soil for the EU Member States has been presented as an agricultural problem due to nitrate and phosphate from inorganic and organic manure. Pesticides have been considered but proxy data used to represent this rather than pesticide usage per se. For CEE countries, there are other sources of diffuse pollution such as nuclear production (radioactive contamination) and industry (hydrocarbons). Future maps portraying diffuse pollution must take a more consistent approach across Europe by considering or addressing the same problem. In effect the diffuse pollution map illustrates an agricultural problem in the EU-15 and an industry and radioactive contamination problem in CEE countries, thus making European comparisons difficult. Eurostat is collecting agricultural data for the CEE countries that would enable an agricultural diffuse pollution map to be calculated for this area of Europe. Pesticide usage data for CEE countries is also recorded by the associated statistical departments and it is possible that this could be mapped, or a similar approach applied, in the hot spot mapping indicating low agricultural chemical usage based on land cover. Eurostat will expect to have new pesticide statistics available in early 2002. The farm structural survey (FSS) for 2000, covering the EU, will be available around mid-2002 and new nutrient balances could be calculated then. It is anticipated that many CEE accession countries will participate in the 2003 FSS. This data will be a useful source for updating the diffuse pollution map concerning agricultural problems. The EEA should seek to source data from EU Member States concerning radioactive contamination or areas of diffuse contamination from industry.

Local contamination: the 'iron works' data set seems adequate for illustrating the problem of local contamination. This data set needs updating though for CEE countries. If feasible, the 'iron works' database should also capture the detail reported on for CEE countries i.e. reflect the contamination type (e.g. coal mine, shale mine, oil and gas extraction, chemical industry). Many of the EIONET reviewers indicated that other data sets were available for their country and these could be used to update or expand the map, although care must be taken to ensure comparability between countries in the data selected.

Acidifying and eutrophying deposition: the data used in the study is based on EMEP 1996. More recent data should be sourced

from EMEP and, if available, at a higher resolution. Consideration should be given to working with EMEP to explore if the data layers collected can be combined to identify hot spots of deposition.

Soil sealing: this report makes recommendations concerning the updating of the soil-sealing map. The JRC Murbandy and LaCoast databases probably allow the best assessment of soil sealing, although not even these databases comprehensively cover Europe. Comparisons in the Corine land-cover maps for 1990 and 2000 would provide an indication of the expansion of urban areas and the consequential loss of soil and this may be a more useful and simpler map to interpret and use than the one published in the 'Down to earth' report.