Green infrastructure and territorial cohesion
The concept of green infrastructure and its integration into policies using monitoring systems

European Environment Agency

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Executive summary

The point of departure for this analysis is to support the European process towards territorial cohesion and green infrastructure development, in particular the development of a strategy for green infrastructure. This report explores the concept of green infrastructure, with illustrative examples of green infrastructure initiatives on the ground and further analyses of the integration of green infrastructure into policy sectors. It provides examples of monitoring systems/spatial information that can be utilised for spatial planning of green infrastructure at national and regional levels, and closes with exploitable opportunities and conclusions.

The concept of green infrastructure

No single widely recognised definition of green infrastructure is identified in literature. However, the latest European Commission description of green infrastructure, shown in Box ES.1, adopts an all-embracing version of the concept.

A number of key underlying features and principles of the green infrastructure concept are identified from the literature, including connectivity, multifunctionality and smart conservation. Based on the range of benefits, it is possible to group the definitions of green infrastructure broadly under two concepts based on scale: urban scale and landscape scale (regional, national and transnational). These two uses of the term are obviously related — in both cases, the focus is on the development and protection of networks of green, natural features. Green infrastructure is not only about connecting ecosystems per se, but also about strengthening them and their services — something which can be achieved by (re)-connecting measures, but also by improving the landscape's permeability (which implicates different ecosystems). However, the baseline land use is different: in the first case, it involves a built-up urban area; in the second case, it can involve a built-up area as well as intensively farmed land, or simply an ecosystem of a different type to the one we are trying to connect.

The tools and approaches used to manage green infrastructure tend to vary at these different scales, as do the key sets of benefits green infrastructure can deliver. There is also a difference between the physical structures counting as a part of the green

Box ES.1 What is green infrastructure?

Green infrastructure is a concept addressing the connectivity of ecosystems, their protection and the provision of ecosystem services, while also addressing mitigation and adaptation to climate change. It contributes to minimising natural disaster risks, by using ecosystem-based approaches for coastal protection through marshes/flood plain restoration rather than constructing dikes. Green infrastructure helps ensure the sustainable provision of ecosystem goods and services while increasing the resilience of ecosystems. The concept is central to the overall objective of ecosystem restoration, which is now part of the 2020 biodiversity target.

It also promotes integrated spatial planning by identifying multifunctional zones and by incorporating habitat restoration measures and other connectivity elements into various land-use plans and policies, such as linking peri-urban and urban areas or in marine spatial planning policy. Its ultimate aim is contributing to the development of a greener and more sustainable economy by investing in ecosystem-based approaches delivering multiple benefits in addition to technical solutions, and mitigating adverse effects of transport and energy infrastructure.

Source: Directorate-General for the Environment ([1]).

([1]) See http://ec.europa.eu/environment/nature/ecosystems/green_infrastructure.htm.

infrastructure. For example, a field inside the city might count towards urban green infrastructure (if it provides an area suited to water infiltration and can also be used for recreation, for example), but agricultural land may not be commonly counted towards green infrastructure in the broader landscape, when the focus is on potential migration corridors for particular species.

The key, however, is to understand green infrastructure as more than a sum of its parts — functional interconnectivity brings added benefits to green assets that previously may have been recognised only for a single function, such as parks, coastlines or embankments. A disconnected series of inadequately managed natural elements deliver far fewer public benefits than they have the potential for — the approach that seeks to maximise those benefits is at the core of green infrastructure.

Following on from the importance of interconnectivity, green infrastructure can be further understood in two other ways. A broader definition uses the term to include both green spaces and the fact that they are interlinked. A narrow definition uses it only to refer to the linkages and to the concept of interconnectivity.

The classification of green infrastructure benefits depends on which definition is used. In the broadest sense, green infrastructure carries all the benefits provided by green spaces and structures that are integral to it. In the narrow sense, the benefits of green infrastructure are only the additional ones derived from interlinking: possibility of species migration, resilience to change including climate change, higher recreational value, etc. A comprehensive list of the potential assets that make up green infrastructure (Landscape Institute, 2009) can be grouped into three broad categories of scales:

*   local, neighbourhood and village scale;
*   town, city and district scale;
*   city-region, regional and national scale.

Table ES.1 Potential assets that make up green infrastructure grouped into three scale groups

Local, neighbourhood and village scale	Town, city and district scale	City-region, regional and national scale
• street trees, verges and hedges • green roofs and walls • pocket parks • private gardens • urban plazas • town and village greens and commons • local rights of way • pedestrian and cycle routes • cemeteries, burial grounds and churchyards • institutional open spaces • ponds and streams • small woodlands • play areas • local nature reserves • school grounds • sports pitches • swales (preferably grassed), ditches • allotments • vacant and derelict land	• business settings • city/district parks • urban canals • urban commons • forest parks • country parks • continuous waterfronts • municipal plazas • lakes • major recreational spaces • rivers and floodplains • brownfield land • community woodlands • (former) mineral extraction sites • agricultural land • landfill	• regional parks • rivers and floodplains • shorelines • strategic and long distance trails • forests, woodlands and community forests • reservoirs • road and railway networks • designated greenbelt and strategic gaps • agricultural land • national parks • national, regional or local landscape designations • canals • common lands • open countryside

A green infrastructure approach to land use and spatial or territorial planning promotes the widest range of functions that can be performed by the same asset, thereby unlocking the greatest number of benefits. This approach can help manage land in a more sustainable way, maximising the potential multiple benefits and managing the potential conflicting demands and pressures, such as housing, industry, transport, energy, agriculture, nature conservation, recreation and aesthetics.

Green infrastructure can provide environmental, economic and social benefits. It can encourage greater integration of the concerns surrounding sustainable management and use of our natural capital that forms the basis for a healthy economy. Investment in green infrastructure, in development and use of ecosystem-based approaches to adaptation and mitigation provides jobs and business opportunities, and thus contributes to biodiversity objectives and to a green, resource-efficient and low-carbon economy.

Table ES.2 Potential topics and benefits of green infrastructure grouped according to main ecosystem service types

Habitat services

1. Biodiversity/species protection:
   (a) habitats for species
   (b) permeability for migrating species
   (c) connecting habitats

Regulating services

1. Climate change adaptation:
   (a) mitigating urban heat island effect
   (b) strengthening ecosystems' resilience to climate change
   (c) storing floodwater and ameliorating surface water run-off to reduce the risk of flooding
2. Climate change mitigation:
   (a) carbon sequestration
   (b) encouraging sustainable travel
   (c) reducing energy use for heating and cooling buildings
   (d) providing space for renewable energy

Provisioning services

1. Water management:
   (a) sustainable drainage systems — attenuating surface water run-off
   (b) fostering groundwater infiltration
   (c) removal of pollutants from water
2. Food production and security:
   (a) direct food and fibre production on agricultural land, gardens and allotments
   (b) keeping potential for agricultural land
   (c) soil development and nutrient cycling
   (d) preventing soil erosion

Cultural services

1. Recreation, well-being and health:
   (a) recreation
   (b) sense of space and nature
   (c) cleaner air
   (d) tourism/ecotourism
2. Land values:
   (a) positive impact on land and property
3. Culture and communities:
   (a) local distinctiveness
   (b) opportunities for education, training and social interactions
   (c) tourism opportunities

Green infrastructure is already a widely used concept; many examples exist of its application at various scales and for different purposes. This report includes several case studies illustrating the potential benefits of green infrastructure and the different delivery mechanisms in practice.

An investigation of the link between green infrastructure and ecosystem services illustrates the synergy between the two. Indeed, the purpose of green infrastructure can be construed as maintaining, strengthening and restoring ecosystems and the services they provide. From an analysis of a typology of ecosystem services and of the potential benefits of green infrastructure, links are identified across all categories of ecosystem services: provisioning, regulating, habitat and cultural.

Key opportunities include the following:

1. Whilst there is no recognised definition of green infrastructure, is not necessarily important to try to define it as a single concept, given its broad application. However, using and promoting key principles of green infrastructure is a more useful approach.
   Key principles could include:
   (a) strategically planned and delivered network of high-quality green spaces and other environmental features;
   (b) delivering multifunctional benefits
      — designing and managing land as

a multifunctional resource capable of delivering a wide range of environmental and quality-of-life benefits, including maintaining and improving ecological function;
   (c) helping to deliver place-making
      — recognising the character and distinctiveness of different locations and ensuring that policies and programmes (spatial planning and other sectors) respond accordingly;
   (d) delivering 'smart' conservation — addressing the impacts of urban sprawl and fragmentation, building connectivity in ecological networks and promoting green spaces in the urban environment (including through adaptation and retrofitting).

2. Green infrastructure benefits could be presented in terms of ecosystem services as this provides a relatively consistent and effective language that also has growing resonance with policymakers and other stakeholders. However, green infrastructure includes the spatially explicit delivery of ecosystem services — this is the difference and added value compared to the more general and implicit description of ecosystem services. Green infrastructure can be used to show benefits and deficits on local, regional and national levels, and therefore is closer linked to planning, decision-making and policymaking. This might be an argument supporting the use of the term green infrastructure in place of the more abstract ecosystem service concept.

Table ES.3 Relationships between green infrastructure benefits and ecosystem services

Main ecosystem service-types	Biodiversity/ species protection			Climate change adaptation			Climate change mitigation			
	Habitats for species	Permeability for migrating species	Connecting habitats	Mitigating urban heat island effect — evapotranspiration, shading & air flow	Strengthening ecosystems' resilience to climate change	Storing floodwater & reducing run-off to reduce risk of flooding	Carbon sequestration	Encouraging sustainable travel	Reducing energy use for heating and cooling buildings	Providing space for renewable energy
Provisioning										
1. Food										
2. Water						●				
3. Raw materials	●									●
4. Genetic resources										
5. Medicinal resources										
6. Ornamental resources										
Regulating										
7. Air quality								●		
8. Climate regulation				●	●		●	●	●	●
9. Moderation of extreme events						●				
10. Regulation of water flows						●				
11. Waste treatment, especially water purification										
12. Erosion prevention										
13. Maintenance of soil fertility										
14. Pollination										
15. Biological control										
Habitat										
16. Maintenance of life cycles of migratory species	●	●	●		●					
17. Maintenance of genetic diversity										
Cultural										
18. Aesthetic information										
19. Opportunities for recreation and tourism										
20. Inspiration for culture, art and design										
21. Spiritual experience										
22. Information for cognitive development										

Table ES.3 Relationships between green infrastructure benefits and ecosystem services (cont.)

Water management			Food production and security				Recreation, well-being & health			Land values	Culture & communities		
Sustainable drainage systems — attenuating surface water run-off	Fostering groundwater infiltration	Removal of pollutants from water (e.g. reed beds)	Direct food & fibre production on agricultural land, gardens, etc.	Keeping potential for agricultural & food security (safeguarding soil)	Soil development and nutrient cycling	Prevent ing soil erosion	Recreation	Sense of space and nature	Cleaner air	Positive impact on land and property	Local distinctiveness	Opportunities for education, training and social interaction	Tourism opportunities
			●	●									
●	●	●											
			●		●								
											●		
									●				
●	●	●											
●	●	●											
						●							
					●	●							
								●			●		
							●						●
								●			●	●	

Integration of green infrastructure into policy sectors

How do we integrate green infrastructure into other policy sectors: cohesion, water, energy, transport, agriculture, climate and biodiversity, and land use? How can green infrastructure provide essential ecosystem services (e.g. pollution reduction, carbon sequestration, noise reduction, biodiversity habitats) and support territorial cohesion?

Biodiversity, agriculture/forestry, regional and urban as well as resource-efficiency and Environmental Impact Assessment (EIA)/Strategic Environmental Assessment (SEA) policies play important roles in planning and financing green infrastructure. Other than these, the main policies benefiting from implementing green infrastructure are nature policy, water and floods policy, soil, marine and coastal, development and climate change policies. Currently, transport and energy policies would gain from the mitigating role green infrastructure delivers, but they need to be considerably more proactive with integration efforts in the mid- and long-term perspective.

Increasing the competitiveness of agriculture in the EU, as well as promotion of biofuels and biomass, can potentially have both positive and negative effects on the delivery of green infrastructure benefits, depending on how they are implemented. On the other hand, green infrastructure benefits may positively impact some other areas of EU cohesion policy, such as maintaining a healthy labour force (by providing recreation and mitigating the heat urban island effect, for example) and by diversifying incomes in rural areas.

On the whole, there are no fundamental conflicts at the policy objectives level that could not be avoided through appropriate instruments and/or implementation practice. The tensions tend to arise from a particular instrument of delivery of the objective or an implementation practice. Table ES.4 below lists some examples of conflicts arising from particular instruments of EU-sector policies and green infrastructure benefits.

In terms of potential mechanisms that could be used to integrate green infrastructure into other policies, existing legislation appears to provide considerable

Table ES.4 Examples of conflicts arising from particular instruments of EU sector policies and green infrastructure benefits

EU environmental and sector policy areas	Brief description of potential conflicts
Climate change	**No conflicts in general.** Carbon *sequestration measures can affect biodiversity.*
Biodiversity	**No conflicts in general.** One could argue that there are potential conflicts in the field of biodiversity such as those concerning Invasive Alien Species (IAS) and connectivity improvements in special cases (this can be theoretically resolved by stating that green infrastructure generally strengthens ecosystems, making them more resistant against IAS intrusion).
Energy	**Securing energy supply** (by constructing gas pipelines, gridlines, new plants) can damage habitat connectivity and decrease areas of green infrastructure. Failures and leakages dramatically jeopardise habitat preservation. **Promoting biofuels** can result in increase of area of intensive farming, decreasing the area of woodlands or number of hedges, for instance. It can also reduce multifunctionality of the farmed land. **Promoting solid biomass** can contribute to the area of woodland and other natural ecosystems, but can also decrease biodiversity in those places.
Transport	**Efforts to minimise congestion** can result in construction of new roads, damaging habitat connectivity and decreasing areas of green infrastructure.
Agriculture	**Efforts to increase competitiveness of EU agriculture** can be implemented through increasing yields and therefore the area for intensive farming, increasing agricultural inputs (fertiliser, pesticides, water), and decreasing the area of woodlands or number of hedges, for instance. It also reduces the multifunctionality of the farmed land. Further green-infrastructure-related issues may arise from certain practices, for example water scarcity.
Cohesion	**Expansion and improvement of transport infrastructure** can weaken habitat connectivity and generally decrease the area occupied by or the efficiency of green infrastructure. Protection of habitats may require **limits on growth** and development of adjacent areas that are not currently enforceable with existing legislations.

scope for the promotion of green infrastructure. It can be argued that the strategic planning of green infrastructure could benefit from EU guidance/legislation setting targets and objectives and describing a process which would allow national/regional/local targets to be set within a strategic spatially defined framework. In this context, Member States would need to identify current assets, functional requirements and benefits of green infrastructure. Together, this could encourage national and local authorities to take this innovative, integrated approach to territorial planning.

Territorial cohesion and its orientation towards territorial assets via a sustainable path like biodiversity or local renewable energy production challenge future regional policy to focus more on territorial potential and smart growth. Regional policy should be considered a tool that addresses the need to support green infrastructure from a territorial cohesion perspective. In this way, regional policy can contribute to achieving the EU's long-term sustainable development objectives beyond 2020.

Beyond the environment and its policies, other sectoral policies at EU level also have a key role to play in implementing green infrastructure and the ecosystems and services they provide, especially policies that shape the use of land and its spatial patterns: regional, agriculture, energy, transport and resource-efficiency policy. The responsibility for promoting and delivering green infrastructure is clearly found at all levels (e.g. European Commission, Member States, and governmental authorities at national and local levels, non-governmental organisations (NGOs), landowners and land users).

This analysis identifies several types of mechanism that could be used to integrate green infrastructure into other policies, including legislation, guidance and strategies, funding, spatial planning and building control, strengthening the use of assessment (e.g. Impact Assessment, SEA and EIA) and communication and capacity building. Table ES.5 below elaborates on the types of mechanisms that could be used to integrate green infrastructure into other policies.

Table ES.5 Potential mechanisms to integrate green infrastructure into other policies

Potential mechanisms	Description
Existing or new European and national environmental legislation	Existing legislation provides considerable scope to promote green infrastructure, although in some cases this potential is not realised. At European level, relevant legislation includes the White Paper Adapting to Climate Change: Towards a European framework for action, Directive 2000/60/EC establishing a framework for the Community action in the field of water policy EU (the Water Framework Directive), Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive), Directive 2009/147/EC on the conservation of wild birds (the Birds Directive), Directive 2007/60/EC on the assessment and management of flood risks (the Floods Directive), Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (the Marine Strategy Framework Directive), and the EIA and SEA directives (see below in same table). Green infrastructure is an important tool for delivering various aspects of these existing directives.
	Several countries have implemented existing EU environmental legislation in a way which helps facilitate the provision of green infrastructure (see section below in same table).
Existing or new European and national legislation on green infrastructure	The EU Commission proposes to develop a policy document on a green infrastructure. This figures prominently in the EU's new post-2010 biodiversity policy, as green infrastructure is considered to be one of the main tools to tackle biodiversity threats resulting from habitat fragmentation, land use change and loss of habitats.
	Several countries have implemented existing EU legislation (see above in same table) and developed national legislation related to green infrastructure (see section below in same table).
European and Member State guidance/management plans on green infrastructure	The provision of guidance or a toolbox of support for the implementation of green infrastructure would be beneficial both at EU and Member State levels. In addition, good practice case studies are a useful resource.
	There are several existing examples of guidance and case studies available.

Table ES.5 Potential mechanisms to integrate green infrastructure into other policies (cont.)

Potential mechanisms	Description
Direct financial support through targeted EU funding and non-EU funding	There are various EU regional policy funding instruments, including the Regional Development Funds and the Rural Development Fund, that can be used to support green infrastructure, some directly and other indirectly (see below in same table). Green infrastructure projects can be directly supported through the European Regional Development Fund (ERDF), the European Social Fund (ESF) and Cohesion Funds as well as other financial instruments. Existing examples are green infrastructure projects funded through LIFE, the EU's financial instrument for the environment and other co-financed green infrastructure projects e.g. ERDF projects. LIFE puts out calls for projects in different environmental categories, one of them being 'Nature and Biodiversity'. Many green infrastructure projects have been funded though this mechanism (EC, 2010). LIFE+ remains an active funding programme; however, there is still scope and need to create other funding opportunities that would specifically target green infrastructure projects, especially of smaller scale and scope.
	In the future (i.e. beyond the current 2007-to-2013 programme) EU regional policy will need to consider how green infrastructure can be conceptualised and supported as a new approach to regional development. Green infrastructure is a potential tool to improve territorial cohesion at environmental level and to ensure ecological continuity. Regional policy has to ensure that programmes do not negatively impact upon green infrastructure (e.g. by reflecting the importance of green infrastructure and the ecosystems and services it provides in SEAs and EIAs). In addition, climate change adaptation funding in the future which utilises green infrastructure will be more important.
	Other non-EU funding sources include national governments, the European Investment Bank (EIB), private banks, developers and third sector organisations. The private sector is already involved in developing green infrastructure through conditions and mitigation as part of major infrastructure projects and urban development schemes, for example (which may also involve the environmental assessment process — see below in same table). Increasingly, the private sector may apply biodiversity offsetting measures on development schemes and as part of corporate social responsibility programmes.
Indirect financial support through European funding in other sector areas (e.g. agriculture)	Agricultural policy and support is particularly relevant to green infrastructure as it seeks to increase the resilience and permeability of the farmed landscape, and to preserve and enhance high nature value in the wider countryside. The Common Agricultural Policy (CAP) aims to encourage the delivery of ecosystem services through sustainable land management, though both the first and second pillars (income support and rural development) have the potential to promote green infrastructure. Agro and forest environment schemes supporting environmental management and sensitive practices are examples of mechanisms that can indirectly support green infrastructure, along with such measures as management plans for Natura 2000 sites, green tourism, training and advisory services.
	A possible strategy of integration of green infrastructure into agricultural policy would be to identify particular practices that enable the agricultural land to contribute to green infrastructure and promote multifunctionality of agricultural land — its role in biodiversity, recreation, water management.
National, regional and local green infrastructural strategies	National, regional and local green infrastructure strategies, either independently or as an integrated topic in wider national strategy would be a welcome addition that would enable delivery of green infrastructure. The basis of the strategy would be the identification of green assets, corridors and areas of special importance to green infrastructure (also outside protected areas) that would help inform EIA, SEA and other policy instruments. Some countries, for example the Czech Republic, Denmark, Germany, Estonia, France, the Netherlands and Slovakia are already active in planning green infrastructure (at least in the ecological network sense) on a national level.
	One mechanism that can be introduced is a set of standards to guide local green infrastructure deficiency and needs analysis, particularly in the urban context. This may include, for example, requirements for a hierarchy of green spaces to be available within a certain catchment per head of population, whilst clearly needing to reflect local circumstances. This is used in the United Kingdom, for example, where Natural England has developed Accessible Natural Greenspace Standards.
	The forthcoming EU green infrastructure policy document could provide a lead to Member States for the need and role of national and lower-tier green infrastructure strategies.

Table ES.5 Potential mechanisms to integrate green infrastructure into other policies (cont.)

Potential mechanisms	Description
Spatial planning system and building control	Spatial planning will be a key tool in the development of green infrastructure. Best practice strategic spatial planning in Europe already supports the integration of biodiversity. Spatial planning can be used to plan the interactions between land uses at the strategic level, guide development away from sensitive areas and promote the restoration and enhancement of ecosystems and connections between natural areas. At the more local building scale, the planning system can be used — via building standards, regulations or codes — to include local green infrastructure such as green roofs and walls as part of development projects, and to promote sustainable urban drainage schemes which could be green infrastructure. There is a clear need for a multilevel policy approach between local, national and European level policy in this area. It is worth noting here some of the findings from the PLUREL project (2011): regional government's role in planning is generally weak across Europe, and economic growth is favoured over sustainability concerns, be they to protect/promote green infrastructure or public transport in lieu of privately owned vehicles, or to support farming in the urban fringe.

The European Spatial Development Perspective (ESDP) has as its objectives the development of ecological networks and the integration of biodiversity considerations into sectoral policies such as agriculture, transport, tourism, recreation and fisheries. Green infrastructure has also been promoted by The European Landscape Convention since 2000, and thus was recognised early on by the landscape profession as having potential for being integrated into regional and town planning policies, as well as into cultural, environmental, agricultural, social and economic policies.

In addition, in the context of Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage (the Environmental Liability Directive) (compensation in advance of a development could be required, e.g. for all new infrastructure development.

Green infrastructure could thus be a way of offsetting the impacts, with developers investing in appropriate green corridors and stepping stones for species dispersal and migration. This would ensure that damages are compensated in the places that are useful and strategic for conservation, rather than in a haphazard fashion. |
| Strengthening the use of assessment: Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) | The application of the EIA or the SEA can be used (in a reactive way) to protect assets that can be classified as green infrastructure and identify suitable mitigation measures for spatial interventions, for example construction of green bridges over new roads. So far, these kinds of interventions have been mostly limited to the Natura 2000 and other protection sites, and not applied to green infrastructure more generally. However, more proactively the SEA and the EIA can be used to assess the compatibility of regional and territorial development with green infrastructure and biodiversity. Its scope can also be broadened by accounting for nature protection in the development of infrastructures and using nature for economic diversification (e.g. the Trans-European Transport Network (TEN-T) revision (EC, 2002) Community Strategic Guidelines (EC, 2005). |
| Communication and capacity building | Communication to key stakeholders regarding the importance of green infrastructure and the ecosystems and services it provides, and capacity building to enable it to be implemented at all relevant scales (EU, national, regional and local), and by all relevant stakeholders. |

Key opportunities include the following:

1. Promoting the concept of green infrastructure to support both environmental policy goals and certain non-environmental policy goals, and to seek opportunities to mainstream green infrastructure into other policies to realise potential synergies.
2. Encouraging the use of existing legislation to promote green infrastructure (e.g. the White Paper *Adapting to Climate Change*; Habitats and Birds Directives; Water Framework Directive; Floods Directive; Marine Strategy Framework Directive; the EIA and the SEA Directives).
3. Emphasising the role of spatial planning in facilitating and delivering green infrastructure, along with a whole range of other mechanisms, including the use of European and national legislation, guidance/management plans, direct and indirect European funding and non-EU funding, national and regional green infrastructural strategies, building control, strengthening the use of assessment and communication, and capacity building.

Monitoring systems for green infrastructure and territorial cohesion developments

Territorial cohesion can be seen as the spatial representation of sustainability, which would mean that assessing policies in terms of the environmental dimensions (e.g. green infrastructure) of territorial cohesion can constitute an important step towards the better integration of environment and sustainability. The monitoring tools mentioned in this section have the potential to play an important role in this type of assessment.

Monitoring systems to detect and measure green infrastructure such as environmental assets and landscape quality are tools that are needed in national and regional planning for setting priorities and targets more effectively. The tools presented in this report demonstrate a starting point for characterising and mapping green infrastructure on the basis of available data. Mapping and modelling green infrastructure also provide a promising selling instrument to raise awareness as to why green infrastructure is needed.

It is recognised that these approaches are still exploratory and need further development to fully address and capture the essence of green infrastructure and the distinction between green and grey ([2]) features. The input data is merged in various processes — some of the methods are more elaborate, some are rather straightforward, and some are even a compilation of other tools. As no single map of green infrastructure exists, the tools presented illustrate various entry points using different components of green infrastructure. This technique enables us to illustrate the modular approach of green infrastructure over various levels and scales.

Two threads of information are tested to define green infrastructure using available spatial data, one at the landscape level and one at the urban level. Within these two threads of information, several approaches are introduced using different data sets as they are intended to define green infrastructure at different resolutions.

The approaches are generally compatible with one another, as they are based on spatially explicit data and geographical information analysis methods. They are complementary and provide information from more than one input data source (i.e. fragmentation, Urban Atlas, protected areas and Coordination of information on the environment (Corine) land cover data). Conceptually, some applications can be used individually or in combination: the Net Landscape Ecological Potential (NLEP), for example, combines three individual applications into one.

The available tools at urban level are limited compared to the approaches available at landscape level. The reason for this is that most research has been undertaken at landscape level. However, within the last couple of years, more research has been devoted to urban level analyses. The Urban Atlas tool is probably the highest resolution database of land use at urban level readily available in Europe.

For the urban scale, the more detailed urban classes from the Urban Atlas are utilised to map green infrastructure in 9 pilot cities — 3 cities in each size category: 50 000 inhabitants to 100 000 inhabitants,

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([2]) Grey infrastructure is manmade improvements that support and improve human settlement such as roads, power lines, water systems, schools and hospitals.

100 000 inhabitants to 500 000 inhabitants, and greater than 500 000 inhabitants. Here an attempt is also being made to link the classes to the different potential benefits of green infrastructure.

The broad approaches at landscape scale identify land cover types favourable to nature (e.g. green urban areas, agro-systems with pastures and/or mosaics of parcels, forests and other semi-natural or natural drylands, wetlands and water bodies) that provide a link between high-quality nature areas (Natura 2000).

A combination of the urban- and landscape-level mapping tools are undertaken to test how both approaches can be integrated. This is most relevant at the regional or subregional scale to test the interface between the urban- and landscape-scale data.

Table ES.6 below provides a summary of the benefits and disadvantages for each approach, and of their potential contribution to mapping and measuring green infrastructure.

Table ES.6 Summary of the benefits and disadvantages of each tool in mapping and measuring green infrastructure

Approaches	Data sets	Description/scope	Benefits	Disadvantages
Urban scale				
Green infrastructure using the Urban Atlas	Urban Atlas data sets	• Green infrastructure maps for European cities can be produced and statistics generated for the areas and percentage of green infrastructure. • Green urban density analysis can be used to characterise European cities in terms of the green access afforded to city residents living in built-up areas. • Linking green infrastructure classes and functions/benefits of green infrastructure. This provides a quantification of the areas by type of function/benefits.	• It is based on the Urban Atlas — reliable and intercomparable urban planning data with high-resolution maps. • Future editions of the Urban Atlas are planned every three to five years, so the approach should provide a good mechanism for monitoring changes and the speed of change.	• The Urban Atlas is initially only available for 117 cities (with Large Urban Zones with more than 100 000 inhabitants). This is planned to increase to more than 300 cities in 2011. • The link between the Urban Atlas codes and the benefits of green infrastructure is, particularly for some benefits, relatively weak, and the relationship needs to be investigated further before quantifiable results can be drawn from it.
Landscape scale				
Green infrastructure using Corine Land Cover	Combination of Natura 2000 and Corine Land Cover data sets	• Maps with individual Natura 2000 areas and green infrastructure corridor layers for Europe including maps focusing on individual countries to illustrate the data at a more detailed level. • The area and percentage of green infrastructure by Environmental Zones (EnZ) and country are presented.	• Based on data sets that are available across Europe. • Relative easy to calculate. • Excepting the selection of Corine classes, it is a relatively objective and robust method • Results are relatively easy to communicate.	• Potentially overestimates the green infrastructure in countries where the dominant landscape matrix is composed of natural classes. • In countries with fragmented landscapes, green infrastructure is potentially underestimated; important ecological stepping stones are not included as part of what is identified as green infrastructure.

Table ES.6 Summary of the benefits and disadvantages of each tool in mapping and measuring green infrastructure (cont.)

Approaches	Data sets	Description/scope	Benefits	Disadvantages
Green Background Landscape Index (GBLI) map and green infrastructure	Combination of Corine Land Cover data sets and smoothen CORILIS layers	• It expresses the 'greenness' or naturality on a pan-European scale, which can be used to infer the 'ecological potential' of landscapes. • It is based on the spatial distribution of pasture, agriculture mosaics, forests and other semi-natural or natural land favourable to nature. • It is an asset in itself as well as an important component of the connectivity between areas of high ecological interest.	• The GBLI map can show changes from 1990 to 2006 in Europe. The map shows clearly increasing or decreasing index values for various parts of Europe.	• Lessons from the GBLI map, for example in terms of smoothing the Corine data, could be considered as part of reviewing the landscape scale green infrastructure mapping approach.
Landscape fragmentation models and green infrastructure	Fragmentation data sets	• Can be used for monitoring the state of the landscape and changes over time. • Increased fragmentation of landscapes provides less connectivity for ecological networks, influencing the sustainability of green infrastructure. • Data on the degree of landscape fragmentation needed for comparing different regions in a green infrastructure and territorial cohesion context.	• Fragmentation maps provide an accurate measurement of landscape fragmentation for most of the European countries which support policymakers in monitoring green infrastructure. • Can be used in developing indicators in support of green infrastructure planning and performance reviews.	• Measures for controlling landscape fragmentation can only be implemented effectively if there is an awareness of the problem and if feasible solutions are proposed.
Net Landscape Ecological Potential (NLEP) and green infrastructure	Corine Land Cover data sets and effective mesh size	• It is a status indicator which at European/national scales helps frame the potential and provides quick monitoring of the state and its usefulness for assessing progress towards biodiversity targets and various scales, for example.	• Provides information on the overall state of the green infrastructure and its changes. • It presents a measurement that can express ecosystems' integrity, and allows a good reading across Europe because of its robust calculation method, which can be aggregated to various reporting units.	• The indicator is not built around ecological data that would exactly demonstrate which are the desired adaptive biological communities, their species composition, diversity and functional organisation comparable to that of a natural habitat in the region under discussion. • The indicator cannot show in which way the ecosystem integrity can be restored, nor does it have a solely ecological meaning.

Table ES.6 Summary of the benefits and disadvantages of each tool in mapping and measuring green infrastructure (cont.)

Approaches	Data sets	Description/scope	Benefits	Disadvantages
Mapping of ecological corridors and green infrastructure	Corine Land Cover data sets and smoothen CORILIS data	• Focus on the interruption of ecological corridors due to traffic infrastructure. Maps ecological corridors for migrating species, and in general to improve the coherence of the ecological network and hence green infrastructure. • It considers potential connectivity, and fragmentation between areas, and analyses the Natura 2000 network in relation to potential connectivity.	• Takes into consideration the species requirements. • The method reveals a measure for landscape permeability from a species point of view and integrates both spatial and functional connectivities.	• Is regarded as a pilot study, as the focus was led on forest-bound species. • This approach has to be combined with other ecological profiles leading to a multifunctional tool on various levels of scale. • The method was developed between 2004 and 2007, without finalising the complete multilevel and multiscale approach in the following years.
Corine ecotones and green infrastructure	Corine Land Cover and Natura 2000 data sets	• It considers transition areas between two different ecosystems, which can support high levels of biodiversity by providing flora and fauna with diverse environments on which to interact. • The ecotone not only contains species common to the communities on both sides; it may also include a number of species only able to colonise such transitional areas.	• The provisioning of multiple habitats for species interaction makes ecotone zones of high biological interest. • Corine ecotones can add value to land cover analyses in the context of green infrastructure assessment used to make landscape analyses in several different contexts, from analysing landscape diversity to assessing habitat fragmentation.	• The creation aspect of the data sets was only completed in 2011, and so many exploratory analyses have yet to be performed to gauge the product's full potential.
Quickscan green infrastructure	Geographical Information System (GIS) tools	• It is a flexible and modular modelling environment currently being developed in the European Environment Agency (EEA). It allows the users to explore the different implications and trade-offs which occur when developing and implementing policy options for Europe.	• Green infrastructure can be explored either as a purely structural theme, by looking at different land cover types and administrative declarations, or it can be explored with a more functional approach, which seeks to identify areas and networks that might not be measured using purely mechanical means.	• The method adapted in the Quickscan tool is purely exploratory and not designed as an exact method for measuring green infrastructure, but rather as a valuable way to explore the data sets in a green infrastructure context.

Table ES.6 Summary of the benefits and disadvantages of each tool in mapping and measuring green infrastructure (cont.)

Approaches	Data sets	Description/scope	Benefits	Disadvantages
Regional environmental characterisation	Geographical Information System (GIS) tools	• Aims to provide a scientifically relevant and politically operational description of the environmental characteristics of European territories so as to support territorial cohesion and green infrastructure. • Two approaches are developed: one on policy impact assessment, and the other on the identification of common current environmental assets.	• The approach on identification of common assets can potentially be used to contribute to the assessment of the spatial impact of European policies. • It can identify region-specific natural and environmental assets. • The potential relevance of the policy impact assessment approach is that it can provide some approximate areas where green infrastructure would be particularly needed because of pollutant levels, for instance.	• The approach on identification of common assets does not explicitly incorporate limits and carrying capacity. • The impact assessment approach has limited use in the identification or characterisation of green infrastructure; its focus is on the quality of three environmental assets i.e. atmosphere, water and soil quality.

The report shows quite well the gaps we are faced with when monitoring green infrastructure. In general, green infrastructure is **likely to be overestimated** with most of the current tools, as a specific land cover element (e.g. forests automatically transformed into green infrastructure — without knowing the specific biodiversity value, water retention capacity value, CO_2 sequestration, etc.).

Key opportunities include the following:

1. Since approaches to identifying and mapping green infrastructure at the landscape and urban scales are both relatively simple and effective, it is recommended that these are developed and promoted further, particularly as the European Commission is committed to developing a green infrastructure strategy. Further work on integrating the two scales of mapping would be beneficial.

2. Further development of the approach to the analysis of green infrastructure at the urban level is needed, in particular by investigating potential methods of linking the Urban Atlas codes ([3]) to potential benefits of green infrastructure. It may well be helpful to consider these benefits of green infrastructure in terms of ecosystem services as part of this development of the methodology.

3. Green infrastructure is an important part of territorial identity and capital, and therefore it is recommended that adding it to the existing data sets used to generate the regional characterisation map is taken under consideration.

4. Specific spatial elements of green infrastructure are still missing and should be considered in modelling and mapping approaches, such as, for example, artificial elements like eco-bridges and special areas in urban environment (semipermeable). Areas with special measures to improve ecological quality such as soil erosion prevention and soil organic matter improvement should be assessed. Small and linear features such as hedgerows, small water courses and forest patches that can act as eco-corridors or stepping stones should be included. Flood plains and natural forests should also be considered.

5. Data sets relevant to green infrastructure could be further analysed, and it could be assessed whether the data are suited and organised in such a way that they can be used for mapping

([3]) For Urban Atlas class codes and nomenclature, see http://sia.eionet.europa.eu/Land%20Monitoring%20Core%20Service/Urban%20Atlas/Urban_Atlas_Nomenclature_html.

green infrastructure. Definition of criteria to evaluate the suitability/usefulness of the data should be undertaken with respect to the individual objectives and benefits they support, as well as the scale and components they address. Using the opposite starting point should also be considered, i.e. which information (data sets) are currently missing when addressing green infrastructure (gap analysis).

Policy context

Understanding the policy context and existing processes is essential to all readers interested in territorial cohesion and green infrastructure developments. This section explores some of the relevant questions critical for this analysis.

What is the aim of the Europe 2020 strategy? As a successor of the Lisbon Strategy, the multifaceted Europe 2020 strategy (EC, 2010d) is designed to help Europe recover from the world's worst economic crisis since the 1930s. The strategy aims to address structural challenges facing Europe today: climate change, globalisation, the ageing population and the economic downturn. The areas of focus include smart growth (education, knowledge and innovation), sustainable growth (a resource-efficient, greener and more competitive economy) and inclusive growth (high employment and economic, social and territorial cohesion).

How will the EU encourage sustainable growth? The target for the EU is to reduce greenhouse gas emissions by 20 % compared to 1990 levels, by 2020. Another target is to increase the share of renewables in final energy consumption to 20 %, and finally to move towards a 20 % increase in energy efficiency. To boost sustainable growth in the EU, flagship initiatives have been established; the one focused on a 'Resource-Efficient Europe' is encouraging a shift towards a resource-efficient and low-carbon economy. This can only be achieved if our economic growth is decoupled from resource and energy use by reducing CO_2 emissions, if greater energy security is promoted, and if the resource intensity of what we use and consume is reduced.

Why does territorial cohesion matter? Territorial cohesion represents 'the spatial representation of sustainability' (Camagni, 2007) and builds on the ESDP (EC, 1999) which aims to provide a balanced and sustainable spatial development strategy for

Europe. It advocates an integrated approach; not only does it focus on specific sectors of development activity (e.g. economic development, environment or transport) but it also recognises that they all affect each other. It considers with its spatial approach a much wider view of development, imperative for achieving a balanced and integrative development.

What is the current state of territorial cohesion actions? The Europe 2020 strategy has fostered communications to support territorial cohesion in Europe as the new goal of the EU. The ministers responsible for spatial planning and territorial development have in cooperation with the European Commission evaluated and reviewed the Territorial Agenda launched in 2007, and agreed upon a new Territorial Agenda 2020. According to the new Territorial Agenda 2020, territorial cohesion is defined as '…an aspiration for a better state of the EU, with harmonious and balanced, efficient, sustainable territorial structure to make sure that the citizens of these places are able to make the most of the inherent features of these territories and where different territories can realise their optimal solution of long term development…' (EC, 2011d).

Moreover, the Territorial Agenda 2020 suggests that the objectives of the EU defined in the Europe 2020 strategy can only be achieved if the territorial dimension of the strategy is taken into account, since the development opportunities of the diverse regions differ.

In the Treaty on the Functioning of the European Union (Articles 174 and 175), it is stipulated that all policies and actions of the Union should contribute to economic, social and **territorial cohesion.** Therefore, those responsible for the design and implementation of sector policies should take territorial cohesion into account. The coherence of different EU policies is of utmost importance for territorial cohesion. Hence, the optimal balance of sustainability, competitiveness and social cohesion can be realised through integrated territorial development.

The proposal of the European Commission in the *Fifth Report on Economic, Social and Territorial Cohesion* stresses the need to better **integrate territorial cohesion** into cohesion policy. Cohesion policy is an important instrument for the implementation of territorial cohesion. The aim is hence to translate the principles of the new Territorial Agenda 2020 into practical arrangements

within cohesion policy. In the Europe 2020 strategy, and particularly in the flagship initiative 'Resource-Efficient Europe' (⁴), the European Council of 17 June 2010 highlighted the need for cohesion policy to support this strategy to help put the EU economy on the path to sustainable and job-creating growth.

The subsequent Commission communication *Regional Policy Contributing to Sustainable Growth in Europe 2020* (COM (2011) 17 final) calls on regional policy stakeholders to invest more in sustainable growth and use funds more effectively. It is recognised that **territorial cohesion** plays a strong role in contributing to the sustainable growth objectives including ecosystem services, biodiversity, eco-innovation, resource efficiency, and a low-carbon and climate-resilient competitive economy.

What is proposed in the Territorial Agenda 2020?
A core objective of the Territorial Agenda 2020 is hence to integrate the goal of territorial cohesion within the Europe 2020 goals. The agenda is tailored to meet challenges in Europe by the global structural changes of the economic crisis, the growing interdependences of EU regions, demographic and social changes, the diverse impact of climate change and the environment, energy concerns, and the loss of biodiversity, as well as to address vulnerable natural, landscape and cultural heritage.

The agenda defines six territorial priorities in order to meet these challenges: promoting polycentric and balanced territorial development; encouraging integrated development in cities, rural and specific areas; having territorial integration in cross-border and transnational functional regions; ensuring global competiveness of the regions based on strong local economies; improving territorial connectivity for individuals, communities and enterprises; and managing and connecting ecological, landscape and cultural values of regions.

Where is the environmental dimension of territorial cohesion? Most discussions focus on the economic and social issues of territorial cohesion, and there is often a tendency to consider environment and territorial cohesion as antipodes. The reason for this is that the environmental dimensions of territorial cohesion are generally poorly understood; they need to be clarified and

placed on an equal footing with the economic and social elements of the concept. In a previous European Environment Agency (EEA) study on territorial cohesion and environment (EEA, 2010e) essential elements of the environment and sustainability were identified based on the elements of territorial cohesion described in the *Green Paper on Territorial Cohesion* (EC, 2008a). Although there is no overall view of what territorial cohesion is, the following environmental dimensions are often considered important ingredients of territorial cohesion: resource efficiency; green infrastructure and Natura 2000; renewables/decentralised renewables; integrated coastal zone management and marine directives; islands and overseas territories; mountain areas; the Alpine and Carpathian Conventions; adaptation to climate change and trans-European networks (TENs) in transport, energy and telecommunications as tools for territorial cohesion (⁵).

What is the role of green infrastructure in a territorial cohesion perspective? The role of green infrastructure is important for the European landscape and its development. Links between green infrastructure and territorial cohesion often exist in spatial planning instruments. In many European countries, spatial planning systems are already in place and offer some protection of green infrastructure elements. However, they often fail to consider and protect green infrastructure as a coherent whole. In the EEA report *Landscape Fragmentation in Europe* (2011), it is mentioned that the value of landscapes is not yet fully reflected in decision-making on transport infrastructure and urban development. Considerations such as biodiversity and landscape quality, i.e. green infrastructure are often marginalised. For example, the restoration of damaged or severed wildlife corridors is a significant step in recreating the opportunities for species to migrate and disperse. Ongoing efforts for implementing a system of green infrastructure aim at addressing this issue at European level. In many countries, some regulations and instruments can already be used either directly or indirectly to promote defragmentation, for example, protected areas, wildlife corridors/habitat networks, and defragmentation plans. Also, critical areas should be identified when further fragmentation is an imminent threat and their rapid preservation is crucial to avoid further fragmentation via roads and railroads. This task

(⁴) See http://ec.europa.eu/resource-efficient-europe.
(⁵) Presentation by DG Environment, 2010. SEA and Territorial Cohesion. DG ENV, A3.

is particularly urgent in regions with a rapid pace of development, as are large parts of central and eastern European countries.

What is the current state of green infrastructure discussions and developments in the EU? The European Commission has initiated a discussion process for European policy to support the further work on green infrastructure. Council Conclusions of March 2010 call for the further elaboration of a concept on green infrastructure. The European Commission is seeking to develop a green infrastructure strategy by 2012 to promote the deployment of green infrastructure in the EU in urban and rural areas, including through incentives to encourage upfront investments in green infrastructure projects and the maintenance of ecosystem services, for example through better targeted use of EU funding streams and public-private partnerships.

In developing the green infrastructure strategy, the European Commission has initiated a discussion process for European policy to support further work on green infrastructure through several workshops/conferences, one held in March 2009 in Brussels, Belgium ([6]) and the latest held in November 2010 ([7]) in Brussels. The aim of these initiatives is to set the scene for the green infrastructure strategy developments. Green infrastructure is also considered a core element in the new biodiversity strategy (EC, 2011b), and the green infrastructure strategy is intended to contribute to the implementation of the EU biodiversity strategy to 2020.

During the European Commission green infrastructure conference in 2010, it was estimated that hundreds of green infrastructure programmes and projects are under way, many co-financed by cohesion policy, in virtually all Member States — mainly driven by biodiversity conservation, sustainable spatial planning, river basin management, recreation and climate change adaptation. In 2011, the European Commission's Directorate-General for the Environment (Environment DG) commissioned several studies to create and assess inventories of green infrastructure initiatives within and outside Europe.

During the Czech Republic Presidency in 2009, a questionnaire was forwarded to EU Member States, requesting information on their efforts to introduce connectivity measures on their territory. Altogether 15 Member States were identified as having partially implemented ecological networks.

In the European Commission note 'Towards better environmental options for flood risk management' (2011d) it is flagged that the role of natural flood management and green infrastructure needs to be further strengthened; flood risk management should work with nature, rather than against it (EC, 2009). According to the note, building up green infrastructure — which requires investment in ecosystems — offers triple-win measures:
(a) contribution to the protection and restoration of floodplain and coastal ecosystems, for instance;
(b) mitigation of climate change impacts by conserving or enhancing carbon stocks or by reducing emissions caused, for example, by wetland and river ecosystem degradation and loss; and
(c) provision of cost-effective protection against some of the threats that result from climate change, such as increased floods.

More specifically, how does green infrastructure fit into the new biodiversity strategy to 2020? The EU biodiversity strategy to 2020 includes six targets which address the main drivers of biodiversity loss, and which will reduce the main pressures on nature and ecosystem services in the EU by anchoring biodiversity objectives in key sectoral policies. One of the targets is to ensure that 'ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems' (EC, 2011b). The European Commission plans to publish a communication further elaborating the respective targets set in the biodiversity strategy, explaining the green infrastructure concept and exploring ways forward at EU level — inter alia delivering a toolbox for implementation and facilitating exchange of practices and integrated planning. This will also contribute to the global aspects of biodiversity loss addressed in the strategy, ensuring that the EU contributes to combating biodiversity loss around the world. The strategy is in line with the commitments made by the EU in Nagoya, Japan.

([6]) See http://www.green-infrastructure-europe.org.
([7]) See http://ec.europa.eu/environment/nature/ecosystems/green_infrastructure.htm.

1 Introduction to the study

1.1 Background

Objectives of the study

This analysis aims to support the European process towards territorial cohesion and green infrastructure development, in particular the development of a strategy for green infrastructure. This is achieved by exploring different ways of making headway in recognising and advancing the environmental dimension — especially green infrastructure — as an ingredient of territorial cohesion. Territorial cohesion must contribute to economic growth in order to achieve the sustainable growth aim of the Europe 2020 strategy. This implies a strong focus on territorial potential and the support of smart and sustainable growth to tackle climate, energy and environmental issues.

The tasks are divided as follows:

- analysis of the concept of green infrastructure, exploring how green infrastructure can form part of proposals to regenerate existing areas through illustrative examples;
- assessment of how to integrate green infrastructure into policy sectors and land uses, and how green infrastructure can provide essential ecosystem services, in particular within urban areas; using examples to illustrate the environmental and socio-economic benefits that green infrastructure can provide, and how and if green infrastructure initiatives in the EU support territorial cohesion;
- proposal of how monitoring systems can be used as a tool in green infrastructure and territorial cohesion developments, and performance assessment.

This report partly builds on previous EEA work focused on the environmental aspects of EU territorial and cohesion policy:

- *Territorial Cohesion — Analysis of environmental aspects of the EU Cohesion Policy in selected countries (2009b).*

- *The territorial dimension of environmental sustainability — Potential territorial indicators to support the environmental dimension of territorial cohesion (2010e).*

1.2 Territorial cohesion

A previous study undertaken by the EEA on territorial cohesion (EEA, 2010e) highlighted that with the entry into force of the Lisbon Treaty on 1 December 2009, territorial cohesion, along with economic and social cohesion, became a goal of the European Union as identified in the previous EU treaty (Title XVIII). This part of the treaty mentions the role of the structural funds and the cohesion fund, but does not really define 'territorial cohesion'. However, the *Green Paper on Territorial Cohesion* (EC, 2008a) states:

> 'The concept of territorial cohesion builds bridges between economic effectiveness, social cohesion and ecological balance, putting sustainable development at the heart of policy design.'

The environmental dimensions of territorial cohesion are generally poorly understood and need to be placed on an equal standing with the economic and social elements of the concept. Indeed, without strongly proclaiming the environmental dimension of territorial cohesion, this concept could represent a step backwards in terms of European efforts for sustainable development.

The previous study by the EEA highlighted that there is no one definition of territorial cohesion; it is often used throughout the EU and its Member States with shades of meaning. However, the previous work recommends that territorial cohesion work should:

- advance a more balanced and harmonious development of the European Union;
- ensure that its citizens are able to use and benefit from the inherent features of their territories;
- encompass the sharing of environmental responsibility and benefits among territories and throughout the EU;

- incorporate managing shared spaces and addressing common concerns, whilst working out solutions for such environmental problems as pollution, water management, and mitigation of and adaptation to climate change;
- include the preservation of natural assets and the protection of natural areas, as well as protect local ability to maximise gains from the territorial capital; the concepts of resource efficiency and ecological balance are implicit here;
- recognise local-regional-global linkages in considering the environmental facet of territorial cohesion.

To ensure that sustainable development is pursued throughout Europe, the concept of territorial cohesion needs to incorporate the idea of sustainable development — including the environmental dimension.

Although the need for a universally accepted definition of territorial cohesion has been the subject of much debate, a more pragmatic approach might focus on its achievement rather than its definition. The underlying theme of this report therefore explores what a move towards territorial cohesion — from an environmental dimension — might look like, and what tools and approaches might support this process.

As an initial proposal, the previous study for the EEA identified essential elements of the environment and sustainability based on the elements of territorial cohesion described in the Green Paper:

- harmonious and sustainable development;
- inherent features of territories: natural features are protected for future generations;
- concentration: addressing differences in density and other natural features;
- connecting territories: strengthening positive natural connections and interactions between territories;
- cooperation: overcoming division.

Table 1.1 (and Annex 1 which expands upon the table) set out potential key elements of the environmental dimension of territorial cohesion as identified in the previous study by the EEA.

Table 1.1   Potential key elements of the environmental dimension of territorial cohesion

Green Paper on Territorial Cohesion — key elements of territorial cohesion	Potential key elements of the environmental dimension of territorial cohesion
Harmonious development	**Harmonious and sustainable development**
1. building bridges between economic effectiveness, social cohesion and ecological balance 2. putting sustainable development at the heart of policy design	1. achieving sustainable development, and thus integrating economic, social and environmental policy goals and actions 2. respecting environmental limits and carrying capacity (as a constraint on economic growth) 3. utilising a high-quality environment as a good and service (e.g. recreation, agriculture, tourism)
Inherent features of territories	**Inherent features of territories**
Citizens able to use the inherent features of their territories: 1. transforming diversity into an asset 2. making the best use of territorial assets (Three specific types of regions are identified that may face particular development challenges: mountain regions; island regions; and the 18 sparsely populated regions, all rural and almost all border regions.)	Natural features are protected for future generations: 1. maintaining/improving natural capital — maintaining local features and environmental quality 2. maintaining and enhancing current ecosystem services and recognising future needs 3. recognising vulnerability to environmental risks

Table 1.1   Potential key elements of the environmental dimension of territorial cohesion (cont.)

Green Paper on Territorial Cohesion — key elements of territorial cohesion	Potential key elements of the environmental dimension of territorial cohesion
Concentration	**Concentration**
Overcoming differences in density:	Addressing differences in density and other natural features:
1. avoiding excessive concentrations of growth	1. addressing environmental problems related to concentration (e.g. pollution or water needs), including negative effects within and among regions
2. facilitating the access to the increasing returns of agglomeration in all territories	2. recognising environmental/ecosystem services
3. recognising that whilst most economic activity is concentrated in towns and cities, rural areas remain an essential part of the EU as they provide most of the natural resources and natural areas	3. concentrated spatial patterns are better performing than low-density patterns (because of better energy performance of buildings, and a possibility to develop public transport facilities)
4. ensuring sustainable territorial development — strengthening economic competitiveness and capacity for growth, while respecting the preservation of natural assets and ensuring social cohesion	
Connecting territories	**Connecting territories**
Overcoming distance or 'strengthening' connections:	Strengthening positive natural connections and interactions between territories:
1. ensuring good intermodal transport connections	1. understanding environmental connections between and within regions (e.g. water, materials, energy) and making these connections more sustainable
2. adequate access to services (e.g. health care, education and sustainable energy, broadband Internet access, reliable connections to energy networks, and strong links between business and research centres)	2. recognising inputs and outputs (interdependences) of environmental (and ecosystem) services within and between regions at different scales
	3. recognising/avoiding negative environmental effects of one region on another (e.g. pollution, climate change, biodiversity loss through flooding, droughts, fires etc.)
	4. avoiding the environmental impacts of connectivity (e.g. pollution, habitat loss, landscape intrusion)
Cooperation: overcoming division:	**Cooperation**
1. addressing problems of connectivity and concentration through strong cooperation at different levels	Overcoming division:
2. ensuring policy responses on variable geographical scales (e.g. neighbouring local authorities in different countries and between neighbouring countries)	1. cooperation on implementing EU environmental laws and policy at all levels (national, regional, local); learning from different regions; supporting regions in meeting common environmental standards: this section might encompass the 'traditional' view of environment in territorial cohesion and cohesion policy
3. addressing environmental problems which do not respect borders and which require cooperation (e.g. problems associated with climate change)	2. recognising the importance of natural as well as solely administrative boundaries in territorial governance
4. governance plays a major role in ensuring territorial cohesion	

1.3   Understanding territorial cohesion in the context of sustainable development

While the *Green Paper on Territorial Cohesion* does not explore in depth the elements of ecological balance and sustainable development, the EEA's study *The territorial dimension of environmental sustainability* develops the environmental dimension of territorial cohesion. This study outlines key elements of this environmental dimension (see Annex 1), thus adding to the elements described in the Commission's Green Paper, which focus more on economic and social aspects.

The environmental dimension of territorial cohesion is nonetheless closely linked to the economic and social dimensions. The description of its elements can be seen as an elaboration of the approach shown in Table 1.2; this links territorial cohesion to sustainable development, as suggested in the quotation from the Green Paper cited above.

Table 1.2   Linking the elements of territorial cohesion and sustainable development

Elements of territorial cohesion	'Pillars' of sustainable development		
	Economic	Social	Environmental
Harmonious development	• More even spread of economic activity across the EU and within countries • More balanced and resource-efficient development (balancing benefits of concentration v costs in terms of congestion, property prices, social exclusion and pollution)	• More balanced development which improves quality of life and reduces social exclusion	• More balanced development which benefits the environment • Respecting environmental limits and carrying capacity • Utilising a high-quality environment as a good and service
Inherent features	• Challenges of development in certain regions given their geographical features and natural hazards	• Framing development around a territory's social capital	• Framing development around a territory's natural capital • Respecting vulnerability to natural hazards/environmental risks
(Overcoming) concentration	• Avoiding excessive concentration and its diseconomies whilst promoting wider access to benefits of agglomerations	• Reducing the negative externalities of agglomeration, spreading the benefits to all groups and ensuring social cohesion	• Preserving the natural resources and assets and environmental quality of rural areas that are attractive places to visit and live • Addressing environmental problems related to concentration, and utilising the benefits
Connecting territories	• Reliable transport, energy and other services for business	• Ensuring access to services, in particular for disadvantaged groups	• Avoiding the environmental impacts of connectivity • Recognising interdependences of environmental services within and between regions
Cooperation	• Economic growth requires multiple levels of cooperation	• Tackling social problems effectively requires cooperation	• Overcoming environmental problems requires cooperation • Cooperation to implement EU environmental laws and policy at all levels

1.4   The potential role and importance of green infrastructure

Environmental solutions for economic development may include the provision of green infrastructure to help, for example, in adapting to climate change in ways that can also improve social well-being. It can also help to increase resilience, reduce vulnerability and restore natural capital. Other solutions may realise opportunities for supporting the provision of local, national or European environmental priorities, for example, maintaining functional peat lands that underpin the local economy with clean water and reduced flood risks. Such benefits can only be achieved through the involvement of a range of stakeholders, acting together to better coordinate a whole range of sectoral policies and programmes.

Investing in and building up green infrastructure calls for smart and integrated approaches to spatial planning so as to ensure that Europe's limited land is utilised as areas capable of providing multiple functions for nature and society. It is an important element of the EU's biodiversity and nature policy that will contribute much to efforts to reach the agreed EU biodiversity targets. Green infrastructure is covered under the EU 2020 biodiversity strategy. It is considered an essential tool to mitigate fragmentation and unsustainable land use both within and outside Natura 2000 areas, and to provide the multiple benefits of maintaining and restoring ecosystems and their services.

Green infrastructure is a tool that has the potential deliver wide range of benefits: from contributing to land conservation and providing clean water to enhancing territorial cohesion. It can also form a key part of proposals to regenerate existing urban areas. Spatial planning brings together and integrates policies for the development and use of land with

other policies and programmes that influence the nature of places and how they function. The spatial planning system therefore provides significant opportunities and challenges for managing the natural environment.

The key existing policy context for green infrastructure as an ecological connectivity provision lies in the Habitats and Birds Directives. Article 10 of the Habitats Directive recognises that ecological coherence of the Natura 2000 network as well as habitat quality is essential for the long-term survival of many species and habitats. Article 3 of the Birds Directive (EC, 2009b) requires the maintenance or re-establishment of a sufficient diversity and area of birds' habitats.

Some Member States (e.g. Denmark, Germany, the Netherlands and later the Czech Republic and Slovakia) implemented the two directives in a way that directly foresees establishment of ecological networks (European Environment Bureau, 2008). The aims of these two articles can also be realised through the application of the EIA and SEA, where assets that can be classified as green infrastructure can be required as mitigation measures for spatial interventions, for example in the construction of green bridges to pass new roads. These kinds of interventions were mostly limited to the Natura 2000 sites, Special Protection Areas and other protection sites.

In 1995, the Council of Europe initiated a campaign for the conservation of nature outside protected areas, known as the Pan-European Ecological Network (PEEN). This is an internationally agreed approach, built upon the ecological network concept as a part of the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) during the third 'Environment for Europe' Ministerial Conference in Sofia, Bulgaria. It was agreed that this ecological network should be established within 20 years.

The Bern Convention on the Conservation of European Wildlife and Natural Habitats of 1979 was another policy instrument promoting wildlife protection outside protected areas. The Council of Europe Emerald Network, for example, is a green infrastructure programme under the Bern

Convention. A further step in institutionalising the concept of green infrastructure was the publication of European Commission guidance on the implementation of Article 3 of the Birds Directive (EC, 2009b) and Article 10 of the Habitats Directive (92/43/EEC) in 2007. This included guidance on the maintenance of landscape connectivity.

The White Paper *Adapting to Climate Change* (EC, 2009) and *The Economics of Ecosystems and Biodiversity* synthesis (TEEB, 2010) both call for the development of green infrastructure in Europe. In its post-2010 objectives, the Commission acknowledges the need for the development of investment in green infrastructure by supporting exchanges of best practices as a basis for an EU strategy on green infrastructure (EC, 2010h). This was endorsed by the Council in March 2010. Green infrastructure is seen as a tool for (re-)connection of now well-established Natura 2000 sites with the wider landscape. The Environment DG views green infrastructure as an important mechanism to support the achievement of EU biodiversity targets.

Following on from the Environment DG workshop on green infrastructure in 2009 ([8]), a conference was organised in Brussels in November 2010 ([9]) to pursue the ongoing discussion process and to support further work on green infrastructure. The objectives of the conference were 'to share views and discuss the state of green infrastructure implementation, to identify gaps in implementation and to highlight the strong linkages to climate change adaptation and mitigation as well as to share good practices and lessons learned. The Commission's initial reflections on the direction further work on green infrastructure could take will be presented and stakeholders and Member States views collected in order to work towards a common understanding and guidelines on the initiative' ([10]).

The Environment Council of European Union has called on the European Commission to further develop green infrastructure, recognising its contribution to climate adaptation and mitigation objectives, prevention of habitat fragmentation, increasing connectivity and maintaining species evolution processes; it has also highlighted that the term should be used in its broader sense, upgrading

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([8]) See http://www.green-infrastructure-europe.org.
([9]) See http://ec.europa.eu/environment/nature/ecosystems/green_infrastructure.htm.
([10]) See http://ec.europa.eu/environment/nature/ecosystems/green_infrastructure.htm.

on ecological connectivity (Environment Council of European Union, 2010).

Outside the biodiversity policy area, green infrastructure has also been promoted by the European Landscape Convention since 2000. The convention promotes landscape planning, management and protection across Europe. Green infrastructure as a concept was recognised early on by landscape professionals for its benefits, and therefore, through landscape architecture and planning, it was indirectly integrated into regional and town planning policies, as well as into cultural, environmental, agricultural, social and economic policies.

There have also been calls on the need for the green infrastructure to form an essential topic of a renewed ESDP — the latter has not been rethought since 1999. EEA also noted in its *10 messages for 2010. Urban ecosystems* (2010) that the green infrastructure concept will be key to further strengthening sustainable urban development and related EU-wide spatial policies and actions like the EU Territorial

Agenda and the Leipzig Charter on Sustainable European Cities.

Green infrastructure can be delivered via the spatial planning system, as an integral part of new development. For regional policy, there is a need to integrate national and regional planning authorities in the projects and ensure an adequate regional framework for successful implementation. Partnerships and cooperation with socio-economic partners and the civil society is a key success factor (Fichter, 2010).

Green infrastructure offers the potential for a wide range of policies to ensure that their needs are implemented on the ground, provided that they contribute to the general purposes which green infrastructure should serve. This is why there is added value in the EU Commission acting in this domain: green infrastructure requires an integrated and coherent approach over large areas, which is not understood to be essential for carrying out spatially effective environmental policies, where the separate sector approach has not worked in the past.

2 The concept of green infrastructure

2.1 Definition of green infrastructure

Green infrastructure as a term does not have a single widely recognised definition. It has been adopted by the various design-, conservation- and planning-related disciplines and been used to apply to slightly different concepts. However, it is possible to identify underlying features, common to all the disciplines that use the term. These include connectivity, multifunctionality and smart conservation. The term is used for a network of green features that are interconnected and therefore bring added benefits and are more resilient. Another common feature is the aim to either protect or develop such networks.

There are differences, however, in the scale and the background (referred to as a basis or matrix in landscape ecology) through which these networks connect valuable natural areas. Different disciplines also focus on different sets of benefits provided by green infrastructure.

Based on scale and range of benefits, it is possible to group the definitions under two concepts:

- green infrastructure at **urban scale**;
- green infrastructure at **landscape scale** (regional, national and transnational).

These two uses of the term are obviously related — in both cases the focus is on the development and protection of networks of green, natural features. Green infrastructure is not only about connecting ecosystems per se, but also about strengthening them and their services — which can be done by (re-)connecting measures, but also by improving the landscape's permeability (which implicates different ecosystems). The baseline land use is however different: in the first case, it involves a built-up urban area; in the second case, it can be a built-up area as well as intensively farmed land or simply a different type of ecosystem to the one we are trying to connect.

The tools and approaches used to manage green infrastructure tend to vary at these different scales, as do the key sets of benefits green infrastructure delivers. There is also a difference between the physical structures counting as a part of the green infrastructure. For example, a field inside the city might count towards urban green infrastructure (it provides water infiltration and can also be used for recreation, for example), but agricultural land may not be commonly counted towards green infrastructure in the broader landscape, when the focus is on potential migration corridors for particular species. The two scales of green infrastructure are compared further in Table 2.1.

Table 2.2 presents some examples of definitions of green infrastructure from existing literature, to highlight the different meanings of the term as used by various disciplines and institutions in Europe and the United States. In addition to scale, the definitions in the literature tend to refer to different types of concepts, with some referring to green infrastructure as an 'approach' or an idea, and others as the physical 'structures' or spaces. Furthermore, if defined as 'structure', the definition refers to either an 'open space, devoid of man's element' or manmade and natural 'elements' such as green bridges and hedges.

The key, however, is to understand green infrastructure as more than a sum of its parts — functional interconnectivity brings added benefits to the green assets, which previously may have been recognised solely for their single function, such as parks, coastlines or embankments. As the Landscape Institute (2009) suggests, 'a series of inadequately connected natural elements deliver far fewer public benefits than they have the potential for' — the approach that seeks to maximise those benefits that result from synergy between elements is the core of green infrastructure.

Following on from the importance of interconnectivity, green infrastructure can be further understood in two other ways:

- a broader definition uses the term to include both green spaces and the fact that they are interlinked;
- a narrow definition uses it only to refer to the linkages and the concept of interconnectivity.

The classification of green infrastructure benefits depends on which definition is used. In the broadest sense, green infrastructure carries all the benefits provided by green spaces and structures of which it is an integral part. In the narrow sense, the benefits of green infrastructure are only the additional ones derived from interlinking: possibility of species migration, resilience to change including climate change, higher recreational value, etc. Benefits from green infrastructure are further described in Section 2.2.5.

Table 2.1   Comparison of green infrastructure at urban and landscape scales

Green infrastructure characteristics	Urban scale	Landscape scale
Short description	• Development and protection of a network of multifunctional green space in urban environments	• Development and protection of connections between valuable habitats in wider landscape scale
Matrix/obstacles	• Urban built-up environment	• Intensively farmed land • Built-up areas • Grey infrastructure
Key associated benefits (as highlighted in the literature)	• Urban heat island mitigation • Water run-off management • Water retention (flood prevention) • Recreation • Visual pleasure, sense of nature and open space • Wildlife habitats	• Species migration • Water retention (water recharge and flood prevention) — to a lesser extent
Most common structures	• Parks, tree-lined avenues, green roofs, agricultural land and woodland inside towns, etc.	• Habitats (In the EU, more specifically the Natura 2000 sites) and corridors • Rivers and streams, hedges, etc. • Overlap with term 'ecological network'
Examples of disciplines using the term	• Urban planning • Landscape architecture • Environmental management	• Species conservation • Spatial planning • Environmental management
Key topic/policy links	• Quality of life in cities • Biodiversity protection • Climate change adaptation • Climate change mitigation	• Biodiversity protection • Climate change adaptation
Key documents using the term	• US EPA, 2007, Green infrastructure: statement of intent. • Landscape Institute, 2009, Green infrastructure: connected and multifunctional landscapes — position document. • The Chartered Institution of Water and Environmental Management, 2010, Multi-functional urban green infrastructure. • Also in the United Kingdom: Natural England and CABE; and the US: The Conservation Fund.	• EC, 2010, Green infrastructure factsheet. • EC, 2010, LIFE building up Europe's green infrastructure. • EC, 2009, Towards a green infrastructure for Europe: Integrating Natura 2000 into the wider countryside (25–26 March 2009) Workshop related materials. • European Environment Bureau, 2008, Building green infrastructure for Europe.
Key documents using the term in both senses	• EEAC, 2009, Biodiversity WG Briefing Paper: Green infrastructure and ecological connectivity. • Environment Council, 2010, Biodiversity: Post-2010 EU and global vision and targets and international ABS regime — Council conclusions.	

Table 2.2   Example definitions of green infrastructure

Definitions	Characterisation	Reference
An interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife.	**Disciplines:** Land conservation **Key benefits:** Conservation **Scale:** Landscape	Benedict, M. and McMahon. E., 2006, Green infrastructure. Linking Landscapes and Communities.
Green infrastructure is the network of natural places and systems in, around and beyond urban areas. It includes trees, parks, gardens, allotments, cemeteries, woodlands, green corridors, rivers and wetlands.	**Disciplines:** Urban design **Key benefits:** Recreation **Scale:** Urban (and beyond)	Commission for Architecture and Built Environment (CABE, 2011b).
Green infrastructure is an approach to land use, underpinned by the concept of ecosystem services. Green assets such as parks, coastlines or embankments have generally been thought of in terms of their single functions — the approach that recognises their vast range of functions and their interconnectivity is called green infrastructure.	**Disciplines:** Landscape architecture **Key benefits:** Multifunctional **Scale:** Landscape	Landscape Institute, 2009. Green Infrastructure Position Statement.
Connections between Natura 2000 sites. Valuable green urban areas and man-made bridges to natural areas, ecological corridors and zones where habitats merge.	**Disciplines:** Species conservation **Key benefits:** Species migration **Scale:** Landscape	European Commission (EC, 2011a).
Green infrastructure maintains and improves ecological functions in combination with multifunctional land uses. Natural and 'man-made' structures or a territory devoid of permanent man-made structures that provide — directly or indirectly, partly or totally — through the vegetation it supports, a series of services to society.	**Scale:** Species conservation **Key benefits:** Multifunctional **Scale:** Landscape	Marco Fritz, European Commission, Environment DG.
Green infrastructure is a strategic approach to land conservation, a 'smart' conservation that addresses the ecological and social impacts of sprawl and the accelerated consumption and fragmentation of open land.	**Disciplines:** Land conservation **Key benefits:** Conservation **Scale:** Landscape	The Conservation Fund's Green Infrastructure Leadership Program (Benedict and McMahon, 2002).
Green infrastructure is an approach to wet weather management that uses soils and vegetation to utilise, enhance and/or mimic the natural hydrologic cycle processes of infiltration, evapotranspiration and reuse.	**Disciplines:** Surface water management **Key benefits:** Water run-off control Scale: Urban	US Environmental Protection Agency, 2008, Managing Wet Weather with Green Infrastructure. Action Strategy.
Green infrastructure is the actions to build connectivity nature protection networks as well as the actions to incorporate multifunctional green spaces in urban environment.	**Disciplines:** Species conservation **Key benefits:** Nature protection **Scale:** Urban	EEAC, 2009, Green Infrastructure and Ecological Connectivity.
Green infrastructure is a concept that is principally structured by a hybrid hydrological/drainage network, complementing and linking relict green areas with built infrastructure that provides ecological functions. It is the principles of landscape ecology applied to urban environments.	**Disciplines:** Urban design **Key benefits:** Water run-off control **Scale:** Urban	Ahern, J., 2007, Green infrastructure for cities: The spatial dimension.
Green infrastructure is a strategically planned and delivered network of high-quality green spaces and other environmental features. It should be designed and managed as a multifunctional resource capable of delivering a wide range of environmental and quality-of-life benefits for local communities. Green infrastructure includes parks, open spaces, playing fields, woodlands, allotments and private gardens.	**Disciplines:** Land conservation **Key benefits:** Recreation **Scale:** Urban	Natural England (Natural England, 2010).

A thorough overview of existing green infrastructure definitions was previously drawn up by Sylwester (2007), who listed definitions of green infrastructure used by several institutions in a similar way. The definitions were analysed based on geography. In the United States, where the term was first used in mid 1990s, green infrastructure is mostly applied to the management of storm water run-off through the use of natural systems. However, in the United States some institutions like the Conservation Fund use the term in its more expanded meaning, also recognising other benefits. He further investigates the use of green infrastructure in the United Kingdom, where the term is frequently present in national, regional and local spatial planning and policy documents. The term is again used predominantly in reference to multifunctional networks of green assets focused on local urban scale.

The European Union's institutions have almost exclusively used the term green infrastructure in its

wider landscape scale sense and with a particular emphasis on ecological connectivity. The EEA and other institutions, when considering the urban environment and related topics (quality of life in cities), often refer to 'green spaces' or 'green systems' rather than green infrastructure. The term was first introduced in the 2009 Commission White Paper Adapting to Climate Change (EC, 2009). The EU Commission has since been supporting the exchange of views and best practices and highlighted the potential of the concept for coordination at local, regional, national and international levels. It has been used by Environment DG in the past in connection with biodiversity; however, the latest Environment DG description of green infrastructure uses a much more comprehensive version of the concept (see Box 2.1).

According to the Commission, green infrastructure is thus aimed at strengthening ecosystems by developing integrated land management and developing green infrastructure that will:

- protect and restore Europe's rich natural heritage;
- counter loss and fragmentation of the natural environment;
- enhance the land's permeability for migrating species, and reconnect habitats that have been separated by fragmentation resulting from intensive land use, transport routes and urban sprawl.

The Commission is promoting and supporting exchanges of best practice as a basis for a policy document on green infrastructure to be developed by 2012. It is clear that the concept needs further clarification in terms of the definition and objectives, including guidance and linkages to broader EU policies and sharing of knowledge and socio-economic benefits with local actors, including impacts.

2.2 Green infrastructure terminology

Definitions of green infrastructure typically list the potential green assets or physical components that make up its integral parts, or the benefits that they bring. The assets included can be man-made or more natural/semi-natural, and of different scales, generally following the scale to which the definition of green infrastructure applies. One of the most comprehensive lists of the potential assets that make up green infrastructure can be found in the Landscape Institute's position document on green

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Box 2.1 What is green infrastructure?

Green infrastructure is a concept addressing the connectivity of ecosystems, their protection and the provision of ecosystem services, while also addressing mitigation and adaptation to climate change. It contributes to minimising natural disaster risks, by using ecosystem-based approaches for coastal protection through marshes/flood plain restoration rather than constructing dikes. Green infrastructure helps ensure the sustainable provision of ecosystem goods and services while increasing the resilience of ecosystems. The concept is central to the overall objective of ecosystem restoration, which is now part of the 2020 biodiversity target.

It also promotes integrated spatial planning by identifying multifunctional zones and by incorporating habitat restoration measures and other connectivity elements into various land-use plans and policies, such as linking peri-urban and urban areas or in marine spatial planning policy. Its ultimate aim is contributing to the development of a greener and more sustainable economy by investing in ecosystem-based approaches delivering multiple benefits in addition to technical solutions, and mitigating adverse effects of transport and energy infrastructure.

Source: EC, 2010a.

Table 2.3   Typical green infrastructure assets and their associated scales

Local, neighbourhood and village scale	Town, city and district scale	City-region, regional and national scale
• Street trees, verges and hedges • Green roofs and walls • Pocket parks • Private gardens • Urban plazas • Town and village greens and commons • Local rights of way • Pedestrian and cycle routes • Cemeteries, burial grounds and churchyards • Institutional open spaces • Ponds and streams • Small woodlands • Play areas • Local nature reserves • School grounds • Sports pitches • Swales, ditches • Allotments • Vacant and derelict land	• Business settings • City/district parks • Urban canals • Urban commons • Forest parks • Country parks • Continuous waterfronts • Municipal plazas • Lakes • Major recreational spaces • Rivers and floodplains • Brownfield land • Community woodlands • (Former) mineral extraction sites • Agricultural land • Landfills	• Regional parks • Rivers and floodplains • Shorelines • Strategic and long distance trails • Forests, woodlands and community forests • Reservoirs • Road and railway networks • Designated greenbelt and strategic gaps • Agricultural land • National parks • National, regional or local landscape designations • Canals • Common lands • Open countryside

Source: Landscape Institute, 2009.

infrastructure (2009). It groups green infrastructure assets into three broad scales (see Table 2.3):

• local, neighbourhood and village scale
• town, city and district scale
• city-region, regional and national scale.

The Environment DG has identified the following potential components of green infrastructure (EC, 2010b):

• **areas with a high value for biodiversity** in protected areas in a coherent network, such as Natura 2000 sites with their buffer zones;
• **healthy ecosystems** and areas of high nature value outside protected areas, such as floodplain areas, wetlands, extensive grasslands, coastal areas, natural forests;
• natural **landscape features** such as small water courses, forest patches and hedgerows, which can act as eco-corridors or stepping stones for wildlife;
• **restored habitat patches** that have been created with specific species in mind, e.g. to help expand the size of a protected area, increase foraging areas, breeding or resting for these species and assist in their migration/dispersal;

• **artificial features** such as eco-ducts or eco-bridges, or permeable soil covers that are designed to assist species movement across insurmountable barriers (such as motorways or paved areas);
• **multifunctional zones** where land uses that help maintain or restore healthy ecosystems are favoured over other incompatible activities;
• areas where measures are implemented to improve the general ecological quality and **permeability** of the landscape;
• **urban elements** such as biodiversity-rich parks, permeable soil's cover, green walls and green roofs, hosting biodiversity and allowing for ecosystems to function and deliver their services; this should also connect urban, peri-urban and rural areas.

In addition to the term green infrastructure itself, there are many other terms used in association with green infrastructure, as described in the box below.

A green infrastructure approach to land use, spatial or territorial planning promotes the widest range of functions which can be performed by the same asset, unlocking the greatest number of benefits (Landscape Institute, 2009). This approach can help

> **Box 2.2   Green infrastructure terminology**
>
> **Green infrastructure assets.** Green infrastructure assets include the natural elements which provide social, environmental or economic benefit. They can be specific sites or broader environmental features within and between rural and urban areas. A useful approach to outlining the different types of green infrastructure assets is to classify them according to the spatial scale at which each would typically be found.
>
> **Connectivity.** Connectivity between different green infrastructure assets will help maximise the benefits that they generate. This connectivity can be visual or notional; however, physical connections make the most impact. This connectivity can enhance public engagement with the natural environment, improve opportunities for biodiversity migration and assist in encouraging sustainable forms of travel.
>
> **Green infrastructure functions.** Green infrastructure functions are the roles that assets can play if planned, designed and managed in a way that is sensitive to, and includes provision for, natural features and systems. Each asset can perform different functions, a concept known as multifunctionality.
>
> **Multifunctionality.** Understanding multifunctionality is central to the green infrastructure approach to land use and spatial planning. Where land performs a range of functions, it affords a far greater range of social, environmental and economic benefits than might otherwise be delivered.
>
> **Ecosystem services.** Underpinning the multiple functions that green infrastructure assets perform is the concept of ecosystem services. Health and well-being depend on the range of services provided by ecosystems and their constituent parts: water, soils, nutrients and organisms. These services include four broad types:
>
> - **supporting:** necessary for all other ecosystem services, e.g. soil formation and photosynthesis;
> - **provisioning:** e.g. food, fibre, fuel;
> - **regulating:** e.g. air quality, climate control, erosion control;
> - **cultural:** non-material benefits for people, including aesthetic qualities and recreational experiences.
>
> **Source:** Landscape Institute, 2009.

manage land in a more sustainable way, maximising the potential multiple benefits and managing the potential conflicting demands and pressures such as housing, industry, transport, energy, agriculture, nature conservation, recreation and aesthetics.

Approaches to green infrastructure vary greatly among the Members States, as does the use of the terminology. Other concepts with very similar or even identical objectives to green infrastructure are also apparent, not least ecological networks. Ecological networks are not the same as green infrastructure, but they generally form part of it. In Europe, the development of such networks was led by the Council of Europe in 1994, in cooperation with other national and international organisations, both governmental and non-governmental; they developed the PEBLDS which aimed to strengthen environment and biodiversity conservation policies.

This led to a campaign for conservation of nature outside protected areas, the PEEN. Following this, numerous national and transnational initiatives were set up throughout 55 states in Eurasia.

2.3   Benefits of green infrastructure

Green infrastructure can provide environmental, economic and social benefits. It can encourage greater integration of concerns about the sustainable management and use of our natural capital, which is the basis for a healthy economy. Investment in green infrastructure, in development and use of ecosystem-based approaches to adaptation and mitigation provides jobs and business opportunities and thus contributes to biodiversity objectives and to a green, resource-efficient and low-carbon economy.

Table 2.4   Benefits provided by green infrastructure identified in some of the literature

Topic area	Benefits	Environment DG (2010)	US EPA (2009)	Landscape institute (2009)	Natural England (2010)	Ahern (2007)	Benedict & McMahon (2006)
Biodiversity/ species protection	Habitats for species			●	●	●	
	Permeability for migrating species	●		●		●	●
	Connecting habitats	●				●	●
Climate change adaptation	Mitigating urban heat island effect with evapotranspiration, shading and keeping free corridors for cold air movement			●	●	●	
	Strengthening ecosystems' resilience to climate change	●		●			
	Storing flood water and ameliorating surface water run-off to reduce the risk of flooding	●	●	●	●	●	●
Climate change mitigation	Carbon sequestration	●		●		●	
	Encouraging sustainable travel			●			
	Reducing energy use for heating and cooling buildings			●			
	Providing space for renewable energy like ground source heating, hydroelectric power, biomass and wind power			●		●	
Water management	Sustainable drainage systems — attenuating surface water run-off		●	●		●	●
	Groundwater infiltration		●			●	●
	Removal of pollutants from water (e.g. reed beds)	●	●				●
Food production and security	Direct food and fibre production on agricultural land, gardens and allotments			●			
	Keeping potential for agricultural land — food security (safeguarding of soil)						
	Soil development and nutrient cycle					●	●
	Preventing soil erosion	●		●			
Recreation, well-being and health	Recreation			●	●	●	●
	Sense of space and nature				●	●	●
	Cleaner air						●
Land values	Positive impact on land and property			●		●	●
Culture and communities	Local distinctiveness			●			
	Opportunities for education, training and social interactions			●	●	●	
	Tourism opportunities			●			

A list of potential benefits associated with green infrastructure compiled from some of the key literature is provided in Table 2.4. It should be noted however, that not every individual component of green infrastructure provides all of the services/ benefits.

Photo 2.1 illustrates the many functions of green infrastructure for the mouth of the River Weaver in Cheshire, United Kingdom.

2.4   Two case studies to illustrate the benefits of green infrastructure

The following two case studies have been included to illustrate the potential benefits of green infrastructure in practice (Table 2.5). Each case study includes an overview of the initiative, the main green infrastructure benefits provided and the key elements of territorial cohesion it provides or supports, including the environmental
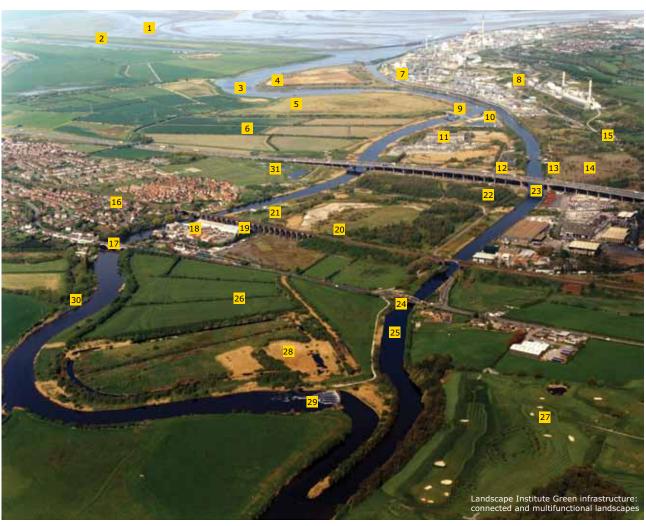
Photo 2.1   Examples of the functions performed by green infrastructure

Landscape Institute Green infrastructure:
connected and multifunctional landscapes

The Mouth of the Weaver

Demonstration of the many ways in which green infrastructure and traditional infrastructure coexist.
This example shows some of the functions performed by different GI assets.

1 River Mersey — biodiversity, sense of place, tourism
2 Manchester Ship Canal — connections
3 River Weaver — biodiversity connections and tourism
4 Former chemical industry lagoon — biodiversity
5 Lagoon/dredging bed — biodiversity
6 Drained estuary marshes, important habitat
* with hedges and ditch network*
7 Large-scale industry, green space between buildings for recreation
8 Nature reserve surrounding power station
9 Bridge — connectivity
10 Lagoon — biodiversity
11 Substation with green setting
12 Ponds used for fishing and biodiversity interest
13 Rowing club — recreation, historic buildings and surroundings
14 Abandoned soap waste lagoons — natural regeneration
15 Ancient woodland fingers
16 Market town — open space and local distinctiveness

17 Gateway to market town — listed building
18 Pathway through industrial estate — connectivity
19 Viaduct — local landmark, historical interest
20 Former chemical works lagoon — biodiversity
21 Sailing club and accessible water front
22 Woodland planted around edges
23 Motorway bridge across Weaver Navigation
*   — views and connectivity*
24 Swing bridge — local landmark
25 Weaver Navigation — recreation, connectivity, biodiversity
26 Agricultural land — ridge and furrow, hedges
27 Golf course — recreation, tourism biodiversity on river edge
28 Former dredging beds now reed beds and swamp
29 Weir listed structure — historic interest
30 Riverside Walk
31 Open space urban fringe

Source: Landscape Institute, 2009.

Aerial shot supplied by Cheshire West and Chester Council as captured by Jefferson Air Photography (23 April 2004).

dimensions. These links to territorial cohesion are organised by the elements discussed previously: harmonious development, inherent features of territories, concentration, connecting territories, and cooperation. See Annex 3 for sources of other case studies and similar illustrations.

Case study 1: Restoration of flood plains and wetland in Babina and Cernovca (Romania)

An example of meeting the objectives of EU territorial cohesion by providing better livelihoods in an underdeveloped area through a green infrastructure project.

Short description

This project is part of a broader initiative led by the World Wildlife Fund (WWF) to establish the Lower Danube Green Corridor, extending over Bulgaria, Romania, Moldavia and Ukraine. This particular project served as a pilot study and is relatively small-scale, covering 36.8 km^2. The removal of the dikes that had previously enabled land to be used for agriculture, but left the land dry and unproductive, was completed in 1996. Cropping and forestry activities ceased being profitable following the change from centralised economies in the 1990s.

Table 2.5   Case studies to illustrate the benefits provided by green infrastructure at landscape and urban scal

Case study	Green infrastructure benefits provided
Landscape scale	
1. Restoration of flood plains and wetland in Babina & Cernovca (Romania)	Protection and restoration of valuable wetland areas along the final 1 000 km of the Danube, including the globally important Danube Delta.
Urban scale	
2. Neighbourhood regeneration in Malmö, Sweden	Adaption and mitigation measures implemented: storm water management, green roofs, green spaces (recreation areas, wildlife habitats), new renewable energy sources, recycling systems, sustainable construction and local transport initiatives.

The region faces a severe risk of floods. The restoration of 21 km^2 of polders in Babina holds 35 million cubic metres of floodwaters at high tide. However, an additional 2.1 billion cubic metres of flood retention capacity through the restoration of floodplains would be needed in total to lower the Danube floodwater peaks by 40 cm. According to the WWF, it would take an additional EUR183 million of investment for the restoration of another 1 000 km^2 of floodplains in the Lower Danube. For the purposes of comparison, the 2005 flood resulted in 84 deaths and EUR 396 million in damages.

Green infrastructure benefits provided:

- connecting habitats along the Danube Green Corridor;
- improving habitats' resilience to climate change;
- flood protection and attenuation;
- improving water quality.

Link to the key elements of territorial cohesion, including the environmental dimensions

- **Harmonious development:** the project increased the economic diversification of rural areas by providing new sources of income to locals, including fishing, reed harvesting, grasslands for livestock grazing and tourism. The WWF's cost–benefit analysis valued this contribution at about EUR 95 800 per year. The one-off cost of the project was EUR 68 000.
- **Inherent features of territories:** the project achieved economic, social and environmental benefits by restoring and putting to use the inherent assets of the area, maintaining and improving natural capital, and addressing current and future environmental vulnerabilities.
- **Concentration (overcoming differences in density):** the restored floodplains addressed environmental and health problems related to population concentration, including water pollution and increased flood risk, in the adjacent areas. The project therefore also improved resilience to climate change.
- **Connecting territories:** the completion of the project increased the connectivity of habitats in the Danube corridor and aimed to improve water quality which could potentially have transboundary benefits.
- **Cooperation:** the project is a part of multinational effort to restore the Danube green corridor and recognises the importance of managing river catchments across administrative boundaries.

Case study 2: neighbourhood regeneration Ekostaden Augustenborg Malmö (Sweden)

Short description

The 32-hectare Augustenborg district of the city of Malmö in Sweden was built in the 1950s. Initially considered highly successful, the mixture of housing, employment and social facilities was falling into decline by the 1970s. The reasons for the spiral of decline were insufficient thermal insulation and a sewage system which regularly became overwhelmed during annual flooding. As more

Photo 2.2   Ekostaden Augustenborg Malmö

In the new storm water system, 70 % of all rainwater from rooftops and other impervious surfaces is collected from gutters and channelled through canals, ditches, ponds and wetlands before finally draining into a traditional closed subsurface storm water system. (Photo: John Dolocek, City of Malmö)

All new, and some existing buildings in the neighbourhood, have green roofs, including the largest green roof (9 500 m²) in Scandinavia. They create valuable habitats and intercept half of the total rainfall. (Photo: Scandinavian Green Roof Institute)

people moved out, flats remained unoccupied and the remaining population became marginalised with a high level of unemployment.

Then in the 1990s, the city council launched a wide-ranging urban regeneration project; initially aiming at innovative environmental and climate improvements, it focused on flooding, waste management and biodiversity. The approach taken to water management and climate adaptation was to create an open, surface-level storm water system, green rooftops and green walls, and improvements to green spaces. The green spaces can be temporarily flooded, helping to manage water by slowing its entry into the conventional storm water system. These measures resulted in a greater resilience to flooding; during a major flood in 2007, Augustenborg coped much more successfully than nearby districts. Beyond that, small allotments to grow food, leisure environments and play areas for children have been created between housing blocks. Improvements included planting flowering perennials and trees, creating wetlands and providing bird and bat boxes.

The project also introduced renewable energy sources, recycling systems, sustainable construction and local transport initiatives.

Green infrastructure benefits provided:

- storm water management — improving resilience to flooding;
- adaption and mitigation measures to climate change implemented (cooling effects of green roofs in summer);
- enhancing the appearance and image of Augustenborg as an attractive and thriving area in a good-quality landscape;
- recreation areas;
- wildlife habitats.

Links to the key elements of territorial cohesion, including the environmental dimensions

- **Harmonious development:** turnover of tenancies decreased by 50 %, unemployment fell from 30 % to 6 %, and 3 new companies were established locally. The one-off cost of the project was about EUR 16.9 million. It was funded by Malmö City and MKB Housing Company; support also came from the Swedish government's local investment programme and from EU's funding instrument

for the environment (LIFE programme) — and EU's specific Community initiative (URBAN).
- **Inherent features of territories:** the project achieved various economic, social and environmental benefits by transforming a declining estate into an exemplar of an environmentally adapted urban area, while also addressing current and future climate vulnerabilities (flooding).
- **Concentration (overcoming differences in density):** the regenerated neighbourhood provides high-standard housing (land consumption saved elsewhere) while carbon emissions and waste generation have been reduced by 20 % due to the better energy performance of the redeveloped buildings and a local transport initiative (car sharing).
- **Connecting territories:** 70 % of all rainwater from rooftops and other impervious surfaces is collected before draining into a traditional closed subsurface storm water system. Biodiversity in the area has increased by 50 %, the green roofs in particular have attracted birds and insects, and the open storm water system provides a better environment for local plants and wildlife.
- **Cooperation:** the strong partnership and leadership of the Housing Company MKB, the housing landlords and local residents at neighbourhood scale were of critical importance in the successful transformation of the estate to an exemplar of an environmentally adapted urban area. The district level administration devolved power of decision to the above parties, while the involvement of the residents in the design phase resulted in sense of ownership, empowerment and raised community awareness.

Further information:

See http://www.malmo.se/sustainablecity.

See http://www.cabe.org.uk/case-studies/ ekostaden-augustenborg.

2.5 Links between green infrastructure and ecosystem services

The term 'ecosystem' is used to express the interdependence of species (plants, animals and microbes) in the living world with one another and with their non-living environment (Millennium Ecosystem Assessment, 2005a), for example coastal and marine ecosystems. Such systems, through
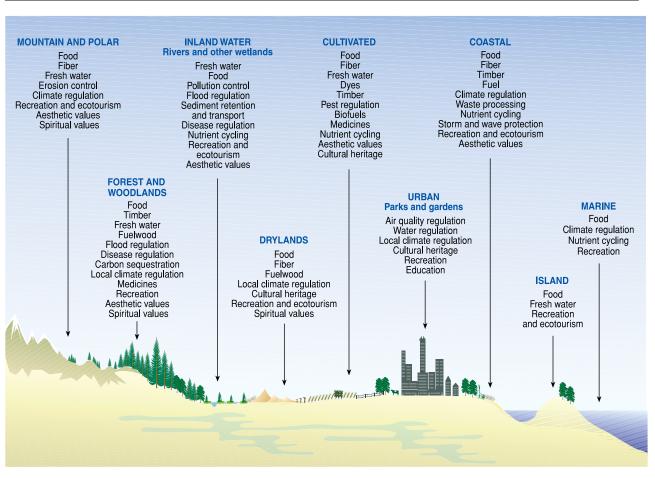
Figure 2.1 Examples of various ecosystem services that different ecosystems provide

MOUNTAIN AND POLAR
Food
Fiber
Fresh water
Erosion control
Climate regulation
Recreation and ecotourism
Aesthetic values
Spiritual values

INLAND WATER
Rivers and other wetlands
Fresh water
Food
Pollution control
Flood regulation
Sediment retention
and transport
Disease regulation
Nutrient cycling
Recreation and
ecotourism
Aesthetic values

CULTIVATED
Food
Fiber
Fresh water
Dyes
Timber
Pest regulation
Biofuels
Medicines
Nutrient cycling
Aesthetic values
Cultural heritage

COASTAL
Food
Fiber
Timber
Fuel
Climate regulation
Waste processing
Nutrient cycling
Storm and wave protection
Recreation and ecotourism
Aesthetic values

FOREST AND
WOODLANDS
Food
Timber
Fresh water
Fuelwood
Flood regulation
Disease regulation
Carbon sequestration
Local climate regulation
Medicines
Recreation
Aesthetic values
Spiritual values

DRYLANDS
Food
Fiber
Fuelwood
Local climate regulation
Cultural heritage
Recreation and ecotourism
Spiritual values

URBAN
Parks and gardens
Air quality regulation
Water regulation
Local climate regulation
Cultural heritage
Recreation
Education

MARINE
Food
Climate regulation
Nutrient cycling
Recreation

ISLAND
Food
Fresh water
Recreation
and ecotourism

Source: Millennium Ecosystem Assessment, 2005a.

their structures and processes, provide functions such as climate regulation. These functions, in turn, provide benefits to humans, known as goods and services (De Groot et al., 2002) (see Table 2.6 for examples of services that different ecosystems can provide). The main difference between functions and services is that a human beneficiary is linked to a service, but not to a function (Chan et al., 2006). There are multiple and competing definitions of what is meant by ecosystem services (ES) (Boyd and Banzhaf, 2005); however, the definition from the Millennium Ecosystem Assessment (MA) is widely used:

'Ecosystem services are the benefits that humans obtain from ecosystems, and they are produced by interactions within the ecosystem … These include provisioning, regulating, and cultural services that directly affect people. They also include supporting services needed to maintain all other services … Ecosystem services affect human well-being and all its components, including basic material needs such as food and shelter…'

The MA groups ecosystem services into four broad categories (see Box 2.3).

The theory behind the potential benefits of an ecosystem services approach to policymaking and strategy development is well established, and the need to move towards the strategic consideration of the natural environment at all stages of decision-making processes well recognised. An ecosystem services approach has the potential to improve the integration of the natural environment by facilitating the consideration of issues horizontally across sectors and components of the natural environment, rather than on a sectoral or silo basis.

Box 2.3 Categories of ecosystem services

Supporting Services Supporting services are those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. (Some services, like erosion regulation, can be categorised as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people).
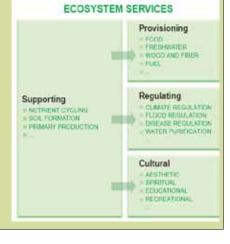
Regulating Services Benefits obtained from the regulation of ecosystem processes.

Provisioning Services Products obtained from ecosystems.

Cultural Services Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences.

Note: Regulating, provisioning and cultural services are all dependent on supporting services.

Source: Millennium Ecosystem Assessment, 2005d.

In the *Economics of Ecosystems and Biodiversity for National and International Policymakers* ([11]) (TEEB, 2009) a list of ecosystem services has been developed based on the MA categorisation of ecosystem services. Current knowledge and data relating to ecosystem services at EU level are not sufficient to provide comprehensive facts and figures and consequently a baseline cannot be fixed; however, recent research provides valuable information on their qualitative status and trends, which is sufficient to target future policy priorities and actions. In the TEEB, ecosystem services are grouped into four main types: provisioning services, regulating services, habitat services and cultural services ([12]).

From the examples provided of different ecosystem services, the close relationship between typical ecosystem services and the benefits that green infrastructure provides is clear. In an impact assessment followed by the European Commission White Paper *Adapting to Climate Change* (2009) it is suggested that 'working with nature's capacity to absorb or control impacts in urban and rural areas can be a more efficient way of adapting than simply focusing on physical infrastructure'. The assessment suggests that resilient ecosystems, as part of the EU's green infrastructure, could play a crucial role in adaptation by improving the soil's carbon and water storage capacity, for example, and conserving water in natural systems to alleviate

the effect of droughts and to prevent floods, soil erosion and desertification. Indeed, the purpose of green infrastructure can be framed as maintaining, strengthening and restoring ecosystems and the services they provide (Wakenhut, 2010).

Table 2.7 illustrates the synergy between ecosystem services and green infrastructure benefits (based on TEEB categorisation of services). This takes a typology of ecosystem services and indicates where potential links exist with the benefits of green infrastructure identified in Section 2.2.5. It shows how there are links across all the categories of services: provisioning, regulating, habitat and cultural. Readers should note that the links identified are for illustrative purposes only; there is potential for many others not on record.

This study's terminology has focused on the broad benefits of green infrastructure rather than presenting these as ecosystem services, which is not to say that the benefits can't take the form of ecosystem services as well.

The following case study illustrates the potential for analysis of the ecosystem services of green infrastructure; it describes research from the United Kingdom that aimed to develop tools and methodologies to deliver an ecosystem-based approach for planning green infrastructure.

([11]) See http://www.teebweb.org/ForPolicymakers/tabid/1019/language/en-US/Default.aspx.
([12]) See http://www.eea.europa.eu/publications/eu-2010-biodiversity-baseline.

Table 2.6   List of ecosystem services according to TEEB

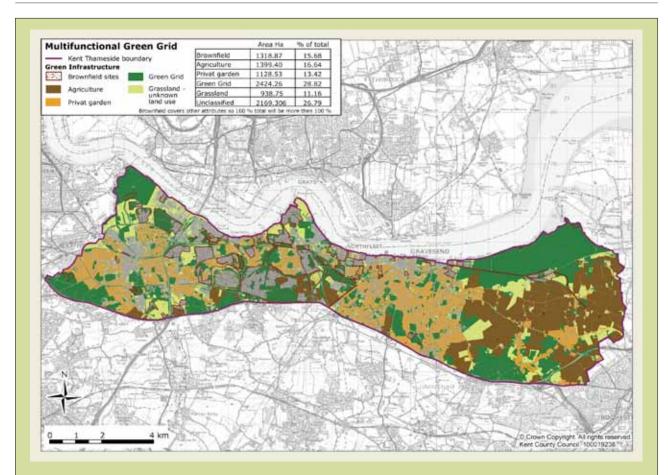|	Main service types
Provisioning services are products obtained from ecosystems such as food, fresh water, wood, fibre, genetic resources and medicines.	**Provisioning services** 1 Food (e.g. fish, game, fruit) 2 Water (e.g. for drinking, irrigation, cooling) 3 Raw materials (e.g. fibre, timber, fuel wood, fodder, fertiliser) 4 Genetic resources (e.g. crop improvement and medicinal purposes) 5 Medicinal resources (e.g. biochemical products, models and test organisms) 6 Ornamental resources (e.g. artisan work, decorative plants, pet animals, fashion)
Regulating services are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination or pest control.	**Regulating services** 7 Air quality regulation (e.g. capturing (fine) dust, chemicals) 8 Climate regulation (including carbon sequestration, influence of vegetation on rainfall) 9 Moderation of extreme events (e.g. storm protection and flood prevention) 10 Regulation of water flows (e.g. natural drainage, irrigation and drought prevention) 11 Waste treatment (especially water purification) 12 Erosion prevention 13 Maintenance of soil fertility (including soil formation) 14 Pollination 15 Biological control (e.g. seed dispersal, pest and disease control)
Habitat services highlight the importance of ecosystems to provide habitats for migratory species and to maintain the viability of gene pools.	**Habitat services** 16 Maintenance of life cycles of migratory species (including nursery services) 17 Maintenance of genetic diversity (especially gene pool protection)
Cultural services include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values.	**Cultural services** 18 Aesthetic information 19 Opportunities for recreation and tourism 20 Inspiration for culture, art and design 21 Spiritual experience 22 Information for cognitive development

Source: TEEB, 2009.

Case study: Developing tools and methodologies to deliver an ecosystem-based approach — Thames Gateway Green Grids

The British Department for Environment, Food and Rural Affairs (Defra) commissioned a study as part of their Natural Environment Policy research programme to evaluate the value and appropriateness of using an ecosystem services approach within existing land-use planning frameworks, particularly its application through a range of decision support tools (e.g. network analysis, STELLA modelling and Geographical Information Systems (GIS)) using Kent Thameside east of London as a case study. The study was conducted between 2006 and 2008.

Kent Thameside is a key development area of the Thames Gateway Growth Area within the British government's Sustainable Communities Plan. The area is subject to various constraints relating to water resource availability, flood risk, air quality, transport and biodiversity, among others. However, there are extensive areas of brownfield (previously developed) land available in north Kent for new development, particularly those resulting from historical quarry and cement works activities in the area. The Channel Tunnel Rail Link (CTRL) passes through Kent Thameside and the new CTRL station at Ebbsfleet is also located within the area.

Multifunctional Green Grid

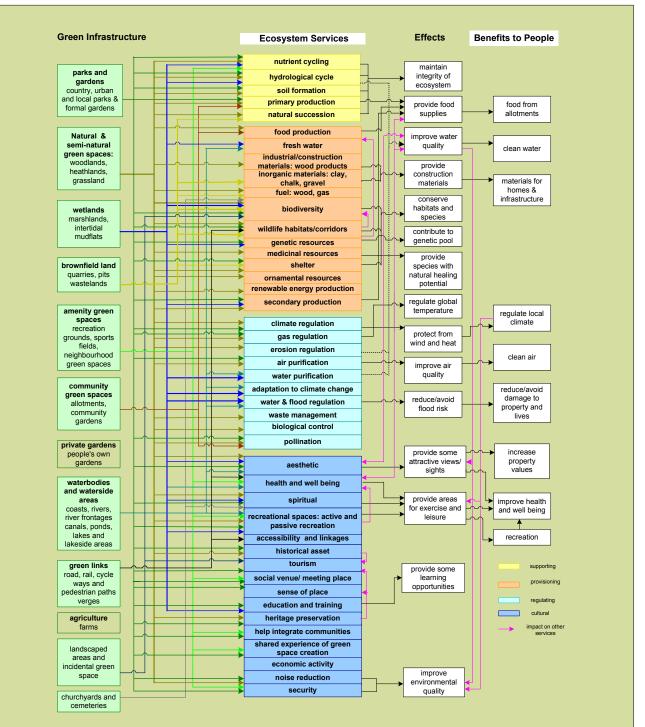|	Area Ha	% of total
Brownfield	1318.87	15.68
Agriculture	1399.40	16.64
Privat garden	1128.53	13.42
Green Grid	2424.26	28.82
Grassland	938.75	11.16
Unclassified	2169.306	26.79

Map of existing land cover/land use as a basis for a multifunctional green grid in Kent Thameside

The project focused on the Green Grid initiative — an important green infrastructure planning concept designed to improve the environmental perception of the Gateway, enhance environmental assets with a network of green spaces and corridors, recognise the importance of multifunctional green spaces for community life, and help ensure that green spaces can also provide important adaptation tools, for example, helping with flood relief and improving quality of life.

The project sought to understand and assess the ecosystem services function provided by the Green Grid to the local area and to local communities. The research was highly participative, including local people and taking into account stakeholder interests from the early stages; they helped identify the uses to which the Green Grid network is put, what benefits people derive from it and their own perceptions of the Green Grid concept in practice. The project then evaluated the interrelationships between these ecosystem services and between ecosystem services and potential development impacts, through a sequential approach to the use of dynamic models and GIS. Network analysis and a specialist modelling software tool called STELLA were used, providing a means of quantifying relationships between environmental, socio-economic and other parameters, supported also with GIS spatial data analysis.

The case study explored different geographical scales within Kent Thameside and for different types of analyses, e.g. impacts of different policy options on ecosystem services, or impact of development on local ecosystem services. In doing so, it provided a better understanding of the nature of ecosystem services provided by the Green Grid, and their interactions. The methodologies tested by this research provided a means of integrating the concept of ecosystem services into existing land use planning frameworks, for example through Local Development Frameworks, Regional Spatial Strategies and sustainability appraisals/SEA. Importantly, ecosystem services provide a different conceptual approach to evaluating sustainability, not so much in meeting environmental, social and economic objectives, but in delivering fundamental provisioning, regulating, cultural and supporting services, so that plans and programmes could be assessed against the area's ability to deliver these services.

Network analysis diagram illustrating the links between elements of the green infrastructure (e.g. parks and gardens, natural and semi-natural green spaces, wetlands), ecosystem services currently provided by the Kent Thameside Green Grid (dividing into supporting, provisioning, regulating and cultural services), and the benefits people derive from these services.

Further information:

Defra, 2011, Case study to develop tools and methodologies to deliver an ecosystem based approach — Thames Gateway Green Grids — NR0109 (http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module =More&Location=None&Completed=0&ProjectID=14753#Description).

Table 2.7   Relationship between green infrastructure benefits and ecosystem services

Main ecosystem service-types	Biodiversity/ Species protection			Climate change adaptation			Climate change mitigation			
	Habitats for species	Permeability for migrating species	Connecting habitats	Mitigating urban heat island effect — evapotranspiration, shading & air flow	Strengthening ecosystems resilience to climate change	Storing floodwater & reducing run-off to reduce risk of flooding	Carbon sequestration	Encouraging sustainable travel	Reducing energy use for heating and cooling buildings	Providing space for renewable energy
Provisioning										
1 Food										
2 Water						●				
3 Raw materials	●									●
4 Genetic resources										
5 Medicinal resources										
6 Ornamental resources										
Regulating										
7 Air quality								●		
8 Climate regulation				●	●		●	●	●	●
9 Moderation of extreme events						●				
10 Regulation of water flows						●				
11 Waste treatment especially water purification										
12 Erosion prevention										
13 Maintenance of soil fertility										
14 Pollination										
15 Biological control										
Habitat										
16 Maintenance of life cycles of migratory species	●	●	●		●					
17 Maintenance of genetic diversity										
Cultural										
18 Aesthetic information										
19 Opportunities for recreation and tourism										
20 Inspiration for culture, art and design										
21 Spiritual experience										
22 Information for cognitive development										

Table 2.7   Relationship between green infrastructure benefits and ecosystem services (cont.)

	Water management			Food production and security				Recreation, well-being & health			Land values	Culture & communities		
	Sustainable drainage systems — attenuate surface water run-off	Groundwater infiltration	Removal of pollutants from water (e.g. reed beds)	Direct food & fibre production on agricultural land, gardens, etc.	Keeping potential for agricultural & food security (safeguarding soil)	Soil development and nutrient cycle	Prevent soil erosion	Recreation	Sense of space and nature	Cleaner air	Positive impact on land and property	Local distinctiveness	Opportunities for education, training and social interactions	Tourism opportunities
				●	●									
	●	●	●											
				●		●								
												●		
									●					
	●	●	●											
	●	●	●											
							●							
						●	●							
									●			●		
								●						●
								●			●	●		

3 Integration of green infrastructure into policy sectors

3.1 Links between green infrastructure and other policy sectors

Several sectors are of relevance to green infrastructure: these include water management, transport, agriculture and forestry, energy and the urban/built environment. Green infrastructure can play a part in meeting requirements of these policy sectors, as shown below.

- The Thematic Strategy on the Urban Environment adopted in 2006 recommends an integrated management of the urban environment to avoid the loss of natural habitats and biodiversity due to urban sprawl.
- The Floods Directive requires that flood risk management plans be drawn up which consider the maintenance and restoration of floodplains,

and the use of soil and water management, spatial planning, land use and nature conservation to reduce risk.

- Agricultural policy, the reform of the CAP can provide instruments for protecting landscape elements and ensuring existing subsidies provide an incentive for farmers to protect farm biodiversity.
- Cohesion policy, which already co-finances investment in green infrastructure, can ensure a roll-out of green infrastructure at local/regional level.

Table 3.1, taken from Natural England's *Green Infrastructure Guidance* in the United Kingdom, illustrates how the functions and benefits of green infrastructure can be highly compatible with other policy objectives.

Table 3.1   Compatibility of green infrastructure functions with examples of other policy objectives

Green infrastructure functions and benefits	Policy priorities							
	Economic	Environmental					Social	
	Economic growth & employment	Protect & enhance cultural heritage	Protect & enhance the landscape, geodiversity & natural environment	Biodiversity conservation & enhancement	Climate change mitigation & adaptation	Promoting sustainable transport & reducing the need to travel by car	Community cohesion & lifelong learning; volunteering	Healthy communities; health & well-being
Access, recreation, movement and leisure	●	●				●	●	●
Habitat provision and access to nature		●	●	●	●		●	●
Landscape setting and context for development	●	●	●				●	●
Energy production and conservation	●				●			
Food production and productive landscapes	●	●	●		●	●	●	●
Flood attenuation and water resource management	●		●	●	●			●
Cooling effect	●		●		●			●

Source: Natural England, 2009.

3.2 Identifying potential policy interactions

The first step in the analysis of the integration of green infrastructure into EU sectoral policies was to screen for existing interactions between the benefits from green infrastructure (see Table 2.4) and the objectives of other sectoral and environmental policies. The supposition was that both might be mutually supportive (i.e. green infrastructure may help to achieve wider EU policy objectives, and in turn the implementation of these policies may support the development of green infrastructure), or at least synergistic in one direction. The key questions in these cases are whether the link is recognised within the policy or its implementation, and whether the synergy could be strengthened.

The other possibility is that of a tension between the policy objective and green infrastructure — the delivery of a policy objective might negatively affect the delivery of green infrastructure and its benefits, or implementing green infrastructure might conflict with another objective. In these cases, the integration of green infrastructure would potentially be realised through a removal or abatement of the conflicting issue in some way, or its implementation might need to be conditioned to avoid the potential negative effect.

An analysis of the interaction between two (or more) policies can be carried out at various levels, and there may well be different types of interaction occurring at these levels. The highest level could be categorised, for example, as policy objectives: policy instruments and policy implementation practices.

Table 3.2 EU environmental and sectoral policy objectives

Climate change
- Reduction in greenhouse gases
- Renewable share of energy
- Reduction in energy consumption
- Resilience to deal with climate impacts

Biodiversity
- Functioning of natural systems, habitats, wild flora and fauna
- Limiting emissions of pollutants fostering eutrophication
- Reverse negative species trends
- Keep fishing within safe limits

Energy
- Supply security
  - Securing energy supply
- Internal market
  - Grid Investments
  - Common rules (access rights, free market, GHG trading)
- Promoting renewable sources of energy
  - Promoting biofuels
  - Offshore energy
  - Promoting biomass
  - Promoting renewable energy generally
- Energy efficiency
  - Building efficiency
  - Cogeneration
  - Products and services efficiency

Transport
- Promote public urban transport
- Quality, safety, reduce hazards
- Environmentally friendly transport
- Modal shift and integration of transport systems
- Transport labour, health and safety
- Technology innovation in vehicles
- Roads & congestion, pricing, tolls, etc.
- Planning for accessibility

Agriculture
- Productive and competitive EU agriculture
  - A fair standard of living for farmers
  - Global competitiveness without distorting trade
- Preserve rural communities (dynamism and sustainability)
  - Agriculture & forestry: restructuring, development, innovation
  - Improving the environment and the countryside: land management
  - Quality of life, diversification in rural areas
- Protect the environment, animal welfare (cross-compliance)
  - EU rules on environment
  - National rules for soil and landscape

Cohesion
- Attractive places in which to invest and work
  - Expand and improve transport infrastructure
  - Strengthen the synergies between environmental protection and growth
  - Address Europe's intensive use of energy sources
- Knowledge and innovation for growth
- More and better jobs
  - Attract and retain more people in employment; modernise social protection systems
  - Improve adaptability of workers and enterprises; improve flexibility of labour markets
  - Increase investment in human capital
  - Improve administrative capacity of public administrations and services
  - Maintain a healthy labour force
- Territorial dimension
  - Ensure the contribution of cities to growth and jobs
  - Support the economic diversification of rural areas, fisheries areas and areas with natural handicaps
  - Promote cross-border, transnational and interregional cooperation to complement all

This study has focused on the identification of potential conflicts at the policy objective level, whilst also identifying the synergies. The analysis so far indicates that the sources of conflict are generally not inherent to the policy objective, but are rather a result of policy instrument or particular implementation practices lower down in the policy implementation hierarchy. Examples of sources of potential conflicts in EU sector policy instruments and of mechanisms for potentially addressing them form part of this study.

The list of environmental and sectoral policy objectives used as part of the analysis draws on a recent EEA analysis (not published), *Analysing Policy Coherence conceptual approach and case studies, (October 2010),* see Table 3.2.

3.3 Green infrastructure benefits and EU policy objectives: synergies and conflicts

Possible interactions between policy objectives and green infrastructure benefits are screened to identify key potential synergies and conflicts. Each of the policy objectives and green infrastructure benefits are considered. The interactions, both for potential conflicts and synergies, are more likely to be mutually supporting/conflicting (as is often the case), rather just going in one direction:

1. conflicts:
    (a) green infrastructure benefit conflicting with policy objective;
    (b) policy objective conflicting with green infrastructure benefit;
2. synergy:
    (a) green infrastructure benefit supporting policy objective;
    (b) policy objective supporting green infrastructure benefit.

A summary of the key interactions identified is included in Table 3.3.

Not surprisingly, EU climate change and biodiversity policy objectives were both identified as having potentially strong synergistic links to green infrastructure benefits. The main potential

Table 3.3   Overview of key interactions between EU sector/environmental policies and green infrastructure benefits

EU environ-mental and sector policy areas	Potential synergies			Potential conflicts		
	Green infrastructure benefits		Policy objective	Green infrastructure benefits		Policy objective
Climate change	Interconnected habitats	←→	Resilience to deal with climate impacts	No conflicts		
	Storing floodwater	←→	Resilience to deal with climate impacts			
	Mitigation of urban heat island	←→	Resilience to deal with climate impacts			
	Encouraging sustainable travel	←→	Reduction in GHGs			
Biodiversity	Interconnected habitats	←→	Sustain and improve biodiversity	No conflicts		
Energy	Reducing energy use in buildings, and encouraging sustainable travel	→	Securing energy supply	Interconnected habitats	←→	Securing energy supply
	Natural habitats	←→	Promoting biomass	Natural habitats	←→	Promoting biomass
	Space for renewable energy	←→	Promotion of renewable energy	Natural habitats	←→	Promoting biofuels
Transport	Encouragement of sustainable travel	←→	Modal shift and integration of transport systems	Natural habitats	←→	Minimising congestion

Table 3.3   Overview of key interactions between EU sector/environmental policies and green infrastructure benefits (cont.)

EU environmental and sector policy areas	Potential synergies			Potential conflicts		
	Green infrastructure benefits		Policy objective	Green infrastructure benefits		Policy objective
Agriculture	Soil development and safeguarding	→	A fair standard of living for farmers	Interconnected habitats	←→	Competitiveness of EU agriculture/a fair standard of living for farmers
	Recreation, sense of space and nature	←→	Quality of life and diversification in rural areas			
	Tourism opportunities	←→	Quality of life and diversification in rural areas			
Cohesion	All benefits of green infrastructure	←→	Strengthen the synergies between environmental protection and growth	Interconnected habitats	←→	Expand and improve transport infrastructure
	Recreation	→	Maintain a healthy labour force	Sense of space and nature	←→	Expand and improve transport infrastructure
	Mitigating urban heat island	→	Maintain a healthy labour force	Soil development and safeguarding	←→	Expand and improve transport infrastructure
	Tourism opportunities	←→	Economic diversification of rural areas	Natural habitats	←→	Economic growth

Key: → = potential synergy; → = potential conflict. Direction of arrow indicates direction of interaction.

conflicts identified are with those cohesion and transport policy objectives promoting expanded and improved infrastructure. Increasing the competitiveness of agriculture in the EU, as well as promotion of biofuels and biomass, can have both positive and negative effects on the delivery of green infrastructure benefits, depending on how they are implemented. On the other hand, green infrastructure benefits can positively impact some other areas of EU cohesion policy — such as maintaining a healthy labour force (by providing recreation and mitigating the heat urban island effect, for example) and diversifying the incomes in rural areas.

Table 3.4   Examples of potential key conflicts identified

EU environmental and sector policy areas	Brief description of potential conflicts
Climate change	**No conflicts in general.** Carbon *sequestration measures can affect biodiversity.*
Biodiversity	**No conflicts in general.** One could argue that there are potential conflicts in the field of biodiversity, such as on IAS and connectivity improvements in special cases (whilst this can be theoretically resolved by stating that green infrastructure is generally strengthens ecosystems, making them more resistant against IAS intrusion.
Energy	**Securing energy supply** (through constructing gas pipelines, gridlines, new plants) can damage habitat connectivity and decrease areas of green infrastructure. Failures and leakages dramatically jeopardise habitat preservation. **Promoting biofuels** can result in increase of areas of intensive farming, decreasing the area of woodlands, number of hedges, etc. It can also reduce multifunctionality of the farmed land. **Promoting solid biomass** can contribute to the area of woodland and other natural ecosystems but also decrease biodiversity in those places.

Table 3.4   Examples of potential key conflicts identified (cont.)

EU environmental and sector policy areas	Brief description of potential conflicts
Transport	**Efforts to minimise congestion** can result in construction of new roads, damaging habitat connectivity and decreasing areas of green infrastructure.
Agriculture	**Efforts to increase competitiveness of EU agriculture** can be implemented through increasing yields and therefore the area for intensive farming, increasing agricultural inputs (fertiliser, pesticides, water), decreasing the areas of woodlands, number of hedges, etc. It also reduces multifunctionality of the farmed land. Further green-infrastructure–related issues may arise from certain practices, for example water scarcity.
Cohesion	**Expansion and improvement of transport infrastructure** can weaken habitat connectivity and generally decrease the area occupied by or efficiency of green infrastructure.
	Protection of habitats may require **limits on growth** and development of adjacent areas that are not currently enforceable with existing legislation.

There are generally no fundamental conflicts at the policy objectives level that could not be avoided through appropriate instruments and/or implementation practice. The tensions tend to arise from a particular instrument of delivery of the objective or an implementation practice. Table 3.4 lists examples of conflicts arising from particular instruments of EU sector policies and green infrastructure benefits.

3.4   How can green infrastructure be implemented in other sector policies?

3.4.1   Potential mechanisms for integrating green infrastructure into other EU sectoral and environmental policies

The need to consider the effectiveness and efficiency of policy measures that can be used for green infrastructure has been recognised in the literature (EEAC, 2009). In addition, the implementation of existing directives such as the Habitats, Birds, Floods, and Water Framework Directives,could already offer some productive solutions to promoting green infrastructure (EEB, 2008). Under these directives, for example, Member States have already committed to meeting ecological objectives for their water bodies as well as for their protected areas by 2015. These set an important timeframe and policy context for the construction of green infrastructure. At the same time, any reforms of existing policies for agriculture, energy and transport would potentially provide an opportunity to better protect the natural capital which green infrastructure helps provide.

The Water Framework Directive is also a potential instrument for green infrastructure development through the introduction of integrated water management at catchment scale. It is the most substantial and comprehensive piece of EC water legislation and requires all surface, groundwater and coastal waters to reach 'good status' by 2015. Under the Water Framework Directive, Member States have to ensure a balance between groundwater abstraction and replenishment, measures that directly contribute to soil moisture and water storage. Water and climate change policies can also be used to support nature protection, with provisions for land management to prevent floods, mudslides or erosion, for example. The link between the Water Framework Directive and green infrastructure is explored in more detail in Section 3.4.2 below.

However, in addition to the utilisation of existing legislation, it could be argued that the strategic planning of green infrastructure could benefit from EU guidance/legislation setting targets and objectives and describing a process which would allow national/regional/local targets to be set within a strategic spatially defined framework. Member States will need to identify current assets, functional requirements and benefits of green infrastructure. Together, this could encourage national and local authorities to take this innovative and integrated approach to territorial planning.

Beyond the environment and its policies (e.g. nature protection, biodiversity, water, climate change,

marine and coastal), other sectoral policies at EU level also have a key role to play in implementing green infrastructure and the ecosystems and services they provide. This is particularly relevant to policies that shape the use of land and its spatial patterns: regional policy, agriculture, transport, energy, transport and resource efficiency policy.

Responsibility for promoting and delivering green infrastructure is clearly shared at all levels (e.g. the European Commission, Member States, and governmental authorities at national and local levels, NGOs, landowners and land users).

The types of mechanisms that could be used to integrate green infrastructure into other policies, including their objectives, instruments and implementation practices, are included in Table 3.5. These include the following:

- existing or new European and national environmental legislation;

- existing or new European and national legislation on green infrastructure;

- European and Member State guidance/ management plans on green infrastructure;

- direct support through targeted European funding and non-EU funding;

- indirect support through European funding in other sector areas (e.g. agriculture);

- national and regional green infrastructural strategies;

- spatial planning and building control;

- strengthening the use of assessment: SEA and EIA;

- communication and capacity building.

Table 3.5   Potential mechanisms that could be used to integrate green infrastructure into other policies

Potential mechanisms	Description	Examples
Existing or new European and national environmental legislation	Existing legislation provides considerable scope to promote green infrastructure, although in some cases this potential is not being realised. At European level, relevant legislation includes the White Paper *Adapting to Climate Change*; Habitats and Birds Directives; Water Framework Directive; Floods Directive; Marine Strategy Framework Directive; and the EIA and SEA Directives (see below in same table). Green infrastructure is an important tool for delivering various aspects of these existing directives. Several countries have implemented existing EU environmental legislation in a way which helps facilitate the provision of green infrastructure (see below in same table).	See Table 3.7 for a comparison of approaches in different example countries.
Existing or new European and national legislation on green infrastructure	The EU Commission proposes to develop a policy document on green infrastructure. This figures prominently in the EU's new post-2010 biodiversity policy; green infrastructure is considered to be one of the main tools to tackle threats on biodiversity resulting from habitat fragmentation, land use change and loss of habitats. Several countries have implemented existing EU legislation (see above in same table) and have developed national legislation related to green infrastructure (see below in same table).	Estonian National Green Infrastructure Strategy (see Annex 4). See Table 3.7 for a comparison of approaches in different countries.
European and Member State guidance/ management plans on green infrastructure	The provision of guidance or a toolbox of support for the implementation of green infrastructure would be beneficial both at EU and Member State levels. In addition, good practice case studies provide a useful resource. There are several existing examples of guidance and case studies available.	See list of references at the end of this report.

Table 3.5   Potential mechanisms that could be used to integrate green infrastructure into other policies (cont.)

Potential mechanisms	Description	Examples
Direct financial support through targeted EU funding and non-EU funding	There are various EU regional policy funding instruments, including the Regional Development Funds and the Rural Development Fund, that can be used to support green infrastructure, some directly and others indirectly (see below in same table). Green infrastructure projects can be directly supported through ERDF, ESF and Cohesion Funds as well as other financial instruments. Existing examples are green infrastructure projects funded through LIFE, EU's financial instrument for the environment, and other co-financed green infrastructure projects e.g. ERDF projects. LIFE has calls for projects in different environmental categories, one of them being Nature and Biodiversity. Many green infrastructure projects have been funded though this mechanism (EC, 2010g). LIFE+ remains an active funding programme; however there is still scope and need to create other funding opportunities that would specifically target green infrastructure projects, especially of smaller scale and scope.

In the future (i.e. beyond the current programme from 2007 to 2013), EU regional policy will need to consider how green infrastructure can be conceptualised and supported as a new approach to regional development. Green infrastructure is a possible tool to improve territorial cohesion at environmental level and to ensure ecological continuity. Regional policy has to ensure that programmes do not negatively impact green infrastructure (e.g. by reflecting the importance of green infrastructure and the ecosystems and services it provides in SEAs and EIAs). In addition, climate change adaptation funding in the future which utilises green infrastructure will be more important.

Other non-EU funding sources include national governments, the EIB, private banks, developers and third sector organisations. The private sector is already involved in developing green infrastructure through conditions and mitigation as part of major infrastructure projects and urban development schemes, for example (which may also involve the environmental assessment process — see below in same table). Increasingly, the private sector may apply biodiversity offsetting measures on development schemes and as part of corporate social responsibility programmes. | Combining LIFE funds and CAP subsidies for establishing long-term protection of Crex crex L 1758 (Corncrake) in Slovenia (see Annex 4).

See European Commission (2010g) and 2011, ERDF funding for ecological corridors in Poland. |
| Indirect financial support through European funding in other sector areas (e.g. agriculture) | Agricultural policy and support is particularly relevant to green infrastructure as it seeks to increase the resilience and permeability of the farmed landscape, and preserve and enhance high nature value in the wider countryside. The CAP aims to encourage the delivery of ecosystem services through sustainable land management; both the first and second pillars (income support and rural development) have the potential to promote green infrastructure. Agro and forest environment schemes which support environmental management and sensitive practices are examples of mechanisms that can indirectly support green infrastructure, along with such measures as management plans for Natura 2000 sites, green tourism, training and advisory services.

A possible strategy of integration of the green infrastructure into agricultural policy would be to identify particular practices that enable the agricultural land to contribute to green infrastructure and promote multifunctionality of agricultural land — its role in biodiversity, recreation and water management. | Combining LIFE funds and CAP subsidies for establishing long-term protection of Corncrake in Slovenia (see Annex 4). |

Table 3.5   Potential mechanisms that could be used to integrate green infrastructure into other policies (cont.)

Potential mechanisms	Description	Examples
National, regional and local green infrastructural strategies	National, regional and local green infrastructure strategies, either independently or as an integrated layer in wider national strategy would be a welcome addition that would enable delivery of green infrastructure. The basis of the strategy would be the identification of green assets, corridors and areas of special importance to green infrastructure (also outside protected areas), which would help inform EIA, SEA and other policy instruments. Some countries, for example the Czech Republic, Denmark, Germany, Estonia, France, the Netherlands and Slovakia are already active in planning green infrastructure (at least in an ecological network sense) on a national level. One mechanism that can be introduced is a set of standards to guide local green infrastructure deficiency and needs analysis, particularly in the urban context. This may include, for example, requirements for a hierarchy of green spaces to be available within a certain catchment per head of population, whilst clearly needing to reflect local circumstances. This is used in the United Kingdom, for example, where Natural England has developed Accessible Natural Greenspace Standards. The forthcoming EU green infrastructure policy document could provide a lead to Member States on the need and role of national and lower tier green infrastructure strategies.	Estonian National Green Infrastructure Strategy (see Annex 4). Green Infrastructure North West (England) (see Annex 4). Green Infrastructure Strategy for Cambridge (United Kingdom) (see Annex 4).
Spatial planning system and building control	Spatial planning will be a key tool in the development of green infrastructure. Best practice strategic spatial planning in Europe already supports the integration of biodiversity. Spatial planning can be used to plan the interactions between land uses at the strategic level, guide development away from sensitive areas and promote the restoration and enhancement of ecosystems and connections between natural areas. At the more local building scale, the planning system can be used — via building standards, regulations or codes — to include local green infrastructure such as green roofs and walls as part of development projects, and to promote sustainable urban drainage schemes as part of green infrastructure. There is a clear need for a multilevel policy approach for and between local, national and European level policy in this area (here it is worth noting that some of the findings from the PLUREL project (2011) include that the regional government's role in planning is generally weak across Europe, and that economic growth is favoured over sustainability concerns, be they to protect/promote green infrastructure, or public transport in lieu of private cars, or to support farming in the urban fringe). The ESDP has as its objectives the development of ecological networks and the integration of biodiversity considerations into sectoral policies such as agriculture, transport, tourism, recreation and fisheries. Green infrastructure has also been promoted by The European Landscape Convention since 2000, and was thus recognised early on by the landscape profession as having potential for being integrated into regional and town planning policies, as well as into cultural, environmental, agricultural, social and economic policies. In addition, in the context of the Environmental Liability Directive, compensation in advance of a development could be required, e.g. for all new infrastructure development. Green infrastructure could thus be a way of offsetting the impacts, with developers investing in appropriate green corridors and stepping stones for species dispersal and migration. This would ensure that damages are compensated in the places that are useful and strategic for conservation, rather than in a haphazard fashion.	Estonian National Green Infrastructure Strategy (see Annex 4). Green Infrastructure North West (England). Green Infrastructure Strategy for Cambridge (United Kingdom) (see Annex 4).

Table 3.5   Potential mechanisms that could be used to integrate green infrastructure into other policies (cont.)

Potential mechanisms	Description	Examples
Strengthening the use of assessment: Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA)	The application of the EIA or SEA can be used (in a reactive way) to protect where assets that can be classified as green infrastructure and to identify suitable mitigation measures for spatial interventions, for example construction of green bridges over new roads. So far, these kinds of interventions have been mostly limited to the Natura 2000 and other protection sites, rather than to green infrastructure more generally. However, more proactively, the SEA and EIA can be used to assess the compatibility of regional and territorial development with green infrastructure and biodiversity. Its scope can also be broadened by accounting for nature protection in the development of infrastructures, and by using nature for economic diversification (e.g. TEN-T revision (EC, 2002), Community Strategic Guidelines (EC, 2005).	Wareham Managed Re-alignment (UK) — Green infrastructure in environmental assessment (see Annex 4). Thames Gateway Green Grids (United Kingdom) (see Section 2.2.7).
Communication and capacity building	Communication to key stakeholders regarding the importance of green infrastructure and the ecosystems and services it provides, and capacity building to enable it to be implemented at all relevant scales (EU, national, regional and local) and by all relevant stakeholders.	Combining LIFE funds and CAP subsidies for establishing long-term protection of Corncrake in Slovenia (see Annex 4). Green Infrastructure North West (England).

Note that the 'Examples' column in Table 3.5 refers to illustrative case studies included in this report.

3.4.2   *An example of the links between the Water Framework Directive and green infrastructure*

As mentioned above, there exist particular synergies between water policy and green infrastructure.

Table 3.6   Links between Green Infrastructure and the Water Framework Directive

Green infrastructure topic area	Green infrastructure benefits	Related provisions of the Water Framework Directive
Biodiversity/species protection	Habitats for species Permeability for migrating species Connecting habitats	• A core objective of the directive is the protection of aquatic (mainly freshwater) ecosystems and associated terrestrial ecosystems. • River systems provide a strong connecting feature of landscapes, for *both aquatic* and other species.
Climate change adaptation	Mitigating urban heat island effect with evapotranspiration, shading and keeping free corridors for cold air movement Strengthening ecosystems' resilience to climate change Storing flood water and ameliorating surface water run-off to reduce the risk of flooding	• The Floods Directive is closely linked to the Water Framework Directive, and from 2015, river basin management plans are to implement the planning under both directives.

Table 3.6   Links between Green Infrastructure and the Water Framework Directive (cont.)

Green infrastructure topic area	Green infrastructure benefits	Related provisions of the Water Framework Directive
Climate change mitigation	Carbon sequestration	• While inland waterways are claimed to provide a more sustainable form of freight transport than roads, and hydropower can reduce greenhouse gas emissions, both types of infrastructure can harm the biodiversity function of water bodies. • The Water Framework Directive sets rules and guidelines for addressing such conflicts (e.g. Article 4).
	Encouraging sustainable travel	
	Reducing energy use for heating and cooling buildings	
	Providing space for renewable energy, such as ground source heating, hydroelectric power, biomass and wind power	
Water management	Sustainable drainage systems — attenuate surface water run-off	• Sustainable drainage and flood risk management is supported by the Floods Directive. • Sustainable groundwater replenishment (good quantitative status) is an objective of the Water Framework Directive.
	Groundwater infiltration	
	Removal of pollutants from water (e.g. reed beds)	
Food production and security	Direct food and fibre production on agricultural land, gardens and allotments	
	Keeping potential for agricultural land — food security (safeguarding of soil)	
	Soil development and nutrient cycle	
	Prevent soil erosion	
Recreation, wellbeing and health	Recreation	• Recreational waters can be designated for protection under the Water Framework Directive, which also refers to the Bathing Water Directive.
	Sense of space and nature	
	Cleaner air	
Land values	Positive impact on land and property	
Culture and communities	Local distinctiveness	
	Opportunities for education, training and social interactions	
	Tourism opportunities	

Water bodies are an important element of green infrastructure; it is useful to consider the synergies between green infrastructure benefits and EU water management, focusing on the Water Framework Directive. Table 3.6 lists the main topics and benefit areas. It shows that the Water Framework Directive addresses many of these, though it does not address food production, economic values or culture and communities.

The role of water bodies in green infrastructure is seen in France's national programme for green infrastructure, which is called the Green and Blue Web (La Trame verte et bleue) and thus puts water

Case study: Green and Blue Infrastructure in France

Short description

The creation of the Green and Blue Infrastructure in France (La Trame verte et bleue) is one of the key measures adopted through the 2007 national public consultation 'Grenelle de l'Environnement'. Law N° 2009-967 of 3 August 2009 ([13]), or Law Grenelle I, establishes the main principles of the Infrastructure in the French legislative framework, and Law N°2010-788 of 12 July 2010, or Law Grenelle II, details the measures that will lead to its implementation. The ultimate objective of this approach is to halt losses of 'ordinary' biodiversity ([14]) through the preservation, management and rehabilitation of networks of natural environments, in order to ensure **ecological continuity**. Zones where animals feed, rest and reproduce can be separated by several metres or kilometres (e.g. from one pond to another) so it is essential to create links between these different zones to allow for the movement of animal and plant populations. In its title and provisions, this national approach explicitly links land infrastructure and water bodies.

The networks are made up of **reservoirs of biodiversity** linked together by **ecological corridors**. Water bodies fall in both categories and are an essential element of ecological continuity.

The green component of Green and Blue Infrastructure includes natural and semi-natural ecosystems on land while the blue component is made up of the water and wetland networks (rivers, streams, canals, ponds, wetlands, etc.), linked with one another via land-water interfaces (wetlands and waterside plants in particular).

([13]) Loi n° 2009-967 du 3 août 2009 de programmation relative à la mise en œuvre du Grenelle de l'environnement.
([14]) As opposed to 'outstanding' biodiversity': exceptional natural ecosystems, symbolic or rare species, etc.

It should be mentioned that Green and Blue Infrastructure is co-financed by the ERDF in some French regions such as Rhône Alpes.

Role of spatial analysis

Spatial planning of Green and Blue Infrastructure is conducted at three different levels.

- **At the national level**, the National Guidelines for the Preservation and Rehabilitation of Ecological Continuities ([15]), adopted by decree, define the national and cross-border issues and ensure overall coherence.

- **At the regional level**, the Regional Schemes of Ecological Coherence ([16]) (SRCE) map out the overall Green and Blue Infrastructure within the region and link measures related to biodiversity protection to spatial planning issues. They must take into account the National Guidelines.

- **At the local level**, the existing planning system (local urban planning documents (PLUs) and territorial coherence schemes (SCOTs)) must take into account the SRCE and comply with the National Guidelines.

The local planning documents are consequently the point where planning for green infrastructure is linked to spatial planning.

Link to implementation of the Water Framework Directive

The objectives of the Water Framework Directive are implemented in France through River Basin Management Plans (SDAGE ([17]) in France), for the larger basin districts, or SAGE for the smaller basin districts. The SDAGE and SAGE are set up by the Basin Committee after a public consultation process.

The Regional Schemes of Ecological Coherence (SRCE) must take into account the River Basin Management Plans (RBMPs) when mapping out the regional Green and Blue Infrastructures. This means integrating the listed rivers, streams, wetlands and all other relevant elements of river basin plan into the planning of the networks.

Similarly, the Basin Committee must respect the principle of ecological continuity when they draw up the RBMPs. As the SRCE had not yet been created in 2009 when the first round of plans were last prepared, the RBMPs will integrate the principle of ecological continuity, and in general take into account the SRCE, in their 2015 revision.

Link to the key elements of territorial cohesion, focusing on the environment dimension

- **Harmonious development.** One of the important features of the Green and Blue Infrastructure is that it takes into account those human activities that it might affect: specifically, its objective is to strengthen activities that depend on ecological continuity and are reinforced by it. The infrastructure has a socio-economic component in the sense that it seeks to maintain rural jobs by diversifying farming activities, it creates new rural and urban jobs in environmental land management. It also works as an organising approach for the landscape, and it contributes to maintaining landscape quality and diversity.

- **Inherent features of territories.** The Green and Blue Infrastructure acknowledges that natural habitats are at risk if they are too fragmented, and aims to prevent biodiversity losses by creating linkages between pools of biodiversity (whether on land or in the water). Ensuring that biodiversity reservoirs maintain their functions, preventing fragmentation through the integration of ecological continuity, and maintaining permeability of urban zones are points that managmemnt must factor into spatial plans (PLUs and SCOTs) as well as transport infrastructure planning.

([15]) Orientations nationales pour la préservation et la remise en état des continuités écologiques.
([16]) Schémas Régionaux de Cohérence Ecologique.
([17]) Schémas Départementaux d'Aménagement et de Gestion des Eaux.

- **Concentration (overcoming differences in density).** This new approach of ecological continuity differs from France's traditional biodiversity conservation methods as it looks at rural and urban territories as a whole and not as separate entities. The goal is that PLUs create links, for example through a network of hedges and small fields and urban parks; rivers and riverbanks are also to be an important element of continuity.

- **Connecting territories.** One of the objectives of the project is to restore connections between different territories. As animal and plant migration do not stop at borders, green infrastructure should be continuous from one territory to another: from rural to semi-urban to urban territories, between different regions and different borderlands.

- **Cooperation.** Different species of animals require different levels of management: for some species of migratory birds, ecological continuity has to be managed at national level, whereas insects or amphibians require local management. Therefore, cooperation between the different levels of government is essential for the infrastructures to work. At national level, planning the national transport infrastructure, with high-speed trains, for example, involves taking into account the Regional Schemes of Ecological Coherence and ensuring that transport infrastructures do not disrupt important ecological continuities. At European level, the Green and Blue Infrastructures belong to the PEEN, established in 1995 by the PEBLDS.

Further information:

French Ministry of Ecology and Sustainable Development, 2011, 'La Trame verte et bleue' (http://www.developpement-durable.gouv.fr/-La-Trame-verte-et-bleue,1034-.html)

Trame verte et bleue, Proposition issue du comite opérationnel trame verte et bleue en vue des orientations nationales pour la préservation et la remise en bon état des continuités écologiques, *Premier Document en appui à la mise en œuvre de la Trame verte et bleue en France,* Version consolidée par l'Etat, Juillet 2010.

Jérôme CHAMPRES, *Trame verte et bleue, une vision paysagère et écologique de l'aménagement du territoire*, Techni-Cités n° 170, pp. 21–23, 23 May 2009.

bodies on an equal level with land elements of green infrastructure. This programme is described in the box below.

3.5 Experience of implementing green infrastructure in different countries

3.5.1 *Examples of the application of green infrastructure across Europe*

Across Europe and beyond, there is considerable existing experience of implementing green infrastructure initiatives. Table 3.7 presents a few examples of different countries' approaches in Europe: Belgium, Denmark, Germany, Estonia, Ireland, France, Hungary, the Netherlands,

Austria and the United Kingdom [18]. Additional examples of projects can be located through the EU-LIFE programme (EC, 2010g) including the EU Commission workshop on Green Infrastructure in 2009 (Sundseth and Sylwester, 2009).

3.5.2 *Experience of the application of green infrastructure in the United States*

Federal level

In May 1999, President Clinton's Council on Sustainable Development produced a report entitled *Towards a Sustainable America — Advancing Prosperity, Opportunity and a Healthy Environment for the 21st Century*. Within this report, several key strategies for

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[18] Green infrastructure examples from Austria, Ireland, Denmark, Belgium, Hungary, France and the Netherlands are taking from the Working group on green infrastructure – scoping document (v1.1).

Table 3.7   Comparisons of some national approaches and experiences of green infrastructure

Country	Summary
Belgium	• LIFE funding enabled Natuurpunt, a Flemish NGO, to acquire land along the banks of the Dijle in Leuven, and to remove obstacles to flooding such as poplars and maize crops. • Before the implementation of project actions, flooding would regularly affect areas of Leuven, including the famous university campus. However, the city has not experienced flooding for several years — since the completion of the project. • The dual conservation and flood management benefits of the project mean that it has been a win-win situation. It has also proved to be a cheaper alternative to constructing a large dam near the city, even when taking into account of the cost of land purchase.
Denmark	• The City of Copenhagen has set out four requirements for green roofs. Buildings with green roofs should be able to meet at least two of the following requirements: absorb 50 % to 80 % of the precipitation that falls on the roof, provide a cooling and insulating effect on the building and reduce reflection, help make the city greener, reduce the urban heat island effect, and counteract the increased temperatures in the city. • They will also contribute to a visual and aesthetic architectural variation that has a positive effect on the quality of the life and double the roof life of the roofing membrane by protecting it against UV rays, for example.
Germany	• In 2002, the German Nature Conservation Act was amended to enable the establishment of an ecological network (Biotopverbund) on at least 10 % of the German territory. The German federal states are tasked with implementing this network through a transboundary approach. • In 2004, a system of common criteria for identifying the components of the ecological networks was agreed on. Through the application of these criteria, the core areas and corridors of national and international relevance are being identified. • In implementing ecological networks, the federal states follow different approaches. Some states use bottom-up approaches with local initiatives applying for funds for local or regional projects. There is no binding time schedule for the implementation of a national ecological network, although the National Strategy on Biodiversity calls for its implementation by 2010. There also is no special budget for the implementation of ecological networks at federal or state level ([19]).
Estonia	• Estonia was the first country to develop the ecological network concept and to elaborate the model into a comprehensive plan and implementation programme. In 1983, this proposal was finalised as a plan to establish a national 'Network of Ecologically Compensating Areas'. • Estonia has viewed spatial planning as the appropriate mechanism through which to deliver the ecological network concept. The 1995 Sustainable Development Act, the 2004 Act on Nature Conservation and the 1995 Planning and Building Act as well as the 2002 Act on Planning require that a green network should be defined at state level, and all 15 counties and municipalities should prepare a map of the ecological network for their territory. As currently delineated, the Estonian Green Network covers about 50 % of the country's territory. • Each county plan lays down the conditions that will apply to the regulation of land use in the development planning process. This identifies the appropriate intensity of land uses and how serious conflicts of interest — such as between a road and a wildlife linkage — should be resolved.
Ireland	• In Anne Valley, an integrated constructed wetland (ICW) was created instead of installing a traditional treatment plant. Not only is the wetland more efficient in clearing (mostly livestock) wastewater than a comparable traditional sewage plant, it also offers multiple benefits for the ecosystem services the wetland provides: water purification, fresh water, climate regulation and carbon sequestration, flood control, recreational aspects, soil formation and nutrient cycling — and it provides a suitable habitat for wetland flora and fauna. • Farmers are quoted as saying that they are only able to retain their farming businesses because of the installation of this wetland, and the aesthetical value of the areas has increased considerably. Capital costs for 1 750 population equivalents were EUR 770 000 + EUR 16 000 for scientific monitoring of the project over 3 years. This sum includes costs for tourism facilities of EUR 220 000, and maintenance costs are lower than for a traditional plant. This compares favourably to estimated costs of EUR 1 530 000 for an equivalent traditional plant. Financing stems from LIFE, INTERREG (an initiative to stimulate cooperation between regions in the EU) and local funding sources.
France	• Within its Grenelle de l'environnement process, France has passed a new law to create a Green (and Blue) Infrastructure (La Trame verte et bleue) across the country — by 2012, this will be an indispensable element of all future spatial planning policies. La Trame verte et bleue is partly co-financed by cohesion policy in some regions. • The legislation is being tested through a series of pilot projects in 45 regional and national parks across France. The Trame verte is founded on scientific data and will be made up of protected areas and other areas that will ensure connectivity and global functionality of biodiversity across the country. The Trame bleue will have an equivalent structure for freshwater bodies and their associated ecosystems.

([19]) Towards a green infrastructure for Europe, ATECMA, 2009. See http://www.bfn.de/0311_biotopverbund.html.

Table 3.7   Comparisons of some national approaches and experiences of green infrastructure (cont.)

Country	Summary
Hungary	• From September 2005 onwards, the Hungarian Tisza River Floodplain was conserved and restored through Integrated Floodplain Management. The project is managed by the UNDP/Global Environment Facility and will mainstream biodiversity conservation within floodplain management across the Tisza river floodplain. It is co-financed by cohesion policy funds of EUR 290 million. • The project will significantly improve management of 1 600 km^2 through activities within pilot areas, while moderately influencing and estimated areas of 9 400 km^2 (about 20 % of the Great Hungarian Plain) applying supportive policy and institutional capacity building at local level. In addition, Hungary is planning to use farmland to hold up to a billion cubic meters of water to prevent flooding elsewhere. The Hungarian government will create reservoirs on farmland near the Tisza that will be allowed to flood during emergencies. Two reservoirs have been operational since end of 2006, and up to 12 are planned to be operational by 2020.
Netherlands	• In 1990, the Dutch government introduced the National Ecological Network (NEN) with the aim of developing a coherent network of natural areas (core areas and nature development areas) connected by ecological corridors by 2018. With this concept, the government replaced traditional site-based conservation with a wider form of protection and nature development, setting clear priorities in a wider national and international context. • Between 1990 and 2006, the environmental conditions and spatial coherence of the NEN have improved with a shift towards less public acquisition of land, coupled with greater scope for wildlife and landscape management by private landowners and farmers through management contracts. • The Dutch-funded project Knowledge for Ecological Networks (Cil, 2009) aims to improve the implementation of ecological networks by involving relevant fields of knowledge not previously involved: exploring possibilities for synergy with other sectors, undertaking stakeholder involvement, and promoting economic and land use activities that are beneficial to maintaining ecological connectivity.
Austria	• In 1965, the whole Rax-Schneeberg-Schneealpen massif was declared a water protection area. The Forestry Office of the City of Vienna administers a total area of approximately 32 000 ha of forest, mountain pastures and meadows, enabling it to coordinate the use of rural, tourism, hunting and fishing activities with the requirements of spring protection. • The per capita consumption of water in Vienna is 150 l per day. About 95 % of its annual water supplies come from springs in the Rax, Schneeberg and Schneealpen mountains and from the Hochschwab mountain massif. • The Vienna City Constitution put Vienna's water and the forests surrounding the springs under protection orders to provide for pure drinking water at any time. Vienna established water protection areas, and preservation areas were proclaimed around the supply sources.
United Kingdom	• Green infrastructure planning and development in the United Kingdom is largely decentralised and has tended to focus on urban and peri-urban areas with a prioritisation of the provision of a network of areas for recreation ([20]). • Each region in United Kingdom has developed its own guidelines for green infrastructure planning, often followed by local or municipal plans. For instance, the Green Infrastructure North West initiative ([21]) has resulted in the production of guidance for planners in producing green infrastructure plans, and supports green infrastructure policy in the NW Regional Spatial Strategy. • Scotland's new National Planning Framework 2 includes a proposition to create a Central Scotland Green Network; this takes the form of a series of projects supported by higher level policy guidance to promote connectivity as well as social and economic cohesion and resilience. • A Natural Environment Framework is also being integrated into the Wales Spatial Plan. This plan is based on an ecosystem-based approach, and takes existing work for a Networked Environmental Region which used GIS to identify and map current ecosystem services. The framework aims to sit alongside the spatial plan and provide a higher level framework to deliver consistent consideration of green infrastructure and ecosystem services in the range of relevant plans and strategies. This is supported at regional level where a number of projects are taking forward the ecosystems approach through initiatives such as Integrated Rural Development and Integrated Coastal Zone Management ([22]).

[20] See COMHAR SDC, http://www.comharsdc.ie/themes/index.aspx?TAuto=10.
[21] See http://www.greeninfrastructurenw.org.uk.
[22] See http://wales.gov.uk/location/south_east_wales/spatial/?lang=en.

achieving sustainability were identified; one of these was green infrastructure, which was defined as:

> '… the network of open space, airsheds, watersheds, woodlands, wildlife habitat, parks, and other natural areas that provides many vital services that sustain life and enrich the quality of life'[23].

Since that time, the United States at federal level has taken an increasingly focused view on the role of green infrastructure; as described in Table 2.2 the US Environmental Protection Agency (EPA) considers green infrastructure to be:

> '…an approach to wet weather management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure management approaches and technologies infiltrate evapotranspire capture and reuse storm water to maintain or restore natural hydrologies'[24].

In 2007, the US EPA and four other national environmental bodies created a partnership which aimed to provide some degree of official federal recognition of green infrastructure as an '**environmentally preferable approach to ... storm water (management)**'. This was initiated through the release of their statement of intent (US EPA, 2007) that was subsequently supported by a wide range of other nature conservation and built environment organisations [25]. Following on from this, the partnership released their *Managing Wet Weather with Green Infrastructure Action Plan Strategy* (US EPA, 2008). The strategy sets out guidelines for the inclusion of green infrastructure in planning, particularly in urban planning. Within this fairly narrow definition of green infrastructure there is recognition of multifunctionality, including specific consideration of the cooling, community and biodiversity benefits of green infrastructure; there is also recognition that these benefits are accentuated in the urban and suburban environment.

The US EPA's perception of the beneficial role of green infrastructure in relation to water management is gaining political traction, and a recent bill was tabled in the US Senate, with a similar bill going through Congress [26], to confirm green infrastructure as the preferred approach for storm water management in the United States [27]. The Act would provide funding for the US EPA to enable financing of grants for planning and implementation of community green infrastructure schemes, as well as the establishment of '**centers of excellence**' for green infrastructure training and research. In addition the Act would support financially those states that develop Green Infrastructure Portfolio Standards (these are incremental targets for the use of green infrastructure in storm water management) [28].

State level

At the state level there are significant differences in states' recognition and implementation of green infrastructure. There is, however, a long history of green-infrastructure–type approaches in some states. For instance, in 1993, the State of Florida set up the Florida Greenways Commission consisting of members from recreation, forestry, agriculture, water management and other relevant stakeholder groups 'to develop a coordinated approach for protecting, enhancing and managing a statewide system of greenways' [29].

In 1995, the Commission set up the Florida Greenways Coordinating Council (FGCC) to implement the creation of a state-wide system to link natural areas to conserve ecosystems and provide additional recreational opportunities for residents and visitors to the state. The FGCC was made up of a wide range of stakeholders across many sectors and at various levels of government agency (local, regional, state and federal). In addition to identifying and managing the creation of the greenways, the FGCC aimed to inform the public of the benefits of green infrastructure and to coordinate with other organisations to enable the implementation of the greenways.

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[23] See http://clinton4.nara.gov/media/pdf/tsa.pdf.
[24] See http://cfpub.epa.gov/npdes/home.cfm?program_id=298.
[25] See http://www.epa.gov/npdes/pubs/gi_supportstatement.pdf.
[26] See http://www.opencongress.org/bill/111-h4202/show.
[27] See http://thomas.loc.gov/cgi-bin/query/z?c111:S.3561.
[28] See http://www.cnt.org/news/2010/07/08/green-infrastructure-surges-across-the-u-s-%E2%80%93-illinois-reaching-for-policy-lead.
[29] See http://www.co.st-johns.fl.us/BCC/Land_Management/LAMP/media/SJC_GBT/perspectives_directives.pdf.

The identification of greenways was supported by a natural environment prioritisation process, supported by the use of GIS; see Map 3.1. This included, among other aspects, considering the current and predicted developmental pressures upon natural areas, and prioritising accordingly.
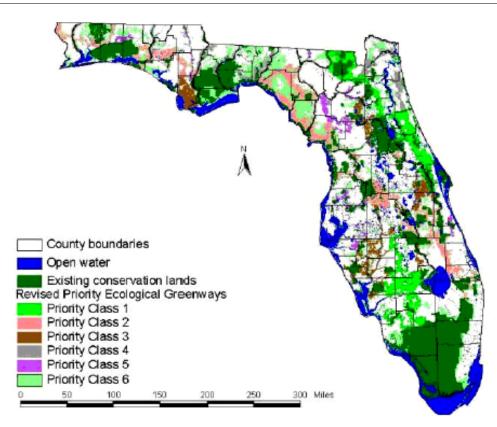
The system was subsequently formalised with the passing of the Florida Greenways and Trails Act (2000). Recent work suggests that more than 2 833 km² of public land and 2 575 km of land and water trails have been designated (The Conservation Fund, 2004).

Maryland has also taken a green infrastructure approach to nature conservation efforts. Their major innovation has been the creation and use of Green Infrastructure Assessments (GIAs) (Weber, 2003).

This tool was created to identify and prioritise the green infrastructure of Maryland; GIAs have a strong conceptual basis in landscape ecology and aim to provide a consistent approach to evaluating conservation and restoration efforts.

Specifically, GIA attempts to recognise:

• a variety of natural resource values (as opposed to a single species of wildlife, for example);
• how a given place fits into a larger system;
• the ecological importance of natural open space in rural and developed areas;
• the importance of coordinating local, state and even interstate planning;
• the need for a regional or landscape-level view for wildlife conservation ([30]).

Map 3.1   Ecological greenways
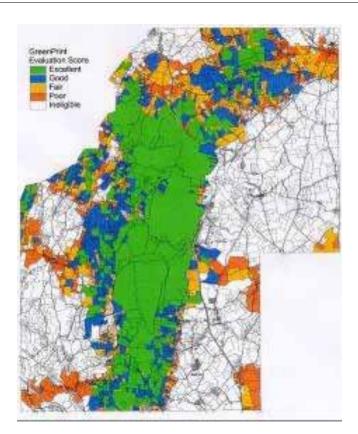

Source: The Conservation Fund, 2004.

([30]) See http://www.dnr.state.md.us/greenways/gi/overview/overview.html#what.

Within the GIA there are two units, hubs and corridors. Hubs are considered to be larger contiguous areas that contain certain features for instance forests of wetland, whereas corridors are areas that connect hubs, for instance areas of streams, ridge lines or forested valleys. These units were ranked and subsequently prioritised based on a range of ecological parameters, the aim being to protect the most valuable habitats. This was supported by a consideration of the development risk posed at each site and a range of other socio-economic considerations (Webber and Wolf, 2000).

This exercise then considered the wider environment by covering the whole of the state in the form of 'cells'. Each of these was given an ecological score based on local features (inter alia, proximity to streams, habitat type) and whether the cell fell within a hub or corridor. The aim of this was to provide more detailed site comparisons and hence prioritisation of resources.

In 2003 green infrastructure was institutionalised into State Land Conservation Planning through the requirement that state land conservation programmes ([31]) must now consider the green infrastructure value of land purchases with the aim to provide a more comprehensive set of ecological corridors, again with the aim of informing the prioritisation of effort and resources (Webber et al., 2006).

Map 3.2   Prioritisation of green corridors through State Land Conservation Planning Source

Source: Maryland Department of Natural Resources ([32]).

([31]) Such as Rural Legacy (http://www.dnr.state.md.us/land/rurallegacy/index.asp) and Programme Open Space Stateside Targeting
http://www.dnr.state.md.us/land/pos/pos_stateside_targeting.asp.
([32]) See http://www.dnr.state.md.us/greenways/gi/overview/overview.html#what.

4 Monitoring systems for green infrastructure and territorial cohesion developments

The *Green Paper on Territorial Cohesion* (EC, 2008a) expresses the need to coordinate and integrate a set of policy actions at the level of a given territory. This given territory can provide internal coherence or functionality that forms a logic base from which policymakers and stakeholders can exploit common territorial capital and tackle common challenges. The appearance of new geographies, which is recognised in the *Green Paper on Territorial Cohesion*, requires a stronger role for future EU cohesion policy for new types of functionally defined territories.

As suggested in a previous EEA study (2010c), territorial cohesion can be seen as the spatial representation of sustainability, which would mean that assessing policies in terms of the environmental dimensions of territorial cohesion can serve as an important step towards the better integration of environment and sustainability. It discusses the potential of tools such as Impact Assessment, the EIA and the SEA to help incorporate the environmental dimensions of territorial cohesion as a reference point for developing and assessing policies and programmes.

European territories have to be understood better — including a more precise idea of how to delineate them and what assets and features contribute to their identity. This implies that territories and ecosystems must be managed with respect for their ecological potential given their changed conditions.

Hence, there is a need for mapping green infrastructure and assessing its ecological potential on the basis of land cover changes, in order to know where to set priorities for investments. Natura 2000 areas and protected natural areas are good starting points, but the mapping and integrity of ecosystems and their services, for example, are also relevant.

This chapter will on the basis of available data introduce potential tools for measuring and assessing green infrastructure at detailed spatial scales or resolutions, developed in an EEA context. All the tools presented have mainly four input data sources, namely:

- fragmentation
- Urban Atlas
- protected areas
- Corine Land Cover.

These types of input data are according to the tools merged in various processes — some of the methods are more elaborated, some are rather straightforward, and others are even a compilation of other tools. As no single map exists of green infrastructure, the tools presented in this chapter illustrate various entry points using different components of green infrastructure. This approach enables us to illustrate the modular approach of green infrastructure over various levels and scale.

Two strings of information are tested to define green infrastructure using available spatial data, one at the landscape level and one at the urban level. Within these two strings of information, several approaches are introduced using different data sets e.g. Corine Land Cover and European Urban Atlas respectively, as they are intended to potentially describe green infrastructure at different resolutions. The Urban Atlas data provide information that map the area of land cover with classes potentially delivering the benefits of green infrastructure, including green urban areas, parks and wetlands — which is not equal per se to green infrastructure, as we do not know whether the areas in question actually deliver what is listed as green infrastructure benefits. It would be beneficial to link the Urban Atlas data sets with peri-urban and non-urban data, e.g. Corine, to see how green infrastructure networks occur outside and inside cities.

It should be noted that the available tools at urban level are limited compared to the approaches available at the landscape level. The reason for this is that most research has been undertaken at landscape level. However, within the last couple of years more research has been devoted to urban level analyses. The Urban Atlas tool is probably the highest resolution database of land use at urban level readily available in Europe.

For the urban scale, the more detailed urban classes from the Urban Atlas are utilised to map green infrastructure in 9 pilot cities — 3 cities in each size category: 50 000 to 100 000, 100 000 to 500 000, and greater than 500 000 inhabitants. For the urban scale, an attempt is also being made to link the classes to the different potential benefits of green infrastructure.

The broad approach at the landscape scale is to identify land cover types favourable to nature (e.g. green urban areas, agro-systems with pastures or mosaics of parcels, forests and other semi-natural or natural dry land, wetlands and water bodies) that provide a link between high-quality nature areas (Natura 2000).

The approaches mentioned below are generally compatible with one another, as they are based on spatially explicit data and geographical information analysis methods. They are complementary and provide information from more than one input data source. Conceptually, some applications can be used individually or in combination, like the NLEP which combines three individual applications into one. It should be noted that most of the tools are exploratory and not consolidated, but are still under development.

A combination of the urban- and landscape-level mapping tools are undertaken to test how the two approaches can be integrated. This is most relevant at the regional or subregional scale to test the interface between the urban- and landscape-scale data.

Based on this presentation, some initial opportunities are presented for the further development of the tools and whether/how they might support green infrastructure planning and implementation, including territorial cohesion.

4.1 Green infrastructure mapping tools at urban level

4.1.1 Defining green infrastructure using the Urban Atlas

This approach derives green infrastructure from the Urban Atlas data, and tested the method on nine pilot cities of different sizes. Urban Atlas codes for inclusion in the green infrastructure are selected and mapped for the whole Large Urban Zone boundary. A link is then drawn between the Urban Atlas codes

and the green infrastructure benefits they could provide to calculate the area providing each benefit.

The methodology is as follows:

1. Selecting and testing nine 'Urban Atlas' pilot cities. Altogether, 3 cities in each size category: 50 000 to 100 000, 100 000 to 500 000, and more than 500 000 inhabitants. The provisional selection is:

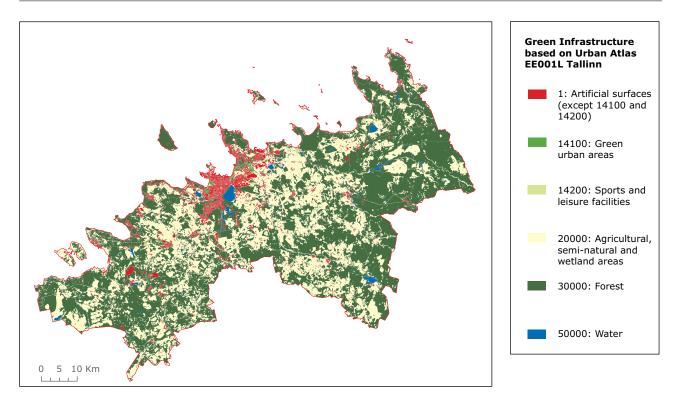| > 500 000 inhabitants	100 000– 500 000 inhabitants	< 100 000 inhabitants
Bratislava (Slovakia)	Schwerin (Germany)	Faro (Portugal)
Tallinn (Estonia)	Varna (Bulgaria)	l'Aquila (Italy)
Bialystok (Poland)	Apeldoorn (Netherlands)	Calarasi (Romania)

2. Creating buffer polygons around defined Urban Atlas classes with different buffer distance (1 km, 3 km and 5 km).
3. Trying to evaluate the following green infrastructure topics:
(a) biodiversity/species protection
(b) climate change adaptation
(c) climate change mitigation
(d) water management
(e) food production and security
(f) recreation, wellbeing and health
(g) land values
(h) culture and communities.
The following Urban Atlas class codes were considered as contributing to the issue: biodiversity/species protection (30000, 50000); climate change adaptation (20000, 30000); climate change mitigation (14100, 14200, 20000, 30000); water management (20000, 30000, 50000); food production and security (20000); recreation, wellbeing and health (14100, 14200, 30000, 50000); land values (14100, 14200, 30000) and culture and communities (14100, 14200). Note that Urban Atlas code 20000 (agriculture) and code 30000 (forest) are not differentiated into more specific land uses.
4. Each Urban Atlas code can be linked to one or more topics to conceptualise the meanings of the function. The above selection of Urban Atlas class codes contributing to green infrastructure topics is a first trial and should be explored further, as there are several ways to approach these linkages.

Green infrastructure maps for nine European cities were produced and statistics generated for the area and percentage of green infrastructure. The example of Tallinn is presented below.

Map 4.1 Green urban infrastructure in Tallinn

Source: EEA, 2010.

Table 4.1   Urban Atlas codes in Tallinn

Urban Atlas CODE	ITEM	Area (km²)	Area (%)
11100	Continuous Urban Fabric (S.L. > 80 %)	7.87	0.18
11210	Discontinuous Dense Urban Fabric (S.L.: 50 %–80 %)	42.93	0.99
11220	Discontinuous Medium Density Urban Fabric (S.L. : 30 %–50 %)	60.54	1.40
11230	Discontinuous Low Density Urban Fabric (S.L.: 10 %–30 %)	21.47	0.49
11240	Discontinuous Very Low Density Urban Fabric (S.L. < 10 %)	0.49	0.01
11300	Isolated Structures	35.77	0.82
12100	Industrial, commercial, public, military and private units	54.24	1.25
12210	Fast transit roads and associated land	0.00	0.00
12220	Other roads and associated land	38.35	0.88
12230	Railways and associated land	5.90	0.14
12300	Port areas	6.25	0.14
12400	Airports	6.60	0.15
13100	Mineral extraction and dump sites	13.77	0.32
13300	Construction sites	6.48	0.15
13400	Land without current use	2.27	0.05
14100	Green urban areas	18.89	0.44
14200	Sports and leisure facilities	7.68	0.18
20000	Agricultural + Semi-natural areas + Wetlands	1 521.86	35.08
30000	Forests	2 436.40	56.16
50000	Water bodies	50.77	1.17
		4 338.56	**100.00**

Table 4.2   Total green infrastructure in Tallinn Large Urban Zone

	Area (km²)	Area (%)
Total Green Infrastructure (code: 14100, 14200, 20000, 30000, 50000)	4 035.61	93.02

The methodology assumed that each of the green infrastructure benefits could be assigned to different land cover codes that would provide them. Areas were calculated from this (see example for Tallinn below).

Table 4.3   Green infrastructure topics in Tallinn Large Urban Zone

Green Infrastructure topics	Area (km²)	Area (%)
Biodiversity/species protection (code: 30000, 50000)	2 487.18	57.33
Climate change adaptation (code: 20000, 30000)	3 958.27	91.23
Climate change mitigation (code: 14100, 14200, 20000, 30000)	3 984.84	91.85
Water management (code: 20000, 30000, 50000)	4 009.04	92.40
Food production and security (code: 20000)	1 521.86	35.08
Recreation, wellbeing and health (code: 14100, 14200, 30000, 50000)	2 513.75	57.94
Land values (code: 14100, 14200, 30000)	2 462.97	56.77
Culture and communities (code: 14100, 14200)	26.57	0.61

This approach drew the following conclusions.

- The urban green infrastructure related to biodiversity and species protection is around 30 % for over half of the Large Urban Zones. However, fragmentation means this is likely to be an overestimation; a fragmentation index would be an interesting next step of this analysis.
- The high percentage of the green infrastructure (79 % to 94 %) adapting or mitigating the climate change effects suggest that nearly all non-built up areas in Large Urban Zones could be considered as contributing to this.
- Regarding water management, the 9 cities seem to be in good health (from 81 % to 95 %). In this case, water management is related to water run-off and infiltration issues that could be assessed through land use and land cover of the Large Urban Zone and not to flood problems that would need a more detailed analysis/assessment at river catchment level. However the main problem of run-off lies in soil sealing in the inner city, and this could be a better indication than an analysis of the whole Large Urban Zone.
- The results show that food production varies a great deal from city to city (from 35 % to 83 %). The importance for this issue lies in the hypothesis that the consumption of the agricultural products is confined to the city and not to the worldwide market. A more detailed assessment could be carried out by correlating the average consumption of food by the citizen with the types of crop shown through land cover analysis.
- For recreation, well-being and health in 7 among 9 cities, the percentage is over 30 %. However, 2 of the smaller cities, Calarasi (RO) and Faro (PT), have less than 15 %.
- The land value results show that in bigger cities (more than 500 000 inhabitants) the percentage is higher than in medium and smaller cities.
- For culture and communities, the results show that eight among nine cities have a percentage less that 1 %.

The advantages of this approach include that:

- it is based on the Urban Atlas, which is reliable and intercomparable urban planning data with high-resolution maps;
- future editions of the Urban Atlas are planned every three to five years, so the approach should provide good mechanism for monitoring changes and the speed of change.

The disadvantages of this approach include that:

- the Urban Atlas has only been available for 117 cities (with Large Urban Zones with more than 100 000 inhabitants), but in 2011 has increased to more than 300 cities;
- the link drawn between the Urban Atlas codes and the benefits of green infrastructure is,

particularly for some benefits, relatively weak and the relationship needs to be investigated further before quantifiable results can be drawn from it.

Potential improvements to the approach include the following.

- Investigating the link between the Urban Atlas codes and the benefits of green infrastructure in more detail. It may not be possible to draw direct links between some benefits and land use and therefore these should be excluded from the analysis (for example culture and communities). Consideration should also be given to the link with ecosystem services rather than just the benefits of green infrastructure identified as part of this study;
- Evaluating fragmentation of urban green infrastructure and integrating this into the approach.
- Considering how to better differentiate within agriculture and forest land. Corine Land Cover data has a three level classification for agriculture and forest which would differentiate better between the land cover types that does not contribute to green infrastructure issues;

however, Corine Land Cover has a much lower spatial resolution than does the Urban Atlas.
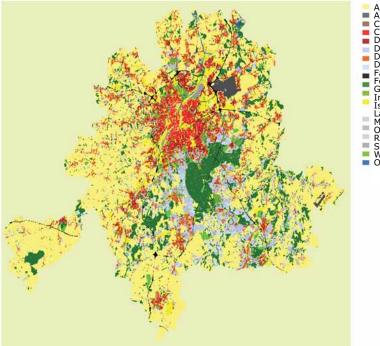
- Considering how other spatial analysis could add value to the approach. For example, the population within a certain distance from green infrastructure could be assessed. Note that as the Large Urban Zones are very different in extent, a population comparison should be conducted with great care.
- The Large Urban Zone is sometimes the best spatial unit to assess certain benefits, however in other cases it would be better to use the inner city or the Urban Morphological Zone (UMZ).
- As future editions of the Urban Atlas become available, the monitoring of change could be integrated into the approach.

Overall, this is a useful and relatively simple approach to identifying green infrastructure at urban scale that can be replicated for the cities which have Urban Atlas data available. Improvements such as those identified above could be investigated further, including how to integrate these with the landscape scale approach. The main area of concern is the robustness of the analysis linking the Urban Atlas codes and the benefits of green infrastructure, something that calls for further analysis.

Table 4.4   Review of the utility of the approaches developed to define green infrastructure

Criteria	Approach to defining green infrastructure at the urban scale
Level of detail and utility of classification of green infrastructure for policy/planning purposes	• Overall, this is useful and relatively simple approach to identifying green infrastructure at the urban scale • Some modifications and additional analyses would provide some added value to help make it more sensitive to local varia*tions*
Potential utility at different scales: • EU policy/pan-European scale • national scale • regional scale • local/city scale	• More suited to local/city scales • Could potentially also be used at regional scale in combination with the landscape approach
Comprehensive coverage/universally available input data	• Can be replicated for the cities which have Urban Atlas data available • The Urban Atlas is initially only available for 117 cities (with Large Urban Zones with more than 100 000 inhabitants). However, this has risen to more than 300 cities in 2011
Repeatability	• Easy to replicate
Ability to measure change/temporal data availability	• Future editions of the Urban Atlas are planned every three to five years, so the approach should provide a good mechanism for monitoring changes and the speed of change
Link to functions/benefits of green infrastructure	• An attempt is made to link the green infrastructure classes and functions/benefits of green infrastructure. This provides a quantification of the area by type of function/benefits

Map 4.2   Urban Atlas Map of Brussels, Belgium. Urban Atlas data are classified into 27 land cover classes, with minimum mapping units of 0.25 ha for urban classes and 1 ha for non-urban classes

- Agricultural + semi-natural areas + wetlands
- Airports
- Construction sites
- Continuous urban fabric (S.L. > 80 %)
- Discontinuous dense urban fabric (S.L. : 50–80 %)
- Discontinuous low density urban fabric (S.L. : 10–30 %)
- Discontinuous medium density urban fabric (S.L. : 30–50 %)
- Discontinuous very low density urban fabric (S.L. < 10 %)
- Fast transit roads and associated land
- Forests
- Green urban areas
- Industrial, commercial, public, military and private units
- Isolated structures
- Land without current use
- Mineral extraction and dump sites
- Other roads and associated land
- Railways and associated land
- Sports and leisure facilities
- Water bodies
- Outside coverage

Source: EEA, 2011.

Utility of the tool

The utility of the green infrastructure approach at urban scale described above is provided in Table 4.4.

4.1.2   *Alternative example of measuring green infrastructure using the Urban Atlas*

Another example using the Urban Atlas is the test case of Copenhagen and Brussels. Here a trial method has been designed to assess the Urban Green component of those cities according to the number of people with access to green urban areas, also using the Urban Atlas data set.
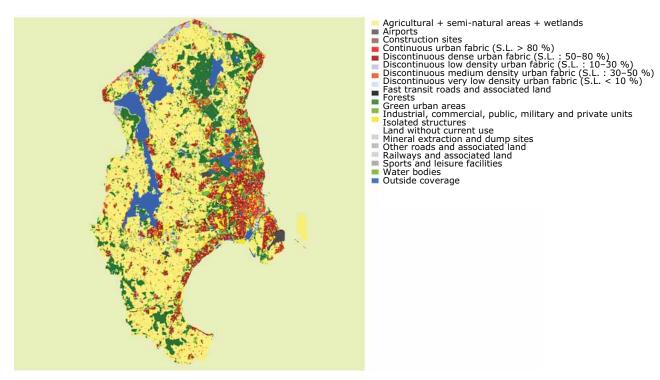
The methodology uses the Urban Atlas classification; it identifies and selects all green land cover classes for each city (including parks, grasslands, water, forest and recreational areas), and converts the polygons to points (see Map 4.4). It further applies the same method to extract land cover classes 'continuous urban fabric' and 'dense discontinuous urban fabric', and convert the polygon shapes to

points (see Map 4.5). By executing a point density, it analyses the urban land cover classes extracted in step two. This produces a 'gravitational field map' for each city, (see Map 4.6) with the densest urban areas showing the highest gravitational fields. Finally, it reclassifies the green urban areas according to their location on the gravitational field map, scoring those green areas in the densest urban localities as the highest (see Figures 4.1 and 4.2).

One might consider adding a weighting to green classes in order to increase contextual sensitivity. It might also be useful to consider including the class 'agricultural, semi natural and wetlands' into the Green Urban grouping.

Comparing the two cities using the above method, it is clear that Copenhagen offers its residential areas a greener way of life than Brussels does. This is further reflected in the pie charts (see Figure 4.1) which show that Copenhagen has a high proportionality for each of the top five green urban density classifications. When looking at the proportion of Urban Green Areas as a percentage

Map 4.3   Urban Atlas Map of Copenhagen, Denmark. Urban Atlas data are classified into 27 land cover classes, with minimum mapping units of 0.25 ha for urban classes and 1 ha for non-urban classes
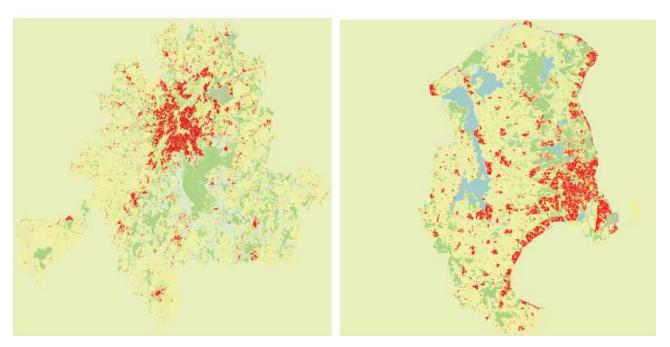

Agricultural + semi-natural areas + wetlands
Airports
Construction sites
Continuous urban fabric (S.L. > 80 %)
Discontinuous dense urban fabric (S.L. : 50–80 %)
Discontinuous low density urban fabric (S.L. : 10–30 %)
Discontinuous medium density urban fabric (S.L. : 30–50 %)
Discontinuous very low density urban fabric (S.L. < 10 %)
Fast transit roads and associated land
Forests
Green urban areas
Industrial, commercial, public, military and private units
Isolated structures
Land without current use
Mineral extraction and dump sites
Other roads and associated land
Railways and associated land
Sports and leisure facilities
Water bodies
Outside coverage

Source: EEA, 2011.

Map 4.4   The green land cover classes are grouped and extracted for Brussels and Copenhagen including parks, grasslands, water, forest and recreational areas
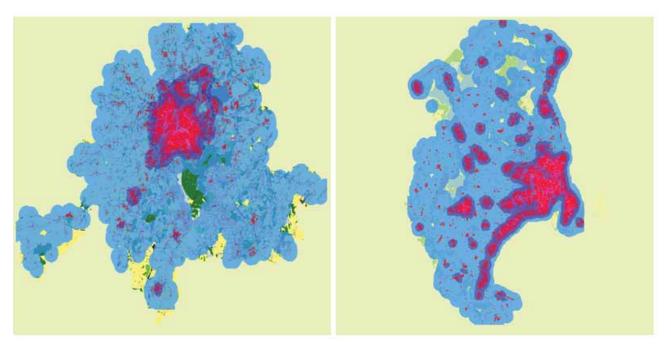

Source: EEA, 2011.

Map 4.5   **Urban Atlas classes 'continuous urban fabric' and 'dense discontinuous urban fabric' are grouped and extracted in preparation for density analysis to determine the most built-up urban areas of Brussels and Copenhagen**
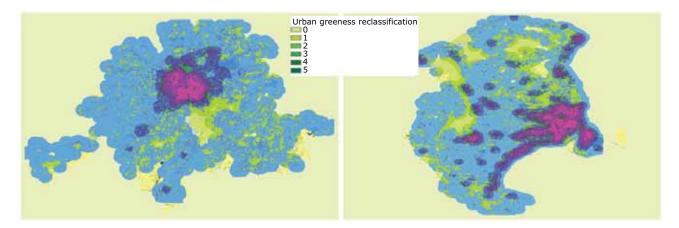

Source: EEA, 2011.

Map 4.6   **Running a point density analysis on the urban land cover classes extracted in step two produces a 'gravitational field map' for each city, with the densest urban areas (in red) showing the highest 'urban gravity', and the pale blue areas showing the lowest 'urban gravity'**
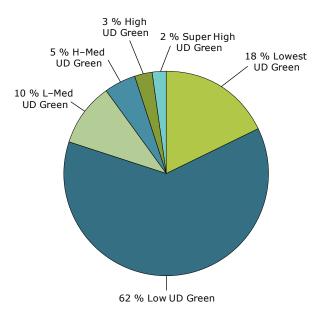

Source: EEA, 2011.

Figure 4.1 Reclassifying the green urban areas according to their location on the gravitational field map produces these results

Urban greenness reclassification
- 0
- 1
- 2
- 3
- 4
- 5

Brussells Green Urban Areas Composition

1 % High UD Green

3 % H–Med UD Green

5 % L–Med UD Green

2 % Super High UD Green

13 % Lowest UD Green

76 % Low UD Green

Copenhagen Green Urban Areas Composition

3 % High UD Green

5 % H–Med UD Green

10 % L–Med UD Green

2 % Super High UD Green

18 % Lowest UD Green

62 % Low UD Green

Source: EEA, 2011.

of the total city area (see Figure 4.2), Brussels has a comparatively lower score in each of the green urban classes as compositional elements of the city landscape.

Utility of the tool

This type of urban green density analysis can be used to characterise European cities in terms of the green access afforded to city residents living in built-up areas. It could also be developed further to obtain more meaningful information about urban green infrastructure, namely to identify pockets of high potential biodiversity in built-up areas.

However the method is still under development. There are several foreseeable ways in which it could be improved.

- By considering the coastline. Coastal cities offer much more to their residents than just the land contained within the city limits.
- By considering population numbers. Population data disaggregation by Urban Atlas could provide extra insight into the expected value obtained from dense urban green areas.
- By considering the landscape outside of city limits. Nature corridors between cities and external natural areas can promote city biodiversity.

Figure 4.2 Comparing the urban green areas as a percentage of the total city area, it is clear that Copenhagen achieves higher scores in all of the 6 urban green density classifications

Urban Green Areas – As % of Total City Area, Brussels vs Copenhagen by Urban Green Densities

Source: EEA, 2011.

4.2 Green infrastructure mapping tools at landscape level

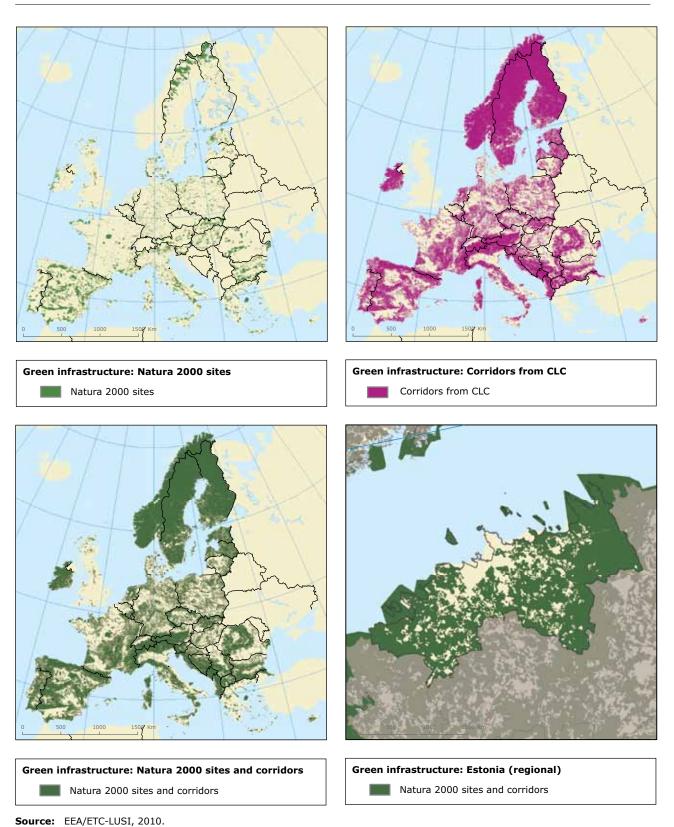### 4.2.1 Defining green infrastructure using Corine Land Cover

This approach derives green infrastructure from a combination of Natura 2000 sites and selected Corine Land Cover classes that are directly connected to the Natura 2000 sites. It has the benefits of being replicable across Europe as it is based on data sets that are available Europe-wide (except for Corine data for Greece and the United Kingdom, countries that do not form part of the official data set yet).

The approach is highly sensitive to which Corine classes are included or excluded, and therefore this aspect of the approach may have to be considered further. Ideally a consensus should be reached on which classes should be used, and this should be made transparent as part of the use and presentation of the results.

The methodology is based on the following:

- Taking the polygons of Natura 2000 as core areas of green infrastructure.
- Merging feature classes together (code 2.3.1, 2.4.2, 2.4.3, 2.4.4, 3.x.x, 4.x.x, 5.x.x) from Corine Land Cover 2006 (EU plus Switzerland, excluding the United Kingdom, Greece and Ireland) to create a single feature. As 3.3.x (areas with no or little vegetation) is a critical class for a green infrastructure asset, in a small demonstration area it will be revealed how the exclusion of this class is affecting the results.
- Creating a new layer by dissolving adjacent polygons.
- Selecting polygons connected to (which intersect) polygons of Natura 2000 (CORRIDORS of the green infrastructure).
- Merging CORRIDORS and CORE AREAS obtaining the EU green infrastructure layer.

Map 4.7 below shows the results, with the individual Natura 2000 areas and green infrastructure corridor layers illustrated, then combined into a green infrastructure map of Europe. A map focusing on Estonia is presented to illustrate the data at a more detailed level. The area and percentage of green

Map 4.7   Defining green infrastructure using Corine Land Cover and Natura 2000

Green infrastructure: Natura 2000 sites

    Natura 2000 sites

Green infrastructure: Corridors from CLC

    Corridors from CLC

Green infrastructure: Natura 2000 sites and corridors

    Natura 2000 sites and corridors

Green infrastructure: Estonia (regional)

    Natura 2000 sites and corridors

Source: EEA/ETC-LUSI, 2010.

infrastructure by Environmental Zones (EnZs) and country are then presented (note NUTS 0 is included but data for NUTS 2 and 3 were also produced).

The approach presents the area of green infrastructure per EnZ and per country (see Tables 4.5 and 4.6 below) and from these figures concludes that two main types of countries can be identified with contrasting results.

- Countries where the dominant landscape matrix is relatively natural, such as those with large areas of forests or alpine areas. In these countries, most of the Corine classes selected for the green infrastructure selected classes are somehow connected, and this leads to very large contagious areas with fuzzy borders that are still connected. In these countries, relatively few and small Natura 2000 areas are sufficient to select most of the polygons in order to establish a 'corridor', because the landscape matrix stretches all around these Natura 2000 areas. Examples include the northern countries, Norway, Sweden and Finland, which are almost completely classified as green infrastructure, as the dominant landscape is a very natural one (mostly forest environment). The same is true for mountain areas (Alps, Pyrenees, Dinaric Mountains, Carpathian Mountains, etc.).
- The other type of country is those where the dominant landscape matrix is composed of human-induced landscape features. These landscape features are both artificial areas and more or less intensive agricultural areas. Within these areas, only those natural elements (relevant and selected Corine classes for green infrastructure) that are directly connected to

a Natura 2000 site are included. This means that a natural element which may be close to or between two Natura 2000 areas is not selected and therefore not part of the green infrastructure, if it is not directly spatially connected to one of these sites. These natural elements are therefore islands in the dominant human-influenced landscape, and these islands are mostly not selected as green infrastructure.

The results are similar to previous studies; they identified two broad types of countries. In countries where the dominant landscape matrix is relatively natural, such as those with large areas of forests or alpine areas (e.g. Scandinavian countries), the approach identifies large areas as connected green infrastructure. In countries where the dominant landscape matrix is composed of human-induced landscape features, the approach gives a more fragmented pattern of green infrastructure with some natural elements not identified as green infrastructure.

It is important to realise that these broad land cover classifications used to establish quantifiable potential green infrastructure accounts do not focus enough on the intensity of land use and quality of green infrastructure and ecosystems. Nonetheless, such assessments do help achieve a more in-depth analysis.

The advantages of this approach include that:

- it is based on data sets that are available across Europe;
- it is relatively easy to calculate;

Table 4.5   Potential green infrastructure per environmental zone

Environmental Zone	Area of green infrastructure (km²)	Percentage of green infrastructure
Alpine north	310 813	93 %
Boreal	604 122	72 %
Atlantic north	79 669	27 %
Nemoral	175 048	35 %
Continental	476 212	38 %
Atlantic central	181 764	36 %
Alpine south	261 109	86 %
Lusitania	100 924	52 %
Pannonian	100 949	24 %
Mediterranean mountains	196 172	36 %
Mediterranean north	193 418	37 %
Mediterranean south	137 850	24 %

Table 4.6   Potential green infrastructure per country

Country	NUTS 0 area (km²)	Area of green infrastructure (km²)	Percentage of green infrastructure
Norway	323 452	319 570	98.8 %
Finland	344 636	313 731	91.0 %
Sweden	456 981	407 979	89.3 %
Ireland	72 910	62 062	85.1 %
Albania	29 102	22 864	78.6 %
Estonia	46 635	36 398	78.0 %
Bosnia and Herzegovina	51 209	39 890	77.9 %
Slovenia	20 301	15 356	75.6 %
Former Yugoslav Republic of Macedonia	25 157	18 916	75.2 %
Latvia	64 895	47 742	73.6 %
Austria	83 904	60 001	71.5 %
Liechtenstein	162	111	68.5 %
Switzerland	41 291	28 117	68.1 %
Portugal	89 738	57 192	63.7 %
Luxembourg	2 597	1 576	60.7 %
Croatia	59 004	35 244	59.7 %
Slovakia	49 016	28 957	59.1 %
Spain	509 471	300 125	58.9 %
Bulgaria	111 224	62 440	56.1 %
Malta	402	219	54.4 %
Italy	305 164	151 750	49.7 %
Netherlands	40 531	20 058	49.5 %
Czech Republic	78 881	37 683	47.8 %
France	553 970	262 869	47.5 %
Romania	238 251	103 518	43.4 %
Germany	362 916	155 715	42.9 %
Poland	312 979	127 475	40.7 %
Lithuania	65 330	25 331	38.8 %
Cyprus	9 635	3 447	35.8 %
Hungary	93 029	31 167	33.5 %
Belgium	30 607	10 110	33.0 %
Denmark	47 062	10 382	22.1 %

Note: Greece and the United Kingdom had not yet released the Corine Land Cover 2006 data when drafting was carried out and are therefore not included.

- it is, apart from the selection of Corine classes, a relatively objective and robust method;
- the results are relatively easy to communicate.

The disadvantages of this approach include that:

- it potentially overestimates green infrastructure in countries where the dominant landscape matrix is composed of natural classes (or in these countries the areas that are classified as green infrastructure dominate, and the approach is not sophisticated enough to distinguish differences within these areas);

- no distinction is made between elements in the landscape that really have the function to connect between two Natura 2000 areas and elements that are just part of large polygons that are connected to a Natura 2000 area;
- in countries with fragmented landscapes, green infrastructure is potentially underestimated, as important ecological stepping stones are not included as part of what is identified as green infrastructure.

Potential improvements to the approach could include:

- reviewing the selection of Corine classes and testing the sensitivity;
- considering how islands of green infrastructure could be better reflected in the method (for example, by using a species approach where landscape features are evaluated based on the migration and dispersal needs of species);
- integrating fuzzy neighbourhood tolerances as have been applied elsewhere by EEA using the CORILIS method (10 km smoothing algorithm), something successfully demonstrated in the green background index (EEA, 2006a);
- developing the methodology to link green infrastructure categories to the benefits/ functions it provides.

Overall this is useful and relatively simple approach to identifying green infrastructure at landscape scale, that can be replicated across Europe; it could be improved by being integrated with the urban-scale approach, and through the suggestions above.

Utility of the tool

The utility of the landscape level approach described above is provided in Table 4.7 below.

4.2.2 Green Background Landscape Index map and green infrastructure

The Green Background Landscape Index (GBLI) is a Corine-based index that expresses the 'greenness' or naturality on a pan-European scale, which can be used to infer the 'ecological potential' of landscapes (it is a crucial component of the composite NLEP indicator). It is based on the spatial distribution of pasture, agriculture mosaics, forests and other semi-natural or natural land favourable to nature. It is an asset in its own right as well as an important component of the connectivity mapping between areas of high ecological interest.

The CORILIS ([33]) smoothing algorithm has been applied to each of the natural Corine Land Cover classes, which are then aggregated. The index is normalised from 0 to 100. The GBLI Map shown below was produced by adding the smoothed CORILIS layers derived from land cover maps for the following combined Corine classes:

- pastures and mosaic farmland (2b)
- forests and transitional woodland shrub (3a)
- natural grassland, moors, heathland and sclerophyllous vegetation (3b)

Table 4.7   Review of the utility of the approach developed to define green infrastructure

Criteria	Approach to defining green infrastructure at the landscape scale
Level of detail and utility of classification of green infrastructure for policy/planning purposes	• Overall this is a useful and relatively simple approach to identifying green infrastructure at landscape scale • Some modifications and additional analyses would provide added value to help make it more sensitive
Potential utility at different scales: • EU policy/pan-European scale • national scale • regional scale • local/city scale	• More suited to the more strategic level EU policy/pan-European and national scales • Could potentially be used at regional scale or even local/city scale in combination with the higher resolution from the urban approach
Comprehensive coverage/universally available input data	• Can be replicated across Europe where Corine data is available (note there are some gaps in the 2006 coverage)
Repeatability	• Easy to replicate
Ability to measure change/temporal data availability	• The updating of the Corine data would allow periodic monitoring of change • The first Corine database was Corine Land Cover 1990, which was finalised in the 1990s. This was followed by Corine Land Cover 2000, an update of the database and a mapping of changes using the year 2000 as reference. The updated Corine Land Cover 2006 was completed in most countries in early 2010
Link to functions/benefits of green infrastructure	• The current approach has not attempted to make a link between the green infrastructure classes and the functions/benefits of green infrastructure

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([33]) The purpose of CORILIS is to calculate 'intensities' or 'potentials' of a given theme in each point of a territory. CORILIS results in probability surfaces (varying from 0 to 100) for the presence of a certain Corine Land Cover class within a defined smoothing radius (5 km in this instance). Individual CORILIS layers from a given level can be aggregated to upper levels by simple addition.
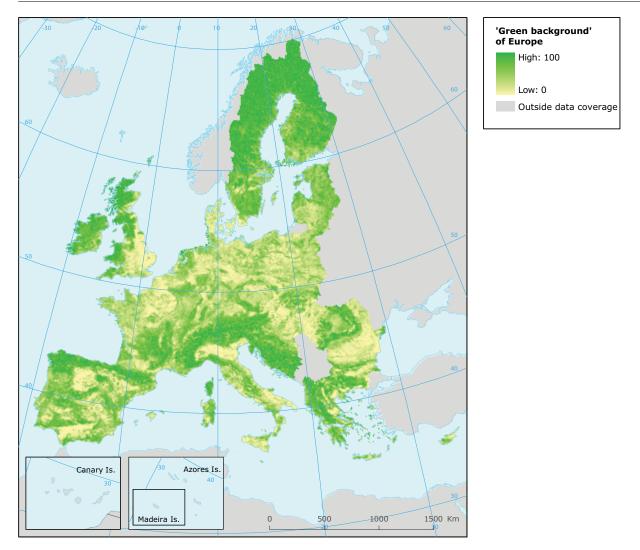
- open spaces with little or no vegetation (3c)
- wetlands (4)
- water bodies (5).

Map 4.9 shows decreasing GBLI values in parts of eastern Ireland and parts of eastern Europe including Poland, Romania, Austria and western France as well as central Italy and southern Spain. There are also increases in Green Background Landscape values for parts of central eastern Europe, notably in the Czech Republic. These changes can be largely attributed to changing farming practices over the 1990 to 2006 period, reflected mainly in the Corine Land Cover data as farmland abandonment in increasing GBLI areas, and intensification of agriculture and urban sprawl in decreasing GBLI areas.

The GBLI Map provides a similar map to the landscape-scale green infrastructure map, although in terms of the land cover data, the GBLI Map uses more sophisticated processing and slightly different input classes. The use of Natura 2000 sites and connectivity of natural areas to them is a major difference between the approaches.

Utility of the tool

Lessons from the Green Background Landscape map, for example in terms of smoothing the Corine data, could be considered as part of reviewing the landscape scale green infrastructure mapping approach.
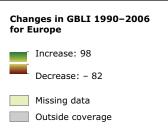
Map 4.8   GBLI Map (2000), an aggregate indicator measuring less intensive land use for Europe, displayed in grades of green

Source: EEA, 2006a.

Map 4.9   Changes in 1990–2006 GBLI Map

4.2.3 *Landscape fragmentation models and green infrastructure*

The use of fragmentation analysis as a tool for territorial and green infrastructure planning is important; the increased fragmentation of landscapes over the last 20 years provides less connectivity for ecological networks, influencing the sustainability of green infrastructure. Hence, data on the degree of landscape fragmentation are needed that are suitable for comparing different regions from a territorial cohesion perspective and in a green infrastructure context.

Landscape fragmentation is the result of transforming large habitat patches into smaller, more isolated fragments of habitat. This process is most evident in urbanised and/or otherwise intensively used regions where fragmentation is the product of the linkage of built-up areas via linear infrastructure such as roads and railroads.

Landscape fragmentation can be used for monitoring the state of the landscape and changes over time. To measure the degree of landscape fragmentation, the method of the effective mesh size

is used, which is based on the probability that two points chosen randomly in a region are connected, practically assumed to be realised if both are located in the same patch. This can be interpreted as the possibility that two animals placed in different locations somewhere in a region can find each other within the region without having to cross a barrier such as a road, urban area or major river. By multiplying this probability by the total area of the reporting unit, it is converted into the size of an area which is called the effective mesh size. The smaller the effective mesh size, the more fragmented the landscape.

The EEA and the Swiss Federal Office for the Environment (EOEN) investigated the degree of landscape fragmentation in 28 countries in Europe for the first time at the levels of countries, regions and grids of 1 km^2 cells for 3 different fragmentation geometries.

Map 4.10 presents an example in the English Channel region which allows the reader to visually compare the regions and distinguish more detail. From the map it is clear that there are almost no areas of low fragmentation left in Belgium,

the Netherlands and northern France. This has significant consequences for green infrastructure such as biodiversity and landscape quality. The central location of northern France in Europe (with Paris as the important centre) and the high levels of industrialisation and intensive agriculture explain the very high level of landscape fragmentation in this part of France. In contrast, there are still various areas of significant size in the western parts of the United Kingdom.
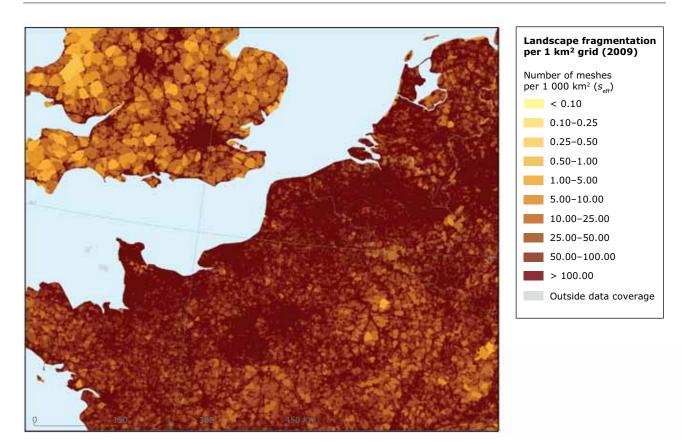
Map 4.11 provides an idea of the size of the huge task of restoring wildlife corridors once the landscape has become heavily fragmented. It is wise policy to implement effective measures to avoid an increase of the level fragmentation as much as possible, particularly as it is not known when the 'point of no return' will be reached.

Utility of the tool

Measures for controlling landscape fragmentation can only be implemented effectively if there is an awareness of the problem and feasible solutions are proposed. Decision-makers and the general public must therefore be made more aware of the problems of landscape fragmentation and habitat loss, and need to be informed about suitable measures to control them.

Fragmentation maps provide an accurate measurement of landscape fragmentation for most of the European countries that support managers and policymakers in monitoring the environmental dimension of territorial cohesion and hence allocating resources towards the protection and restoration of biodiversity and landscape quality. Fragmentation analysis can be used in developing indicators in support of green infrastructure planning and performance reviews. The effective mesh size is an important criterion for consideration in green infrastructure planning and regional planning.

Map 4.10   Map of effective mesh density values in a 1 km² grid in the Channel region

Landscape fragmentation per 1 km² grid (2009)

Number of meshes per 1 000 km² (s_{eff})

- < 0.10
- 0.10–0.25
- 0.25–0.50
- 0.50–1.00
- 1.00–5.00
- 5.00–10.00
- 10.00–25.00
- 25.00–50.00
- 50.00–100.00
- > 100.00
- Outside data coverage

Map 4.11   Overlay of the wildlife corridor network of transregional importance in Switzerland (shown in blue)

Wildlife corridor network of trans-regional importance in Switzerland

Size of remaining patches in km²

0–5	11–25	51–100	301–1 000	> 2 500	Mountains	Built-up areas
6–10	26–50	101–300	1 001–2 500		Lakes	Wildlife corridor

Note   The transregional corridor network in Switzerland for terrestrial fauna includes the wildlife corridors and the transregional movement axes (Holzgang et al., 2001; Bertiller et al., 2007). Red, yellow and green colours indicate the sizes of the remaining patches.

4.2.4   Net Landscape Ecological Potential and green infrastructure

The NLEP provides a strong platform starting point when looking to explore the potential green infrastructure available at pan-European scale, while using a relatively fine spatial resolution of 1 km. This multicriteria-based indicator incorporates elements of landscape fragmentation in combination with protected areas, and certain 'green' land Corine Land Cover classes, to build a picture of the European landscape's ability to support the integrity of ecosystems (EEA, 2008).

The NLEP for Europe is the combination of three different geographical data sets (layers, indexes).

- The so-called GBLI (EEA, 2006a ([34])) expresses the vegetation potential of the territory according to land use intensity; at the most aggregated level, land cover types are aggregated in two classes: 'green' for the least intensive use, and 'non-green' for the most intensive use (i.e. cropland and artificial land). The data are computed from Corine Land Cover and updated accordingly.
- The social value given to nature is assessed via the importance of its designation by science and

([34]) *Land accounts for Europe 1990–2000. Towards integrated land and ecosystem accounting*. EEA Report No 11/2006. See in particular page 71.

policy; this is computed from the combination of European (Natura 2000), internationally, and nationally (Common Database on Designated Areas or CDDA) designated sites. It captures what cannot be seen from the satellite images, namely the species richness/habitats of the landscape that has motivated its designation for nature conservation.
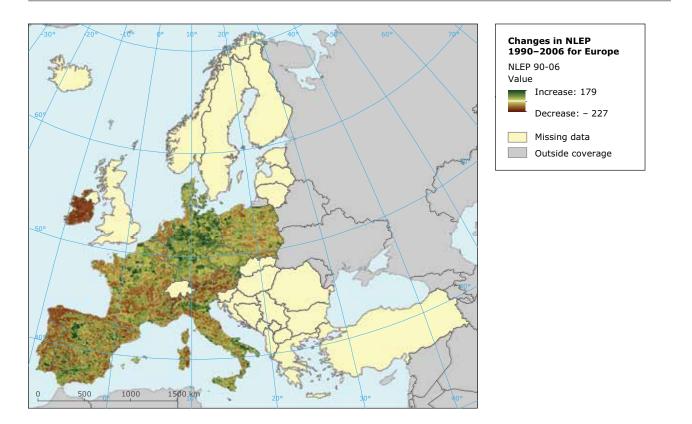
- The fragmentation of landscape by roads and railways, which is not captured in the previous two layers. The indicator retained is the effective mesh size, for its natural logarithm (ln) value. The lower the effective mesh size, the higher the fragmentation.

The three layers are computed using the standard European 1 km² grid; they are finally combined for producing NLEP.

Looking at Maps 4.12 and 4.13, we see that most of Europe's NLEP in the period from 1990 to 2000 is either stable or in decline. Improvements appear in east Germany and the Czech Republic, for example, mainly due to farmland abandonment and changes in agricultural practices.

The NLEP is a composite indicator, meaning it considers many aspects relevant to the provision of healthy ecosystems. It is important to be informed about the fragmentation of landscapes in such considerations. To this end, the NLEP uses effective mesh size, which provides information on the 'patch size' of landscapes, and takes into account transport networks as well as land cover characteristics.

Utility of the tool

The NLEP indicator provides information on the overall state of the green infrastructure and its changes. It presents a measurement that can express ecosystems' integrity and allows a good reading across Europe because of its robust calculation method, which can be aggregated to various reporting units (see Map 4.13 'NUTS changes'). It is a status indicator which at European and national scales helps frame the potential, provides quick monitoring of the state, and is useful for assessing progress towards biodiversity targets at various scales, for example. At local scale, NLEP can highlight areas with different potential for maintaining green infrastructure because it

Map 4.12   Change in NLEP 1990–2006, by 1 km² grid

Map 4.13   Mean change in NLEP 1990–2006, by NUTS 2/3

Mean changes in NLEP
1990–2006 by NUTS 2/3
for Europe

- – 85 to – 70
- – 69 to – 50
- – 49 to – 30
- – 29 to – 10
- – 9 to – 0
- 1 to 10
- 11 to 30
- 31 to 50
- 51 to 88
- Missing data
- Outside coverage

expresses the localised ecosystem values on a per kilometre basis.

By presenting temporal changes in the NLEP score, it is possible to reach a conclusion concerning what these changes mean for possible ecosystem integrity in different parts of Europe, at the macro scale, i.e. looking across the region. This assessment allows us to simultaneously assess changing landscapes in the context of the problems associated with uneven spatial distribution of ecosystems (green landscapes), and of their nature conservation value (protected areas), and of pressures exerted on them (fragmentation due to transport).

The indicator is not built around ecological data that would exactly demonstrate which are the desired adaptive biological communities, their species composition, diversity and functional organisation comparable to that of a natural habitat in the region under discussion. In this respect, the indicator cannot show in which ways ecosystem integrity can be restored, nor does it have a pure ecological meaning. Even though the indicator can be calculated in any disaggregated manner, its meaningfulness has not been tested yet for assessing ecosystem integrity at the micro scale.

4.2.5   Mapping of ecological corridors and green infrastructure

Another approach to consider in green infrastructure discussions is the work on mapping of ecological corridors in 2005 (ETC, 2005). Raising the issue of the interruption of ecological corridors due to traffic infrastructure leads to national and international initiatives to map ecological corridors (e.g. the PEEN) for migrating species and in general to improve the coherence of the ecological network and hence green infrastructure. This may be relevant as it considers potential connectivity and fragmentation between areas, and analysed the Natura 2000 network in relation to potential connectivity (see maps below). It also used smoothed Corine data to derive CORILIS data. There is also a range of connectivity analyses carried out by the Joint Research Centre (JRC) (in particular on forests), performed on Corine Land Cover but also including ancillary data to improve information content and scale.
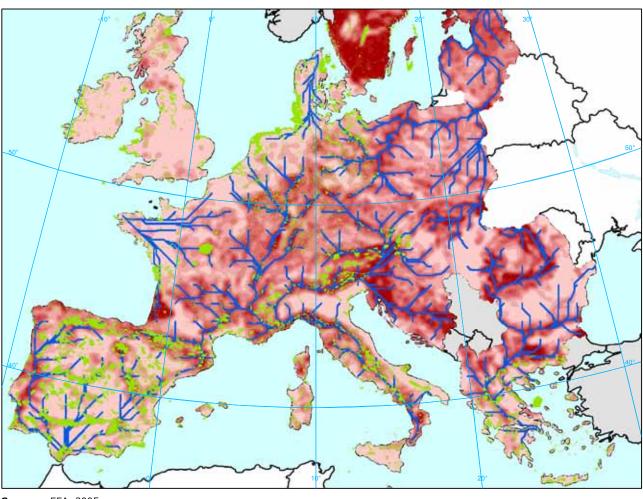
Such ecological networks are based, on the one hand, on designated areas (e.g. Natura 2000 or sites under national nature protection regimes), and on the other hand, on semi-natural areas connecting

these sites. To bridge the gap between national activities and a Europe-wide picture, the Corine Land Cover data are the only base from which to provide a Europe-wide picture of the situation for areas of potential connectivity.

This tool for mapping of ecological corridors takes into consideration species requirements. The integration of species requirements is the result of cooperation with the scientific group developing the Landscape Assessment using Rules for Configuration of Habitat (LARCH) model ([35]).

As most of the Natura 2000 areas have a significant correlation with forest cover, many of the sites are located within higher CORILIS forest values. Thus most of the corridors run through Natura 2000

areas, or in other words, Natura 2000 areas form a significant backbone for potential connectivity (see Map 4.14). However, the current corridor analysis shows some drawbacks when it comes to priorities on north-south or east-west corridors, like in Spain.

The distribution of Natura 2000 areas in Spain rather tends to illustrate an east-to-west connectivity instead of a north-to-south connectivity. Due to the fact that only one point in Spain is used as source point for the corridor analysis, all the corridors turn to run from north to south, and the corridors running from east to west are underestimated. This could be improved by using a point moved more to the eastern coastline instead of the very southern point.

Map 4.14   Natura 2000 protection sites (light green) superimposed on corridors (blue) and CORILIS forest

Source: EEA, 2005.

([35]) The LARCH model is an expert model developed by Alterra to define the areas requirements of certain species groups.

This connectivity drawback from the automated analysis could be overcome by a partly manual digitisation of missing corridors.

The intersection between Natura 2000 areas and the core area/corridor system indicates that almost 20 % of the corridors are already protected Natura 2000 sites (See Table 4.8 and Map 4.15).

The indicative map of the PEEN for central and eastern Europe identifies the core nature areas of European importance, existing corridors between these areas, and where new corridors could and should be established to meet the connectivity requirements of key species.

Utility of the tool

The ecological corridor tool is one of the few tools that integrates a species approach. Thus the landscape is not viewed from an arbitrary land cover point of view, but rather, the species requirements are integrated into the tools. Species have varying demands with regard to the size of the habitat that provides sufficient area to maintain a viable population. Having said this, the ability of species to migrate from one habitat patch to the other one is quite species specific and can be expressed by the migration distance.

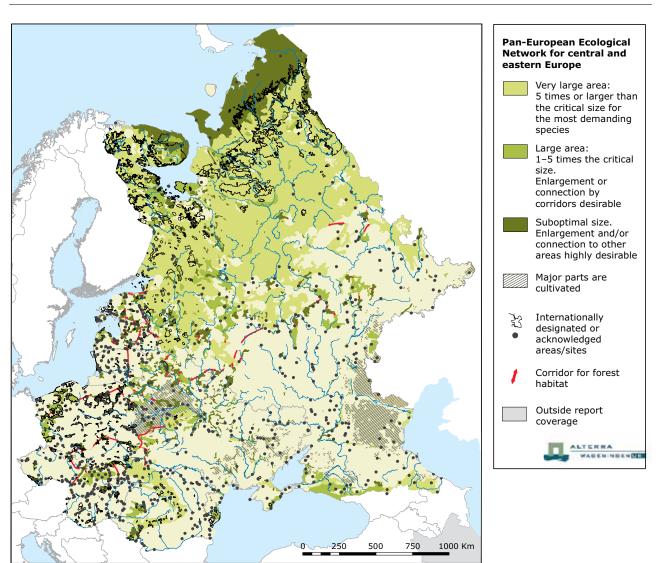The current tool can be regarded as a pilot study, as the focus was on forest-bound species. This

Table 4.8   Area in km² of Natura 2000 sites within the core area/coridor system

Type of corridor	Total area (ha)	Natura 2000 sites within core/corridor area	Percentage
Core area	8 691 203	1 717 985	20 %
Corridors	2 247 236	403 838	18 %
Total	**10 938 439**	**2 121 824**	**19 %**

Map 4.15   Natura 2000 protection sites as part of the core area/corridor system

Source: EEA,

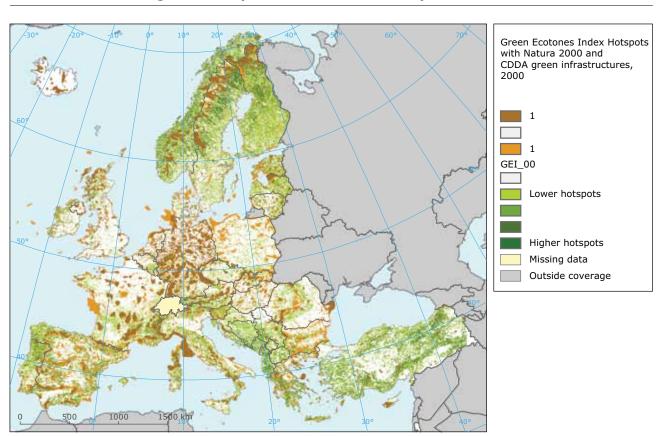**Map 4.16   Indicative map of PEEN for central and eastern Europe, identifying the core nature areas of European importance**
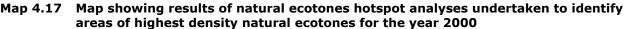

Pan-European Ecological Network for central and eastern Europe

- Very large area: 5 times or larger than the critical size for the most demanding species
- Large area: 1–5 times the critical size. Enlargement or connection by corridors desirable
- Suboptimal size. Enlargement and/or connection to other areas highly desirable
- Major parts are cultivated
- Internationally designated or acknowledged areas/sites
- Corridor for forest habitat
- Outside report coverage

Source: EEA, 2007.

approach has to be combined with other ecological profiles, leading to a multifunctional tool on various levels of scale. The method was developed between 2004 and 2007, without finalising the complete multilevel and multiscale approach in the following years; it reveals a measure for landscape permeability from a species point of view, and integrates both spatial and functional connectivities.

4.2.6   Corine ecotones and green infrastructure

Building upon some of the advances made during the ecological corridors mapping exercises in 2005 and in 2010, the EEA undertook a project using Corine Land Cover to map ecotones for

Europe. An ecotone is a transition area between two different ecosystems that can support high levels of biodiversity by providing flora and fauna with diverse environments in which to interact. Offering multiple habitats for species interaction renders ecotone zones of high biological interest. The ecotone not only contains species common to the communities on both sides; it may also include a number of species only able to colonise such transitional areas. This can produce an edge effect along the boundary line, with a greater than usual diversity of species.

In reality, ecotones may be narrow or wide, and appear on the ground as a gradual blending of the two communities across a broad area, or as a sharp

Map 4.17   Map showing results of natural ecotones hotspot analyses undertaken to identify areas of highest density natural ecotones for the year 2000

Note: The hotspots are overlaid with protected areas (Natura2000 and CDDA) as a precursor to identifying green infrastructures.
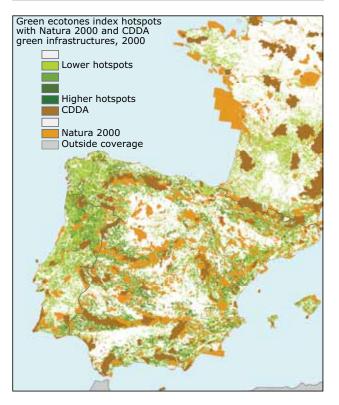
Source: EEA, 2011.

boundary line. This makes exact identification of ecotones difficult using remotely sensed data of pan-European extent. However, Corine Land Cover data can be used to assess land cover transitions as a proxy indicator of ecotones, identifying areas that would be particularly suited to the provision of diverse habitats. As such, Corine ecotones (the proxy assessment of true ecotones) can add value to land cover analyses in the context of green infrastructure assessment used to make landscape analyses in several different contexts, from analysing landscape diversity (see Map 4.17) to assessing habitat fragmentation (see Map 4.18).

Using Corine ecotones to help identify green infrastructure

In the landscape context of green infrastructure defined in this report, one of the essential elements of the green infrastructure is identified as protected areas covered under the directives of Natura 2000

and the CDDA. The spatial distribution of these protected areas can give vital information about the green infrastructure. Areas in isolation may be very important for conservation, but do little to promote species migration or habitat resilience to anthropogenic pressures or climate change. On the other hand, protected areas located in the vicinity of other protected areas, and furthermore surrounded by natural landscapes (even if not protected) can form part of a network of green infrastructures which together add up to more than the sum of their parts, providing and adding ecological resilience.

Map 4.17 shows the results of a hotspot analysis using natural ecotones (as from Corine Land Cover transitions between land cover classes). White EU-27 areas on the map indicate areas in which natural ecotones are very sparse, whereas light green to dark green areas show increasing natural ecotones densities. The orange and brown areas represent CDDA and Natura 2000 areas respectively (there is some overlap in the directives).

Map 4.18   Zoom from Map 4.17

Note: In Spain and Portugal, we can see large clusters of protected areas located in natural ecotone hotspot areas, which could be interpreted as positive aspects of green infrastructure between the sites.
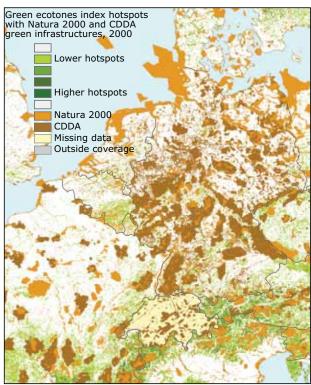
Source: EEA, 2011.

Map 4.19   Zoom from Map 4.17

Note: Looking at central Germany, large numbers of protected sites are located within close proximity of one another, but there are very sparse natural ecotones between the sites.

Source: EEA, 2011.

Comparing Maps 4.18 and 4.19, a different picture of green infrastructure is given for Portugal and Spain compared to central Germany, in which large numbers of protected areas are seen to be located in a landscape with very few natural ecotones to act as potential 'bindings' of green infrastructure.

Using Corine ecotones to help characterise forest fragmentation

The temporal availability of Corine ecotones has been used to help characterise forest fragmentation between 1990 and 2006 (see Maps 4.20 and 4.21). Map 4.20 shows the identification of urban-forest ecotones hotspots (i.e. the land cover transitions between urban and forest areas) for 1990.

Map 4.21 shows the same analyses applied to the 2006 data set. Using the exact same parameters, it is clear when comparing the two figures that there is a considerable increase in the urban forest ecotones
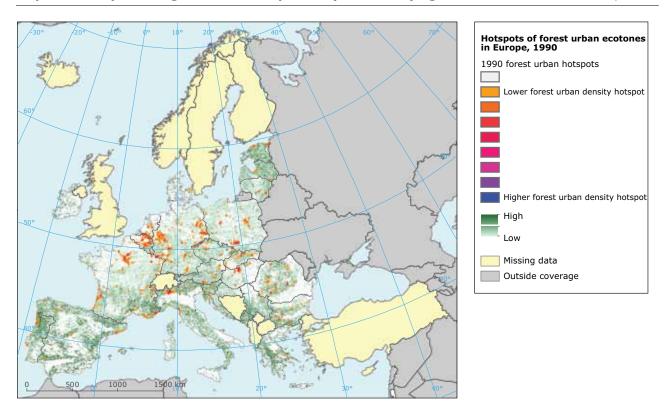
hotspots between the years of 1990 and 2006. An analysis of change in the amount of transition areas in which forests are involved, and especially in the amount of transitions between forests and artificial areas, shows an increase that is dramatic in areas like coastal and central Europe.
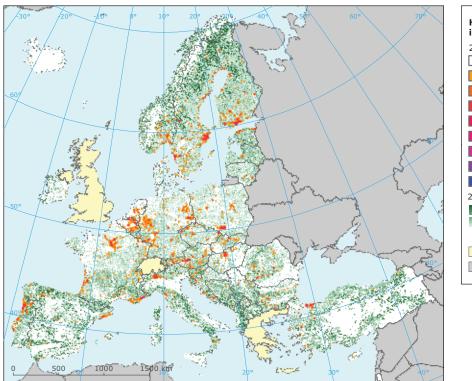
Utility of the tool

The ecotones data product shows a lot of promise as a reinforcing tool for green infrastructure analyses. The creation aspects of the data set were completed in early 2011, and so many exploratory analyses are needed to gauge the product's full potential. However, because of how the product has been created, we can say that there are a plethora of different analyses to which it could be applied, from inferring the temporal fragmentation of forest patches (Maps 4.20 and 4.21) to assessing the suburban nature in linkages of cities.
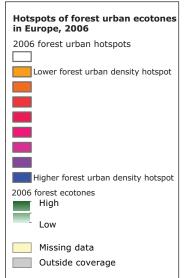
Map 4.20   Map showing results of hotspot analyses identifying forest and urban ecotones, 1990

Source: EEA, 2011.

Map 4.21   Between 1990 and 2006 an increase in the density in ecotones between forest and urban areas is observed, indicating an increased encroachment onto forest by urban areas

Source: EEA, 2011.

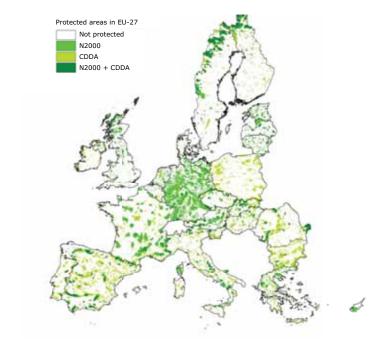### 4.2.7 *Quickscan green infrastructure*

Quickscan is a flexible and modular modelling environment currently being developed in the EEA (³⁶); it allows users to explore the different implications and trade-offs which occur when developing and implementing policy options for Europe. Quickscan brings together a range of GIS tools and analytical methods to facilitate explorations of such 'What if?' scenarios, at a range of spatial and temporal scales.

Green infrastructure is an ideal test bed for development of the Quickscan modelling environment because of the multithematic and cross-cutting nature of the theme. The Quickscan team recently explored a green infrastructure scenario in a workshop environment: participants posed a set of questions related to green infrastructure and the Quickscan team endeavoured to answer them using the modelling environment.

When it comes to answering the questions 'What is green infrastructure?' and 'How can green infrastructure be measured?', there are two emerging ideas. Green infrastructure can be explored either as a purely structural theme, by looking at different land cover types and administrative declarations (e.g. protected areas), or it can be explored with a more functional approach, which seeks to identify areas and networks which might not be measured using purely mechanical means.

Quickscan can be used to analyse questions such as 'What is the current and potential area of green infrastructure in the EU-27, if considering different green infrastructure components?'

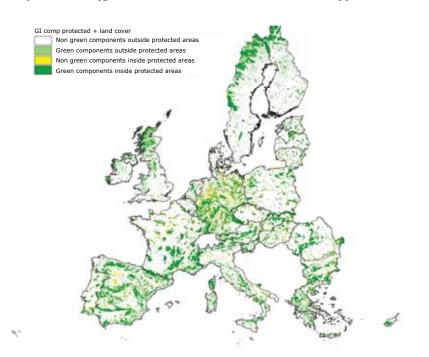**Map 4.22   Stepwise analysis of search area for green infrastructure components**

Step 1: Protected — whole area of N2000 and CDDA (including green and not-green areas)

Protected areas in EU-27
- Not protected
- N2000
- CDDA
- N2000 + CDDA

Note: Looking just at the directives covering protected areas (i.e. Natura 2000 and CDDA), we can see that a reasonable amount of land has been declared as protected, providing elements of green infrastructure for Europe.

(³⁶) Quickscan team: Verweij, P.J.F.M., Roos-Klein Lankhorst, J., Pérez-Soba, M., Knapen, M.J.R., Winter, W.P., van Eupen, M. (2011). 'Develop a Quick Scan application for decision support in the context of strategic environmental assessment'. Final report phase 1 to the restricted call for tender EEA/IEA/10/001. Alterra Wageningen UR.
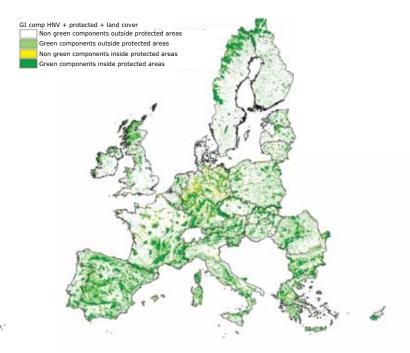
Map 4.22   Stepwise analysis of search area for green infrastructure components (cont.)

**Step 2: Green protected (only area from green components of N2000 and CDDA);
       Green non-protected (green area from Corine Land Cover))**

Note: Considering the protected elements of European land, we can also consider natural Corine Land Cover classes that are external to these protected areas. This adds a dimension of connectivity between the sites and could be used as a measure of green infrastructure or green networks connecting protected areas.
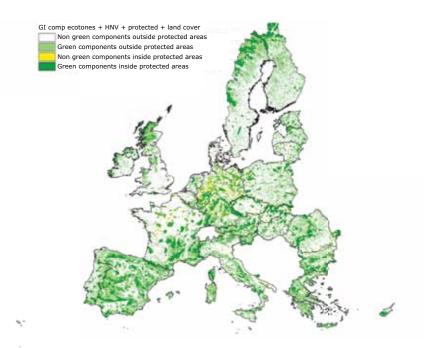
Step 3: + High Nature Value Farmland (HNVF) (both inside and outside protected areas)

Note: HNVF can be used to assess the natural aspects of agriculture that can be beneficial for the provision of ecosystem goods and services, as well as providing habitats for species. As such, we can consider HNV as part of the green infrastructure big picture.

Map 4.22   Stepwise analysis of search area for green infrastructure components (cont.)

Step 4: + natural ECOTONES (transition areas between two adjacent but different plant communities, such as forest and grassland both inside and outside protected areas)

GI comp ecotones + HNV + protected + land cover
☐ Non green components outside protected areas
☐ Green components outside protected areas
☐ Non green components inside protected areas
☐ Green components inside protected areas

Note: Corine ecotones provide a measure of landscape diversity which can be useful in providing resilient habitats and strengthening ecological corridors between protected areas. Areas of high natural ECOTONES can be considered as another additive element to green infrastructure.

Figure 4.3 below illustrates the average percentage of green infrastructure components for the areas of EU-27 Member States.

Figure 4.4 illustrates the percentage of search areas for green infrastructure components per NUTS 0 in the 27 EU Member States.
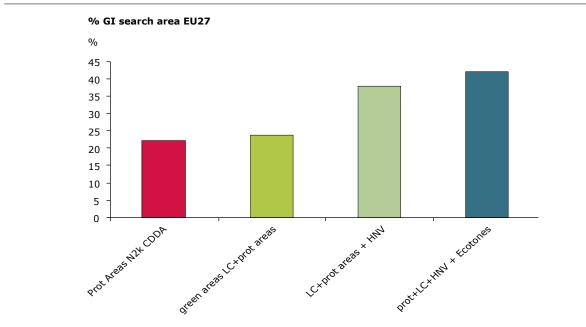
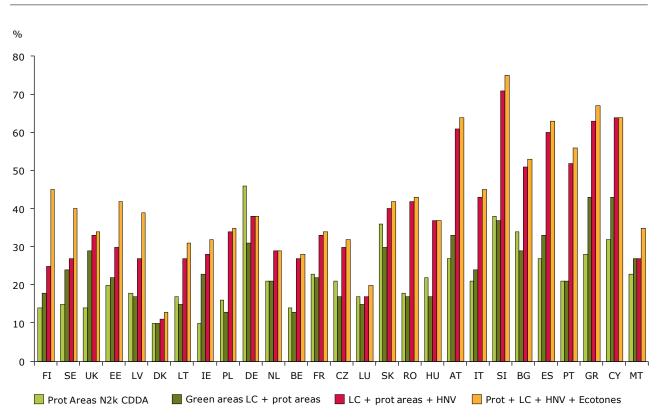**Figure 4.3 Average percentage of green infrastructure components of EU-27 Member States**

% GI search area EU27

Source: EEA, 2011.

Figure 4.4 Percentage search areas for green infrastructure components per NUTS 0

%

| | Prot Areas N2k CDDA | | Green areas LC + prot areas | | LC + prot areas + HNV | | Prot + LC + HNV + Ecotones |

Source: EEA, 2011.

Utility of the tool

It is important to emphasise that this method adapted in the Quickscan tool is purely exploratory and not designed as an exact method for measuring green infrastructure, but rather as a valuable way to explore the (sometimes overlapping) data sets in a green infrastructure context.

4.2.8   *Regional environmental characterisation*

Environmental assets and features are key aspects of defining a territory. Characterisation (for example landscape and environmental characterisation) is one way of investigating, defining and recording the key assets and inherent features of a territory. Environmental attributes of a territory can be explicitly recognised as a legitimate aspect of territorial cohesion in order to ensure that sustainable development lies at the heart of policy design.

Environmental characterisation of territories could potentially provide baseline information about the environmental and natural assets of a specific region that make it unique or important, and supports territorial identity, something that would also help inform future policy. The aim of developing approaches to regional environmental characterisation is to provide a tool to define the environmental character and assets of European regions. These can be used to contribute to the assessment of the spatial impact of European policies, and in particular territorial cohesion, on the environment at regional level.

Two alternative approaches based on GIS analysis are developed. These are outlined in the text below. The first approach is geared more towards 'policy (impact) assessment'; the second is more focused on the identification of common current environmental assets in support of the discussion on territorial cohesion and green infrastructures, including the identification of territorial identity and the exploitation of common territorial capital.

An overview of the two approaches and the results is presented below ([37]).

([37]) EEA/ETC-LUSI, 2010. GIS analysis in support of conflict analysis of European policies. Activity 4.5. Draft Version 1.0. 28.10.2010.

Environmental characterisation of European regions: policy impact assessment

The objective of the method is to support the assessment of the effects of a policy on regional environmental quality. The approach is based on the assumption that a policy will bring about changes in the current use of the land of a region, which in turn will affect its environmental quality described by changes in its environmental assets, defined by a set of variables.

This method focuses on three major environmental assets: atmosphere, water and soil quality. A short list of indicators/data for each environmental asset was selected for the initial work in 2010. The suitable indicators/data had to fulfil the following criteria:

- Europe-wide coverage;
- available from one source, i.e. no integration from national data sources needed;
- available in GIS-compatible format;
- existence of a legal or de facto threshold/target/ limit value;

- all indicators/data referring to more or less the same time period.

In addition, the selection should be balanced across the three environmental assets. With a view to an assessment of urban policy issues, the following final indicators/data were selected (the source of the data set in parentheses follows each one):

1. air quality:
   (a) PM_{10} (EEA — AirBase);
   (b) ozone (EEA — AirBase) ;
2. soil quality:
   (a) soil sealing (EEA — High Resolution Degree of Imperviousness);
   (b) soil erosion (PESERA — JRC);
3. water quality:
   (a) water pollution (EEA — ECRINS/WISE).

The methodology developed operates at three aggregation levels:

- quality of selected environmental variable/ indicator (e.g. PM_{10}), based on the comparison of
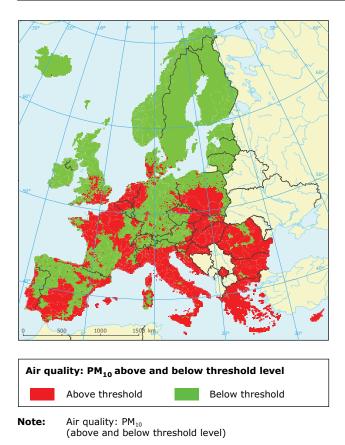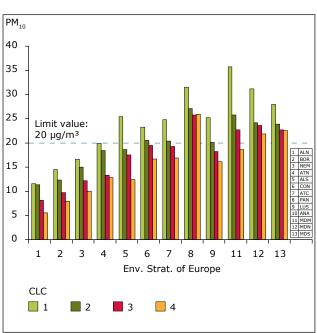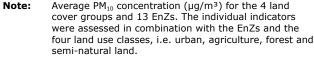
Figure 4.5 Air quality and average PM_{10} concentration

Air quality: PM_{10} above and below threshold level

🟥 Above threshold   🟩 Below threshold

Note: Air quality: PM_{10}
(above and below threshold level)

Source: EEA/ETC-LUSI, 2010

Note: Average PM_{10} concentration (µg/m³) for the 4 land cover groups and 13 EnZs. The individual indicators were assessed in combination with the EnZs and the four land use classes, i.e. urban, agriculture, forest and semi-natural land.

the individual variable/indicator value with the respective threshold;

- environmental quality for each asset (i.e. air, water and soil), based on the aggregation of the individual environmental variables'/indicators' quality (i.e. for air aggregation of PM_{10} and ozone);
- overall environmental quality, which considers equal the weight of the considered individual environmental assets' quality.
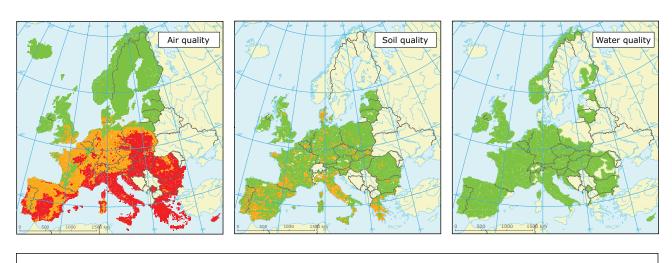
The GIS analysis is implemented using a 10 x 10 km grid (calculation unit) while the results are presented and described at the scale of the 13 environmental zones. These EnZs are just one example out of a range of other spatial units which could be used to present the results.

A limited number of indicators are selected with a legal or de facto threshold (deduced from target or limit value) within three major environmental assets, i.e. atmosphere, water and soil quality. For each of the selected indicators or data that describe

the quality of a particular environmental asset the corresponding legal threshold is chosen for classifying each grid cell as 'bad' (or non-compliant) and 'good' (compliant) (see the example map above for one of the indicators used under air quality — PM_{10}). The individual indicators are then assessed in combination with the EnZs and the four land use classes selected i.e. urban, agriculture, forest and semi-natural land.

The individual results per indicator are then aggregated to provide an integrated assessment of the quality per environmental assets, based on whether some or all of the variables are below or above the relevant threshold.

The evaluation of this combined indicator clearly poses the question of relevance of complicated thresholds applied to environmental indicators. The water quality component is systematically good, making the contribution of this component nil. Compliance value for nitrate, which is a significant indicator of human pressure on the aquatic environment, is only related to health hazard,

Map 4.23   Regional Environmental Characterisation based on aggregated results for each environmental asset

Regional Environmental Characterisation based on aggregated results for each environmental asset – air quality, soil quality and water quality

- 🟥 Bad
- 🟧 Moderate
- 🟩 Good

Source: EEA/ETC-LUSI, 2010.

and the retained concentration, 50mg NO_3/l, is far beyond natural values or recommended values for many industrial uses. Hence, compliance thresholds are not suited to this purpose; values based on statistical distribution established from natural concentration would be more appropriate.

In parallel, the accuracy of aggregation method should be questioned. The EEA is finalising the implementation of stratified statistics; first results clearly demonstrate high diversity of situations per natural sub-basin. Once completed and harmonised, these results could serve to populate the combined indicator and make it more discriminating.

Environmental characterisation of European regions: identification of common assets

The objective of the method is to develop a regional characterisation based on the identification of assets of European regions in order to support their further development and /or to identify common challenges and pressures.

The *Green Paper on Territorial Cohesion* is about ensuring the harmonious development of places and ensuring that their citizens are able to make the most of inherent features of these territories. A given territory should provide internal coherence or functionality that forms a logic base from which policymakers and stakeholders can exploit common territorial capital and tackle common challenges. The appearance of new geographies demands a stronger role for future EU cohesion policy for new types of functionally defined territories. The aim of this work is to develop one such 'new geography' which supports territorial identity through the identification of current natural and environmental assets. The characterisation of territories provides baseline information about the environmental 'value' of a specific region, i.e. if the region owns environmental assets that make it unique and that hence could support the development of the region by properly and sustainably exploiting the asset.

The methodological approach is based on geospatial analysis of different input data sets that are combined with each other and jointly analysed.

The approach mixes different types of input data sets and groups the variables selected in five broad classes, which are added up to produce a five-degree classification of 'environmental assets'.
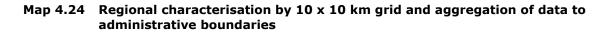
Step 1 involves the selection of environmental variables. This uses a series of predetermined criteria, such as the data sets could/should be: quantitatively, qualitatively or presence/absence; spatially explicit; balanced across the environmental asset, etc.
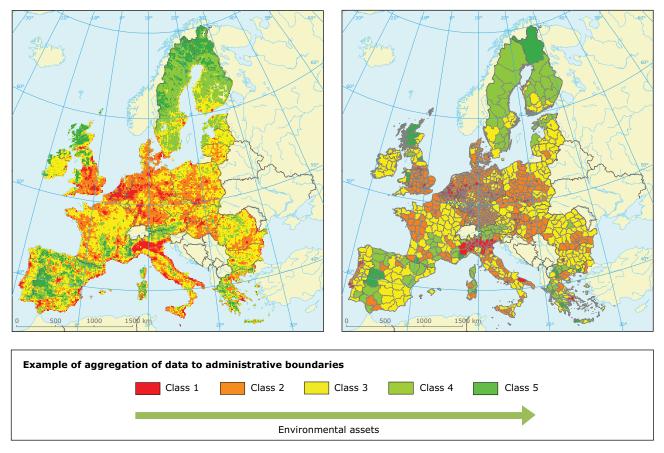
The following environmental assets have been selected:

- rural typologies (based on accessibility and GDP);
- high nature value farmlands (based on Corine Land Cover);
- proximity to natural areas (based on Corine Land Cover semi-natural classes, N2000, Corine Land Cover water);
- air quality (PM_{10}) (based on AirBase);
- degree of soil sealing (based on FTSP data set on imperviousness/soil sealing).

All input data sets are resampled to 10 x 10 km grid cells to enable efficient processing and to allow later aggregation of the results to different reporting units (e.g. the grid itself, administrative units, biogeographic regions, watersheds).

Step 2 involves the regional environmental characterisation. The range of values in the different input data sets are standardised into five classes according to the statistical distributions of indicator current values. These five classes are assumed to represent a gradient of 'natural and environmental assets' for each grid cell (from 'very low natural assets' to 'very high natural assets'). Each grid cell contains a score according to each of the individual input data sets. The scores in each grid cell are summed up to calculate an overall score. The results of the data processing are classified in a similar way as the input data sets, based on median and standard deviation. The class boundaries for assigning the regions are again based on average and standard deviation.

Map 4.24   Regional characterisation by 10 x 10 km grid and aggregation of data to administrative boundaries

Example of aggregation of data to administrative boundaries

Class 1   Class 2   Class 3   Class 4   Class 5

Environmental assets

Note: Regional characterisation (raw data, 10 x 10 km grid)

Source: EEA/ETC-LUSI, 2010.

Map 4.24 (left) shows the regional characterisation at full resolution (10 x 10 km grid). The regions are relatively scaled along their degree of environmental assets (low to very high amounts of assets). The same colour indicates a similar score in environmental assets, independent of the combination of the five input data sets, i.e. a region scoring 15-15-3-3-1 would classify for the same class (degree of environmental asset) as one with a score of 1-6-10-10-10.

Map 4.24 (right) demonstrates the use of different spatial units (i.e. administrative units) for the description and presentation of the results. The grid data are aggregated to the administrative units according to the majority class within each region.
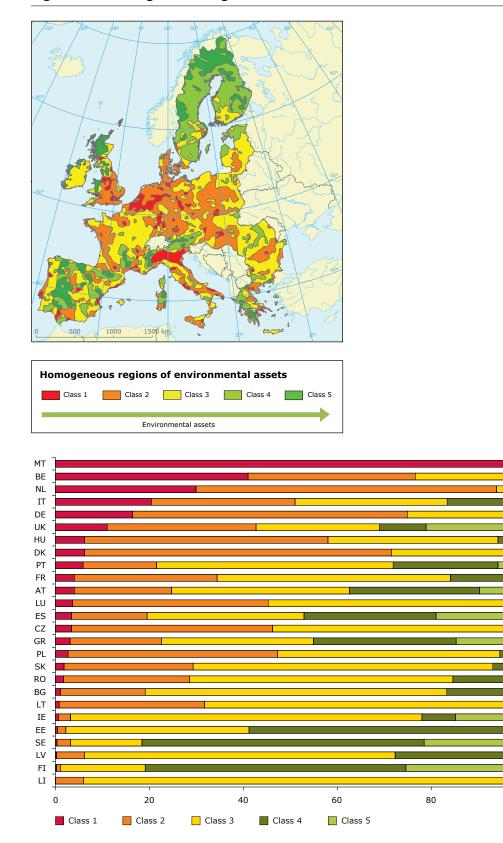
Figure 4.6   Homogeneous regions of environmental assets

Note: Country statistics: This figure shows the list of countries sorted by their degree of natural and environmental assets. Countries with a low degree of natural assets are listed first. Due to the resolution of the grid data (10 x 10 km) Malta was dominated by a low degree of environmental assets (this could be corrected by using the high-resolution data (1 x 1 km)).

Source: EEA/ETC-LUSI, 2010.

In addition to the aggregation of the grid data to a given reporting unit, like NUTS regions, the grid data itself can be used to create homogeneous regions directly from the raw data. By eliminating small areas and filtering, the data can be generalised and larger homogeneous regions can be derived (see Figure 4.6 above). These homogeneous regions can then be further characterised by adding additional information to the resulting regions. This would, for example, allow differentiation of similar (dark green) regions in Spain, Scotland or Scandinavia based on their dominating land cover types, their biogeographic regions or population density. This attribution of the homogeneous regions has not been undertaken yet.

Utility of the tool

The approach of policy impact assessment is likely to be of limited use in the identification or characterisation of green infrastructure, as its focus is on the quality of three environmental assets, i.e. atmosphere, water and soil quality. Its potential relevance is that it could highlight some very approximate areas where green infrastructure would be particularly needed, because, for example, of pollutant levels and soil safeguarding benefits. In this way, it could provide input for determining priority issues that a particular green infrastructure can help address.

The approach on identification on common assets is more related to green infrastructure, as it includes data such as proximity to natural areas and fragmentation by urban areas. It could provide a good orientation as to the areas where efforts should be focused on protecting green infrastructure, and where on developing green infrastructure.

In addition, as the aim of regional environmental characterisation work is to provide a tool to define the environmental character and assets of European regions, and potentially to contribute to the assessment of the spatial impact of European policies (particularly territorial cohesion) on the environment at regional level, consideration could be given to adding a green infrastructure layer (once available) to the analysis to form part of the approach. Green infrastructure is an important part of territorial identity and capital, and it could add value to the existing data sets used to generate the regional characterisation map — although consideration would need to be given to the degree

of overlap with other data sets already used, such as rural typologies and proximity to natural areas, with which there could be a strong correlation (in these instances, its addition would be of limited value). Still, this tool could also process the environmental information at European level, especially with regard to identifying the strengths or the problems in a certain region.

Potential objectives of regional environmental characterisation as part of the territorial cohesion and green infrastructure debate could include the following:

• to provide a scientifically sound and politically operational description of the environmental characteristics of European territories to support territorial cohesion;
• to strengthen territorial identity — the need to enable regions to identify their territorial assets within the framework of spatial development policies;
• to identify region-specific natural and environmental assets;
• to help assess and then monitor the positive and negative impacts of European policies, including the allocation of funding to support existing natural assets and regional sustainable development;
• to identify high-diversity areas from the point of vulnerability of territories to natural risks;
• to highlight the potential and the weaknesses of areas;
• to use the risk information for a strategic environmental assessment and also for future spatial planning policies;
• to use the Regional Environmental Characterisation tool for a regional characterisation of ecosystem services, something that would require a consolidation of the approach; once the JRC has finalised the different ecosystem service maps, they can be analysed as are the present data sets.

In Table 4.9, the two approaches to regional environmental characterisation have been evaluated to explore whether they meet these objectives and have the potential to support and inform the different elements of the environmental dimension of territorial cohesion (whether the approach fully, partially or does not support each element is also indicated). See Annex 1 for further details concerning these elements.

Table 4.9   Analysis of the potential of the two regional environmental characterisation approaches to inform the elements of the environmental dimension of territorial cohesion

Key elements of the environmental dimension of territorial cohesion	The impact assessment approach	The identification of common assets approach
Harmonious and sustainable development	**Partially supports** • The approach utilises limits/thresholds which link to environmental policy goals and are a reflection of environmental quality • The focus of the approach is on the environmental media and assets, not the wider goods and services that derive from them	**Partially supports** • The approach does seek to define environmental quality, and to an extent relates this to goods and services • The approach utilises both qualitative and quantitative data • The approach does not incorporate limits and carrying capacity explicitly
Inherent features of territories: natural features are protected for future generations	**Partially supports** • The approach does not attempt to define homogeneous territories • The approach does not consider land use/cover as a source of information on environmental assets/features or character, but as the receptor of pressure from a policy which in turn will change the state of the region. From the approach described it is unclear how change in land use will be assessed and feed into the approach • The use of limits/thresholds in the method is a reflection of environmental quality • The focus of the approach is on the environmental media and assets, not ecosystem services. It does not relate to current services or future needs (unless this is inherent in any of the limits/thresholds) that derive from them • Current set of indicators do not consider vulnerability to environmental risks (refers to other indicators being used as appropriate, but a major limitation is availability of suitable data and limits/thresholds upon which the approach relies)	**Partially supports** • The approach does attempt to define homogeneous territories • These homogeneous regions could be further characterised by including additional information to the resulting regions — although the attribution of the homogeneous regions has not been undertaken yet • The current set of indicators do not consider vulnerability to environmental risks
Concentration: addressing differences in density and other natural features	**Partially supports** • The current set of indicators/variables includes issues associated with concentration, like pollution and soil sealing	**Partially supports** • The current set of indicators/variables includes issues associated with concentration, like pollution and soil sealing
Connecting territories: strengthening positive natural connections and interactions between territories	**Does not support** • Does not consider the natural connections and interactions between territories • Potential to aggregate the results to different reporting units	**Partially supports** • Potential to aggregate the results to different reporting units • Homogeneous regions identified are potentially transboundary • Potential to include green infrastructure data into method.

Table 4.9 **Analysis of the potential of the two regional environmental characterisation approaches to inform the elements of the environmental dimension of territorial cohesion (cont.)**

Key elements of the environmental dimension of territorial cohesion	The impact assessment approach	The identification of common assets approach
Cooperation: overcoming division	**Does not support** • Does not consider the issue of cooperation • Does not present final results in spatial format. • Results current presented using EnZs, but the draft report states that this is just one example out of a range of other spatial units which could be used to present the results	**Partially supports** • Homogeneous regions identified and are potentially transboundary • Results can be aggregated into different reporting units

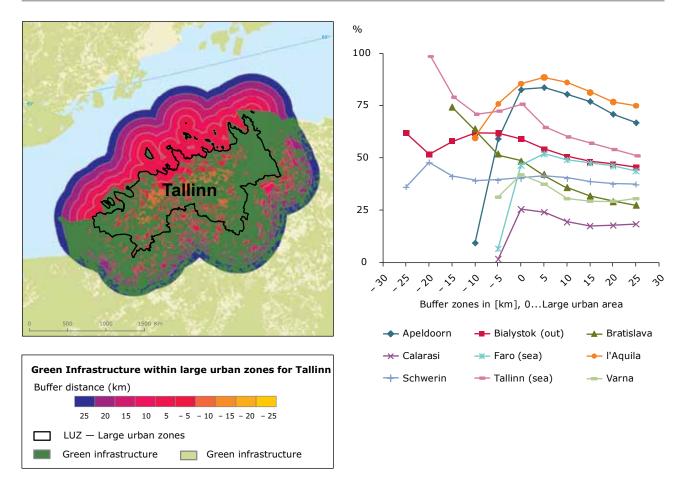## 4.3 Combination of urban- and landscape-level approaches

A further development of the landscape and urban approaches to defining green infrastructure follows to test how the two approaches can be integrated. This is most relevant at regional or subregional scale so as to test the interface between the urban and landscape scale data.

The nine selected large urban zones (LUZs) are buffered in steps of 5 km (inside and outside the urban zone). Within these zones, the area and percentage of green infrastructure is calculated. Figure 4.7 shows an example of the resulting green infrastructure map within large urban buffer zones for Tallinn.

Utility of the tool

From the graph, it can be concluded that some cities have more green infrastructure inside the urban zone than outside in relation to the area. This would appear to be counter-intuitive and the approach is likely to need further refinement, but this result is likely to reflect that the urban approach to mapping the green infrastructure classifies more areas than the landscape approach which is perhaps not surprising as the latter requires an area to be connected to a Natura 2000 site via the particular Corine Land Cover classes. Three cities (Calarasi (Romania), Apeldoorn (the Netherlands) and Faro (Portugal)) do not follow this general trend; they show a dramatic decrease inside the urban buffer zone. One reason could be that the cities are quite small, and the innermost district (inside buffer of 5 km to 10 km) is the most densely populated.

Figure 4.7   Example of green infrastructure map within large urban buffer zones for Tallinn, and graph of the percentage of green infrastructure for all the sample cities

Source: EEA/ETC-LUSI, 2010.

5   Conclusions and opportunities

5.1   The concept and deliverability of green infrastructure

There is no single widely recognised definition of green infrastructure. However, underlying features include connectivity, multifunctionality and smart conservation. Based on the scale and range of benefits, it is concluded that it is possible to group the definitions broadly under two concepts based on scale: connected green open spaces at an urban scale; and connectivity between valuable habitats and protected areas at a landscape scale (regional, national and transnational).

Definitions of green infrastructure typically list the potential green assets or physical components that make up its integral parts, or the benefits that they bring. The Environment DG has identified the following potential components of green infrastructure; they provides a useful starting point:

- areas with a high value for biodiversity in protected areas in a coherent network;
- healthy ecosystems and areas of high nature value outside protected areas;
- natural landscape features;
- restored habitat patches that have been created with specific species in mind;
- artificial features designed to assist species movement across insurmountable barriers;
- multifunctional zones where land uses that help maintain or restore healthy ecosystems are favoured over other incompatible activities;
- areas where measures are implemented to improve the general ecological quality and permeability of the landscape;
- urban elements such as biodiversity-rich parks, green walls and green roofs.

A list of potential benefits associated with green infrastructure was compiled from some of the key literature, and this included benefits under the following topics:

- biodiversity/species protection
- climate change adaptation
- climate change mitigation

- water management
- food production and security
- recreation, wellbeing and health
- land values
- culture and communities.

Potential principles or objectives of green infrastructure could include the following.

- **Strategically planned and delivered** networks of high-quality green spaces and other environmental features.
- **Delivering multifunctional benefits** — designing and managing land as a multifunctional resource capable of delivering a wide range of environmental and quality of life benefits, including maintaining and improving ecological functions.
- **Helping to deliver place-making** — recognising the character and distinctiveness of different locations and ensuring that policies and programmes (spatial planning and other sectors) respond accordingly.
- **Delivering 'smart' conservation** — addressing the impacts of urban sprawl and fragmentation, building connectivity in ecological networks and promoting green spaces in the urban environment (including through adaptation and retrofitting).

Green infrastructure is already a widely used concept and many examples of its application at difference scales and for different purposes already exist. The report includes several case studies illustarting the potential benefits of green infrastructure and different delivery mechanisms in practice. It has been shown that these case studies generally exhibit many or all of the key elements of territorial cohesion, including the environmental dimensions: harmonious development, inherent features of territories, concentration, connecting territories and cooperation.

Investigation of the link between green infrastructure and ecosystem services illustrates the synergy between the two. Indeed, the purpose of green infrastructure can be defined as maintaining,

strengthening and restoring ecosystems and the services they provide. From an analysis of a typical typology of ecosystem services and the potential benefits of green infrastructure, links were identified across all the categories of ecosystem services: supporting, regulating, provisioning and cultural services.

5.1.1 Opportunities

Key options include the following.

1. Whilst there is no recognised definition of green infrastructure, is not necessarily important to try to define it as a single concept given that its application is so broad. However, using and promoting some key principles of green infrastructure is a more useful approach and should be promoted.
    Key principles should include:
    (a) strategically planned and delivered networks of high-quality green spaces and other environmental features;
    (b) delivering multifunctional benefits;
    (c) helping to deliver place-making;
    (d) delivering 'smart' conservation.
2. As part of any further development of this work, green infrastructure benefits could be presented in terms of ecosystem services, as this provides a relatively consistent and effective language, and has growing resonance with policymakers and other stakeholders.

5.2 Integration of green infrastructure into policy sectors

The analysis of the integration of green infrastructure in the EU sectoral and environmental policies identified many existing interactions — both potential synergies and conflicts. Some of the key potential conflicts identified were with energy, transport, agriculture and cohesion policy, and included, for example, that:

*   promoting biofuels can result in increase of area of intensive farming, decreasing the area of woodlands, number hedges, etc., and can also reduce multifunctionality of the farmed land;
*   efforts to minimise congestion can result in construction of new roads, damaging habitat connectivity and decreasing areas of green infrastructure;
*   expansion and improvement of transport infrastructure can weaken habitat connectivity and generally decrease the area occupied by green infrastructure.

In terms of potential mechanisms that could be used to integrate green infrastructure into other policies, it was concluded that existing legislation provides considerable scope to promote green infrastructure (e.g. the White Paper *Adapting to Climate Change*, the Habitats and Birds Directives, the Water Framework Directive, the Floods Directive, the Marine Strategy Framework Directive, and the EIA and SEA Directives). Beyond the environment and its policies, other sectoral policies at EU level also have a key role to play in implementing green infrastructure and the ecosystems and services it provides, especially policies which shape the use of land and its spatial patterns such as regional policy, agriculture, transport, energy, transport and resource efficiency policy.

The types of mechanisms identified that could be used to integrate green infrastructure into other policies include:

*   existing or new European and national environmental legislation;
*   existing or new European and national legislation on green infrastructure;
*   European and Member State guidance/management plans on green infrastructure;
*   direct support through targeted European funding and non-EU funding;
*   indirect support through European funding in other sector areas (e.g. agriculture);
*   national and regional green infrastructural strategies;
*   spatial planning and building control;
*   strengthening the use of assessment, e.g. Impact Assessment, the SEA and EIA;
*   communication and capacity building.

One of the key tools identified (including through the case studies) to develop green infrastructure was spatial planning; this can be used to plan the interactions between land uses at the strategic level, guide development away from sensitive areas and promote the restoration and enhancement of ecosystems and connections between natural areas.

5.2.1 Opportunities

Key options from this part of the study include:

*   promoting the concept of green infrastructure to support both environmental policy goals and certain non-environmental policy goals, and seeking opportunities to mainstream green infrastructure into other policies to realise the potential synergies;

- linking green infrastructure to ecosystem services and encouraging the use of existing legislation to promote green infrastructure (e.g. the White Paper *Adapting to Climate Change*, the Habitats and Birds Directives, the Water Framework Directive, the Floods Directive, the Marine Strategy Framework Directive, and the EIA and SEA directives);
- emphasising the role of spatial planning in facilitating and delivering green infrastructure, along with a whole range of other mechanisms, including the use of European and national legislation, guidance/management plans, direct and indirect European funding and non-EU funding, national and regional green infrastructural strategies, building control, strengthening the use of assessment and communication, and capacity building.

5.3 Monitoring systems for green infrastructure and territorial cohesion developments

Green infrastructure is a potential tool to improve territorial cohesion from an environmental perspective and to ensure ecological continuity. The analysed tools can help identify and monitor/map green infrastructure and provide relevant spatial data and data analysis to support policymakers in ongoing discussion processes and work on green infrastructure and territorial cohesion. They are useful and relatively simple approaches, and are based on available data sets at European scale. They all have their advantages and shortcomings, and are subject to further developments and improvements to better provide information on green infrastructure and territorial cohesion from an environmental perspective. The approaches are exploratory and not tailored as exact methods for measuring green infrastructure; rather, they should be considered as valuable inputs to explore the (sometimes overlapping) data sets in a green infrastructure context.

It is important to recognise that mapping of green infrastructure is needed to set priorities for future investments but also for targeting green infrastructure projects. The tools are useful not only at European scale, but could also help national and regional authorities shape their initiatives. Hence, coordinated integrated spatial planning can help authorities in land-relevant decisions and the implementation of green infrastructure.

It is evident from the analysis, that the mapping tools for urban level analyses have been weak compared to the more extensive set of mapping tools available at the landscape level. It is only within the last couple of years that research has built up on urban-level analyses of green infrastructure.

As regards the tools and their application, their robustness is open to debate (for example, the analysis linking the Urban Atlas codes and the benefits of green infrastructure); this is where further improvements are recommended. The urban green density analysis can be used to characterise European cities in terms of the green access afforded to city residents living in built up areas. This could be developed further to gain more meaningful information about urban green infrastructure, namely to identify pockets of high potential biodiversity in built-up areas.

The GBLI expresses the 'greenness' or naturality on a pan-European scale, which can be used to infer the 'ecological potential' of landscapes. Lessons from the GBLI map, for example in terms of smoothing the Corine data, could be considered as part of reviewing the landscape-scale green infrastructure mapping approach.

Fragmentation maps provide an accurate measurement of landscape fragmentation for most of the European countries that support managers and policymakers in allocating resources towards the protection and restoration of biodiversity and landscape quality. Fragmentation analysis can be used in developing indicators in support of green infrastructure planning and performance review. The effective mesh size is an important criterion for consideration in green infrastructure planning and regional planning.

The NLEP indicator provides information of the overall state of the green infrastructure and its change. It can express ecosystems integrity and allows a good reading across Europe. It is a status indicator which at European/national scales helps frame the potentials, provides a quick monitoring of the state and is useful for assessing progress towards biodiversity targets at various scales, for example. At local scale, the NLEP can highlight areas with different potential for maintaining green infrastructure since it expresses the localised ecosystem values on a per kilometre basis.

Mapping of ecological corridors is potentially relevant for green infrastructure analysis as it considers potential connectivity and fragmentation between areas, and analyses the Natura 2000 network in relation to potential connectivity. Also, this tool takes into consideration species requirements.

The ecotones data product shows a lot of promise as a reinforcing tool for green infrastructure analyses. The ecotone not only contains species common to the communities on both sides; it may also include a number of species only able to colonise such transitional areas. As such, Corine ecotones can add value to land cover analyses in the context of green infrastructure assessment. It has also been used to make landscape analyses in several different contexts, from analysing landscape diversity to assessing habitat fragmentation.

Green infrastructure has been used as a test bed for development of the Quickscan modelling environment because of the multithematic and cross-cutting nature of the theme. Quickscan brings together a range of GIS tools and analytical methods to facilitate explorations of such 'What if?' scenarios at a range of spatial and temporal scales. As regards questions like 'What is green infrastructure?' and 'How can green infrastructure be measured?', two emerging ideas are presented in this report. Green infrastructure can be explored either as a purely structural theme, by looking at different land cover types and administrative declarations (e.g. protected areas), or it can be explored with a more functional approach, which seeks to identify areas and networks which might not be measured using purely mechanical means.

In terms of the two approaches to Regional Environmental Characterisation, it is clear that the approach on 'the identification of common assets' is more related to green infrastructure; it could be used to characterise the inherent environmental features and assets which help define a territory and provide a useful baseline characterisation of common territorial capital. It could provide a good orientation as to which areas have green infrastructure that needs protecting, and which have grren infrastructure that needs developing. Together with the other approach on 'the impact assessment tool', they could be used effectively, providing the wider environmental context, and putting forward suggestions for areas that need to improve their green infrastructure given the state of the environmental assets, and where environmental limits may be under pressure.

5.3.1 Opportunities

Key options from this part of the study include the following.

- The approaches outlined in this report to identifying and mapping green infrastructure are relatively simple and it is recommended

that these be developed and promoted further, particularly as the European Commission is committed to developing a green infrastructure strategy. Further work on integrating the scales of mapping would be beneficial.
- Further developing the approach to the analysis of green infrastructure at the urban level by, in particular, investigating potential methods of linking the Urban Atlas codes to potential benefits of green infrastructure. It may well be helpful to consider these benefits of green infrastructure in terms of ecosystem services as part of this development of the methodology (one of the case studies illustrated an approach to exploring the links between land use/land cover classes and a typology of ecosystems services; a similar approach may be useful here).
- In developing the approaches to mapping green infrastructure, consideration should be given to some of the techniques used for the Green Background index and work on mapping of ecological corridors, as these may improve the robustness of the green infrastructure characterisation tools.
- Further develop the Regional Environmental Characterisation approach, which identifies the common current environmental assets of territories; it also investigates additional input data such as green infrastructure, and produces more detailed outputs and resolutions, and different reporting units such as landscape character types or river basins. Investigating alternative approaches to Regional Environmental Characterisation would include utilising existing environmental 'stratifications' of Europe, such as landscape character types, as the spatial framework or unit for attributing data on environmental assets.
- Investigate developing Regional Environmental Characterisation based on ecosystem services and functions, as this approach has growing resonance and provides a relatively consistent, effective language and a potential common metric for characterising the attributes of territories.
- Investigate the ecotones data product further through exploratory studies to gauge the product's full potential for green infrastructure analyses.

5.4 Territorial cohesion and green infrastructure

The concept of territorial cohesion and its orientation towards territorial assets via a sustainable path like biodiversity or local renewable energy production challenges the future regional policy to focus more

Table 5.1   Links between the elements of territorial cohesion and the pillars of sustainable development

Elements of territorial cohesion	'Pillars' of sustainable development		
	Economic	**Social**	**Environmental**
Harmonious development	• More even spread of economic activity across the EU and within countries • More balanced and resource-efficient development (balancing benefits of concentration v. costs in terms of congestion, property prices, social exclusion and pollution)	• More balanced development which improves quality of life and reduces social exclusion	• More balanced development which benefits the environment • Respecting environmental limits and carrying capacity • Utilising a high-quality environment as a goods and service provider
Inherent features	• Challenges of development in certain regions given their geographical features and natural hazards	• Framing development around a territory's social capital	• Framing development around a territory's natural capital • Respecting vulnerability to natural hazards/environmental risks
(Overcoming) concentration	• Avoiding excessive concentration and its diseconomies whilst promoting wider access to benefits of agglomerations	• Reducing the negative externalities of agglomeration, spreading the benefits to all groups and ensuring social cohesion	• Preserving the natural resources and assets and environmental quality of rural areas, which are attractive places to visit and live • Addressing environmental problems related to concentration and utilising the benefits
Connecting territories	• Reliable transport, energy and other services for business	• Ensuring access to services, in particular for disadvantaged groups	• Avoiding the environmental impacts of economic connectivity • Recognising interdependences of environmental services within and between regions
Cooperation	• Economic growth requires multiple levels of cooperation	• Tackling social problems effectively requires cooperation	• Overcoming environmental problems requires cooperation • Cooperation to implement EU environmental laws and policy at all levels

on territorial potentials and smart growth. Regional policy should be considered a tool that addresses the need to support the environmental dimension of territorial cohesion. In this way, regional policy can contribute to achieving the EU's long-term sustainable development objectives beyond 2020.

In other words, in order to achieve, or at least move towards territorial cohesion, the importance of the environmental dimension of a territory, including ecosystem services, landscape, biodiversity and

resource protection, must be recognised; this importance must be given due weight within a context of sustainable development, with regard to both policy development and implementation.

For regional policy to move towards sustainable development priorities, an integrated approach for planning, programming and implementation is needed ([38]). This would ensure policy coherence within sectors and policies and hence involvement of all levels of governance and stakeholders in

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([38]) See http://ec.europa.eu/regional_policy/sources/docoffic/official/communic/sustainable/comm2011_17_en.pdf.

planning and decision-making processes. Besides the integration of environmental dimensions into all EU policies, regional policy should also take account of regional and local needs as partnerships and cooperation with socio-economic partners and the civil society are crucial to success.

Regions are increasingly facing environmental limits as they pursue economic development agendas. It is important to secure the integration and coordination of sectoral policies at the most appropriate level and ensure that all issues which increase disparities between territories (or do not utilise their inherent

Case study	Green infrastructure benefits provided	Elements to territorial cohesion (examples)
Landscape scale		
1. Restoration of flood plains and wetland in Babina and Cernovca (Romania)	Protection and restoring valuable wetland areas along the downstream 1 000 km of the Danube, including the globally important Danube Delta.	The project increased the economic diversification of rural areas by providing local people with new sources of income like fishing and reed harvesting. It provided economic, social and environmental benefits by restoring and putting to use the inherent assets of the area, maintaining and improving natural capital and addressing current and future environmental vulnerabilities.
2. European Green Belt project (includes Croatia, Bulgaria, Czech Republic, Slovakia, Hungary, Austria, Slovenia and Germany)	The project aims to create the backbone of an ecological network, running from the Barents to the Black Sea that is a global symbol for transboundary cooperation in nature conservation and sustainable development. Increasing the connectivity between Green Belt areas and the long-term protection of this unique natural heritage. It will contribute to the implementation of NATURA 2000 and EU spatial policies such as the ESDP.	The European Green Belt project is achieving sustainable development at regional and local levels. It has grown to be a formidable marketing instrument for protected and non-protected areas in border regions, and for those that try to find strategic synergies with important economic goals, for example natural and cultural landscapes as an asset in tourism marketing.
3. Natural climate buffers in the Netherlands	Natural climate buffers are areas that help to cushion the effects of climate change. Natural climate buffers (e.g. marshes, peat lands, swamp forests and river floodplains) offer protection to humans, habitat to plants and animals, and attractive natural scenery for all.	This project is an example of delivering the objectives of territorial cohesion by providing climate change adaptation and other benefits through green infrastructure. The project indicates the potential economic benefits of increased areas of high quality recreation and sympathetic waterside development, as well as the low risk that natural climate buffers present when compared to engineered measures.
Urban scale		
4. Heat island management in Stuttgart, Germany	Heat island management by the designation of wind paths across the city and banning the felling of trees of a certain size in inner city areas. As a result, greenery covers more than 60 % of the city.	The high percentage of green infrastructure (parks, gardens) and its maintenance and expansion in Stuttgart help to improve the cohabitation of people in densely populated urban conurbations. Close collaboration between the Office for Environmental Protection and the City Planning and Renewal team means that the recommended green infrastructure solutions are being implemented through spatial planning and development control.
5. Neighbourhood regeneration in Malmö, Sweden	Adaption and mitigation measures implemented, including storm water management, green roofs, green spaces (recreation areas, wildlife habitats), new renewable energy sources, recycling systems, sustainable construction and local transport initiatives.	The turnover of tenancies decreased by 50 %, unemployment fell from 30 % to 6 % and 3 new local companies were established. The project achieved various economic, social and environmental benefits by transforming a declining estate into an exemplar of an environmentally adapted urban area, while also addressing current and future climate vulnerabilities.

features), including climate change, environmental quality and ecosystem services, can be addressed in a 'place-based' context.

The environmental dimension of territorial cohesion is nonetheless closely linked to the economic and social dimensions. The table below shows the links between the elements of territorial cohesion as suggested in the European Commission's *Green Paper on Territorial Cohesion* and the pillars of sustainable development (economic, social and environmental).

Territorial cohesion can be seen as the spatial representation of sustainability, which would mean that assessing policies in terms of the environmental dimensions of territorial cohesion would be an important step towards the better integration of environment and sustainability. The monitoring tools mentioned in the report have the potential to play an important role in this type of assessment. The emerging approaches to Regional Environmental Characterisation, for instance, provide a starting point for developing an operational description of the environmental characteristics of European territories that recognises region-specific natural and environmental assets and limits, to support territorial cohesion.

The case studies presented in this report illustrate the benefits provided by green infrastructure at landscape and urban scale, and generally exhibit many or all of the key elements of territorial cohesion: harmonious development, inherent features of territories, concentration, connecting territories and cooperation.

Table 5.2 Case studies illustrating benefits provided by green infrastructure at landscape and urban scale and linkages to elements of territorial cohesion.

The study also shows that there are strong synergies between many European environmental and non-environmental policy objectives and green infrastructure, and the potential benefits it provides. As part of the development of this area of work, it will be useful to consider green infrastructure benefits in terms of ecosystem services, as this provides a relatively consistent and effective language and has growing resonance with policymakers and other stakeholders. Indeed, the purpose of green infrastructure can be viewed as maintaining, strengthening and restoring ecosystems and the services they provide.

5.4.1 Opportunities

1. The environmental aspects of territorial cohesion need to be put on an equal footing with the economic and social elements of the concept. There is a need for a strong message of the environmental dimension of territorial cohesion, as the concept could otherwise represent a step backwards in terms of European efforts for sustainable development.

2. As territorial cohesion must contribute to economic growth in order to achieve the aims of Europe 2020, the focus on territorial potentials including environmental assets and services should be reinforced.

3. Environment should be seen as a driver for territorialising policies as it has a territorial/spatial dimension. Conversely, territorial cohesion adds new spatial components to environmental assets. Green infrastructure represents environmental assets and should be used as a tool to improve territorial cohesion at the environmental level and ensure ecological continuity.

4. Rather than seeking a definition of territorial cohesion, which eventually makes the concept elusive, a more pragmatic approach might be to focus on the process of achieving territorial cohesion, and exploring what moving towards territorial cohesion — from an environmental perspective — might mean, and what tools and approaches might support this process.

5. Potential objectives of regional environmental characterisation as part of the territorial cohesion debate could include the following, so as to provide a scientifically relevant and politically operational description of the environmental characteristics of European territories to support territorial cohesion:
(a) to strengthen territorial identity — the need to enable regions to identify their territorial assets within the framework of spatial development policies;
(b) to identify region-specific natural and environmental assets;
(c) to help assess and then monitor the positive and negative impacts of European policies, including the allocation of funding to support existing natural assets and regional sustainable development;
(d) to identify high-diversity areas from the point of vulnerability of territories to natural risks.

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Annex 1 Potential key elements of the environmental dimension of territorial cohesion

Table A1.1 Potential key elements of the environmental dimension of territorial cohesion

Green Paper key elements of territorial cohesion	Potential key elements of the environmental dimension of territorial cohesion	Potential criteria to evaluate the environmental dimension of territorial cohesion
Harmonious development ● Building bridges between economic effectiveness, social cohesion and ecological balance ● Putting sustainable development at the heart of policy design	**Harmonious and sustainable development** ● Achieving sustainable development, and thus integrating economic, social and environmental policy goals and actions ● Environmental limits and carrying capacity (as a constraint on economic growth) ● Utilising a high-quality environment as a goods and service provider (e.g. recreation, *agriculture, tourism)*	● Does the policy seek to integrate environmental limits and carrying capacity, as a potential constraint on economic growth? ● Does the policy seek to utilise a high-quality environment as a valuable good/service?
Inherent features of territorie Citizens able to use the inherent features of their territories: ● Transforming diversity into an asset ● Making best use of territorial assets (Three specific types of regions are identified which can face particular development challenges: mountain regions; island regions; and the 18 sparsely populated regions, all rural and almost all border regions)	**Inherent features of territories:** natural features are protected for future generations ● Maintaining/improving natural capital — maintaining local features and environmental quality ● Maintaining and enhancing current ecosystem services and recognising future needs ● Recognising vulnerability to environmental risks	● Does the policy seek to promote/ utilise/respect the inherent environmental features and assets of different territories? ● Does the policy consider current and future environmental vulnerabilities and challenges? ● Does the policy promote concepts such as self-sufficiency and eco-efficiency in the management of natural resources?
Concentration Overcoming differences in density: ● Avoiding excessive concentrations of growth ● Facilitating access to the increasing returns of agglomeration in all territories ● Recognising that whilst most economic activity is concentrated in towns and cities, rural areas remain an essential part of the EU, providing most of the natural resources and natural areas ● Ensuring sustainable territorial development — strengthening economic competitiveness and capacity for growth, while respecting the preservation of natural assets and ensuring social cohesion	**Concentration:** addressing differences in density and other natural features ● Addressing environmental problems related to concentration (e.g. pollution or water needs), including negative effects within and among regions ● Recognising environmental/ ecosystem services	● Does the policy seek to address environmental problems associated with higher concentrations of development, such as pollution to air and water, water resource scarcity, urban heat island effect, as well as promote/recognise the environment efficiencies of high concentration (e.g. provision of environmental infrastructure such as water treatment, certain forms of energy — CHP, public transport, recycling)? ● Does the policy recognise and seek to promote or protect the value of territories to social and economic wellbeing and success, including such factors as carbon sinks, flood risk attenuation, health and quality of life (exercise and visual amenity)?

Table A1.1 Potential key elements of the environmental dimension of territorial cohesion (cont.)

Green Paper key elements of territorial cohesion	Potential key elements of the environmental dimension of territorial cohesion	Potential criteria to evaluate the environmental dimension of territorial cohesion
Connecting territories Overcoming distance or 'strengthening' connections: ● Ensuring good intermodal transport connections ● Adequate access to services (e.g. health care, education and sustainable energy, broadband Internet access, reliable connections to energy networks and strong links between business and research centres)	**Connecting territories** Strengthening positive natural connections and interactions between territories: ● Understanding environmental connections between and within regions, e.g. water, materials, energy, and making these connections more sustainable ● Recognising inputs and outputs (interdependences) of environmental (and ecosystem) services within and between regions at different scales ● Recognising/avoiding negative environmental effects from one region to another (e.g. pollution, climate change, flooding, droughts, fires, biodiversity loss) ● Avoiding the environmental impacts of connectivity (e.g. pollution, habitat loss, landscape intrusion)	● Does the policy consider the interdependences and relationships between territories? ● Does the policy seek to understand and consider the interregional/ transnational connections in relation to environmental and natural resources, for example provided by wildlife corridors, bird migration routes, river corridors, etc.? ● Does the policy seek to minimise the impact of constructing new transport infrastructure to overcome distances or strengthening connections (e.g. pollution, habitat loss, landscape intrusion)? ● Are interregional and transnational environmental and natural resource connections reflected in policy and does policy seek to ensure that outcomes are sustainable and equitable? ● Does the policy recognise and seek to avoid new and reduce existing interregional and transnational environmental impacts arising from connectivity, such as water pollution, losses to habitats and species?
Cooperation Overcoming division: ● Addressing problems of connectivity and concentration through strong cooperation at different levels ● Ensuring policy responses on variable geographical scales (e.g. neighbouring local authorities in different countries and between neighbouring countries) ● Addressing environmental problems which do not respect borders and require cooperation (e.g. problems associated with climate change) ● Governance play a major role in ensuring territorial cohesion	**Cooperation:** overcoming division ● Cooperation on implementing EU environmental laws and policy at all levels (national, regional, local); learning from different regions; supporting regions in meeting common environmental standards: this section might encompass the 'traditional' view of environment in territorial cohesion and cohesion policy ● Recognising the importance of natural as well as solely administrative boundaries in territorial governance	● Does the policy encourage a cooperative approach to implementation and learning in relation to meeting environmental standards, and addressing transboundary environmental effects, between and within regions and Member States? ● Does the policy promote the consideration of natural boundaries/ areas (such as river catchments/ basins) as the most appropriate unit to manage certain environmental assets and issues which cut across administrative boundaries?

Source: From EEA (2010).

Annex 2   Analysis of EU policy areas and environmental policies against the environmental dimensions of territorial cohesion

Extracts from the 2010 report follow.

The tables below use the following scoring system for the 'overall assessment' against each of the five elements of the environmental dimensions of territorial cohesion. This is based on a subjective assessment of the degree to which the policy is considered synergistic or conflicting with the potential criteria listed in Annex 1 to evaluate the environmental dimension of territorial cohesion.

☺	Overall potentially synergistic
☺	Overall potentially neutral
☹	Overall potentially conflicting

Table A2.1 Review of the Water Framework Directive against the key elements of the environmental dimensions of territorial cohesion

Elements of the environmental dimensions of territorial cohesion	Policy area: Water Framework Directive	Overall assessment
Harmonious and sustainable development	**Potential synergies** The central aim of the Water Framework Directive is to 'protect and restore clean waters across Europe and ensure its long-term sustainable use'. Article 4(1) of the directive (EC, 2000) includes the target for Member States to achieve good status in all bodies of surface water and groundwater by 2015. A key aspect of the directive is the aim for water services (clean drinking water, irrigation, hydropower, wastewater treatment, etc.) to be charged at a price which fully reflects the services provided. This explicitly recognises the value of clean, sustainably managed water resources as a valuable good/service. By seeking to charge the real cost (including externalities) of water use, the Water Framework Directive implicitly recognises the environmental limits of water resource exploitation. **Potential conflicts** None identified.	☺
Inherent features of territories	**Potential synergies** Fundamental to the Water Framework Directive is the identification of 'water bodies' by Member States. The designation of water bodies should consider the location, physical characteristics and differences, as well as pressures such as extraction and pollution. Inherent in the river-basin–scale management approach is the consideration of interdependencies and relationships between territories. The Water Framework Directive proposal of intercalibration of water ecosystem status across Europe has the stated intention of enabling a common understanding of ecological status given the different nature of water bodies in Member States and regions (e.g. a mountain lake compared to a tidal river). **Potential conflicts** None identified.	☺

Table A2.1 Review of the Water Framework Directive against the key elements of the environmental dimensions of territorial cohesion (cont.)

Elements of the environmental dimensions of territorial cohesion	Policy area: Water Framework Directive	Overall assessment
Concentration	**Potential synergies** The Water Framework Directive requires Member States to designate artificial and heavily modified water bodies, in which good ecological potential will need to be met (differs from good ecological status targeted in other water bodies). Many of these are likely to be within urban areas. The incorporation of economic principles and water pricing in line with environmental services provided is likely to help address some of the water-related environmental pressures associated with higher concentrated development, particularly water pollution, water resource scarcity, etc. **Potential conflicts** None identified.	☺
Connecting territories	**Potential synergies** An explicit and key aspect of the Water Framework Directive is the management of water issues at the river basin scale. This recognises the inherent 'shared' nature of Europe's water resources, rivers, lakes and seas. Implementation of the Water Framework Directive in relation to an international river basin district should be coordinated between those Member States in the district. Understanding and managing interregional and transnational water pollution/extraction will be an important aspect of this cooperative approach. **Potential conflicts** None identified.	☺
Cooperation	**Potential synergies** The consideration of natural boundaries and areas (in the form of river basin districts and water bodies) is a cornerstone of the Water Framework Directive. A cooperative approach to implementation is also a fundamental aspect of implementation of the Water Framework Directive. **Potential conflicts** None identified.	☺

Table A2.2 Review of the Floods Directive against the key elements of the environmental dimensions of territorial cohesion

Elements of the environmental dimensions of territorial cohesion	Policy area: Floods Directive	Overall assessment
Harmonious and sustainable development	**Potential synergies** The Floods Directive (EC, 2007a) requires Member States to assess, map and plan for the management of flood risks in all watercourses and coastal areas in their territory. Flood risk assessment includes risks to the environment, together with human health, cultural heritage and economic activity. Flood risk management plans (to be developed by 2015) should focus on prevention, protection and preparedness. **Potential conflicts** None identified.	☺
Inherent features of territories	**Potential synergies** Flood risk assessment under the directive is required to be undertaken at a river basin district and associated coastal area scale. Coordination is expected with river basin management plans, developed under the Water Framework Directive. Accounting for interdependencies and relationships between territories should be an inherent aspect of environmental management at this scale. The directive calls for flood risk management plans to be periodically reviewed, and if necessary updated to take account of the impacts of climate change on the occurrence of floods (e.g. paragraph 14, Article 4(2), Article 14(4), Article 16). **Potential conflicts** In some cases, flood risk management protection infrastructure may impact upon protected areas/inherent features of territories, although this will depend on implementation in individual Member States (and the intention of the directive is that environmental features will be protected).	☺
Concentration	**Potential synergies** The directive explicitly refers to urban floods (paragraph 10). Flood risks associated with higher urban concentration (increased run-off, reduced attenuation, etc.) are a significant issue in many urban areas. Reducing flood risks may also address other environmental problems associated with urban areas, such as water pollution (by reducing run-off). **Potential conflicts** None identified	☺
Connecting territories	**Potential synergies** See entry under 'Inherent features of territories'. Paragraph 13 of the directive explicitly recognises the territorial connections in relation to flooding (e.g. river corridors, coastal areas, international lakes). It states that 'Member States should refrain from taking measures or engaging in actions which significantly increase the risk of flooding in other Member States, unless these measures have been coordinated and an agreed solution has been found among the Member States concerned'. **Potential conflicts** None identified.	☺

Table A2.2 Review of the Floods Directive against the key elements of the environmental dimensions of territorial cohesion (cont.)

Elements of the environmental dimensions of territorial cohesion	Policy area: Floods Directive	Overall assessment
Cooperation	**Potential synergies** As noted, flood risk assessment and management is required to be at the river basin district and coastal zone level, and the directive explicitly promotes/requires coordinated activity between and within Member States. For example, paragraph 6 of the directive requires coordination between Member States (and cooperation with third countries) in recognition of the UN Convention on the protection and use of transboundary watercourses and international lakes. Flood risk management information exchange is a key aspect of the strategy to support implementation ([39]). **Potential conflicts** None identified.	☺

([39]) See, for example, Promoting early action, Work programme and mandate 2008-2009, Working group F on Floods (as agreed by the water directors, 29–30 November 2007), at http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/floods_programme/wg_f_floods/workprogramme_2008-9/_EN_1.0_&a=d .

Annex 3 Green infrastructure case studies

Sources of information on green infrastructure case studies:

- European Commission Conference on Green Infrastructure implementation Brussels, 19 November 2010. See http://ec.europa.eu/environment/nature/ecosystems/green_infrastructure.htm.

- European Commission Workshop: Towards Green Infrastructure for Europe, Brussels, 25-26 March 2009. See http://green-infrastructure-europe.org/index.php?option=com_content&task=view&id=141&Itemid=335.

- US case studies. See http://www.greeninfrastructure.net/gi_case_studies.

- CABE case studies. See http://www.cabe.org.uk/sustainable-places/green-infrastructure/examples.

- EU LIFE programme. See http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/nat.htm#green.

Other case studies and initiatives:

- **East London Green Grid**, London, United Kingdom. Creation of a network of multifunctional public spaces providing recreational opportunities and responding to serious environmental challenges such as flooding and the need to create the setting for future development. See http://www.cabe.org.uk/case-studies/east-london-green-grid.

- **Quaggy River flood prevention scheme**, London, United Kingdom. A flood prevention scheme for South London's Quaggy River has opened up a culverted river, with public parks and private gardens serving as floodwater storage areas. See http://www.cabe.org.uk/case-studies/quaggy-river.

- **PLUREL — Peri-urban Land Use Relationships — Strategies and Sustainability Assessment Tools for Urban-Rural Linkages**. PLUREL tools help to improve the quality of life of the population living in cities as well as in the peri-urban and rural surroundings by developing sustainable rural-urban land use relationships. See http://www.plurel.net.

- **Natural Forests and mires in the 'Green Belt' of Koillismaa and Kainuu**, Finland. Conservation of forests and mires in 13 Natura 2000 sites that form part of the regional 'green belt' to provide vital stepping stone for species and habitats and to safeguard the favourable conservation status. See http://www.metsa.fi/sivustot/metsa/en/Projects/LifeNatureProjects/GreenBeltLife/Sivut/Introduction.aspx.

- **Conservation and management of the brown bear**, Austria. Improving the ecological connectivity between the habitats of the brown bear and therefore enabling migration and exchanges between populations. Altogether, 19 proposals for green bridge locations at the Austrian highways were put forward as part of this study. See http://ec.europa.eu/environment/life/project/Projects/files/laymanReport/LIFE02_NAT_A_008519_LAYMAN.pdf.

- **BRANCH Project: 'Biodiversity Requires Adaptation in Northwest Europe under a Changing Climate: Final Report'**, Northwest Europe. Helping wildlife to adapt to climate change through spatial land use planning systems and the creation of a landscape and coastline that can withstand the effects of climate change. BRANCH provides the guidance and evidence to take action. See http://webarchive.nationalarchives.gov.uk/20090703091708/http://www.branchproject.org/about.

- **Econnect: restoring the web of life**, including Austria, France, Germany, Italy, Liechtenstein and Switzerland. Protection of biodiversity in the Alps through ecological connectivity across the Alpine range. Particular attention is given to region's high in biodiversity value to establish and increase the links between them and towards other neighbouring ecoregions. See http://www.econnectproject.eu/cms/?q=homepage/en.

Green infrastructure in Ireland. See http://www.comharsdc.ie/themes/index.aspx?TAuto=10.

Additional case study examples

Case study 1: European Green Belt Project (includes Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary Slovakia and Slovenia)

Short description

After World War II, Europe became separated by a gigantic border construction known as the Iron Curtain. The death zone split countries and families and the Iron Curtain divided eastern and western Europe for almost 40 years. In 1989, political change came after a period of demonstrations and political negotiations, and the reunification of Germany and Europe followed.

The only positive outcome of this strongly protected borderline is that nature seized the deserted border areas and a string of beautiful habitats with rare plants and animals evolved. The ecological network, which is rich in diversity of plants and animals, forms a living monument of European history. In November 1989, a first meeting of nature conservationists from east and west was held; participants coined the name 'Green Belt' for the former Inner German border and presented a resolution for its protection. In 2003, the idea of the 'European Green Belt' was born, today the backbone of an ecological network running 8 500 km from the northern tip of Europe to the Black Sea. The route of the Green Belt unveils most impressive and sensitive landscapes and it displays the typical natural flora and fauna of the regions along its course. Hundreds of animal and plant species on the Red List have made their homes in the Green Belt, which creates a unifying link between habitats that are otherwise fragmented in today's cultural landscape.

A lot of local and regional initiatives were introduced to increase the connectivity between Green Belt areas, as well as to encourage sustainable regional development (ecotourism). Cycle and adventure hiking trails, mobile exhibitions, and

Figure A3.1 Green Belt

Green Belt, Rhön, Germany (Photo: K. Leidorf).

The Route of the Green Belt (http://www.euronatur.org/ Green-Belt-Europe.405.0.html)

Educational project in the Green Belt, Slovakia (Photo: R. Slovakia).

educational excursions with schooled Green Belt guides in national parks, biosphere reserves, nature parks and border museums can teach visitors how to find traces of history in the landscape and how to learn from nature without destroying it. Above all, locally, regionally and internationally improved cooperation between transport planning, regional planning, game management, agriculture and forestry, nature conservation and corresponding research is needed. A shared vision for the conservation of biodiversity and the promotion of sustainable regional development remains as the mutual driving force.

Green infrastructure benefits provided

- various habitats for species;
- permeability for migrating species such as wolves, bears, lynx, or amphibians and birds;
- a living monument of European history;
- tourism opportunities;
- opportunities for social cross-border interactions.

Link to the key elements of territorial cohesion, including the environmental dimensions

- **Harmonious development:** The European Green Belt project is achieving sustainable development at regional and local levels. It has grown to be a formidable marketing instrument for protected and non-protected areas in border regions and for the people that try to find strategic synergies with important economic goals, for example natural and cultural landscapes as an asset in tourism marketing. Transboundary cooperation in regional development and the securing of resources will help to conserve and develop functioning natural and cultural landscapes of European significance.

- **Inherent features of territories:** The green belt is a living monument of European history and therefore various habitats and natural capital will be protected for future generations.

- **Concentration (overcoming differences in density):** Almost 40 years of cutting off contacts between developing processes has shown how land use changed. Nature seized the deserted border areas while nearby intensification occurred. Today a string of beautiful habitats with rare plants and animals connects Europe's landscapes and forms a living monument of European land use history.

- **Connecting territories:** The project increases ecological connectivity between various habitats at landscape level, especially by way of legal protection. The European Green Belt contributes — because of its history — not only to the understanding between eastern and western states (long standing and new EU states as well as candidate countries) but it can also make the request for nature conservation clear for a broad, international public.

- **Cooperation:** The project has partners in many states along the route. The following should be mentioned: International Union for Conservation of Nature (IUCN), German Federal Agency for Nature Conservation, The European Nature Heritage Fund (EuroNatur), Friends of the Earth Germany.

> **Further information:**
>
> See http://www.euronatur.org/Green-Belt-Europe.405.0.html.
>
> See http://www.greenbelteurope.eu.

Case study 2: Dutch nature conservation organisations. More Nature and Dry Feet: Climate buffers for a safer and more beautiful country

An example of delivering the objectives of EU territorial cohesion by providing climate change adaptation and other benefits through green infrastructure.

Short description

Six Dutch nature conservation bodies have produced a strategy that seeks to redress the over-reliance on engineered (grey) infrastructure. It is suggested that these engineered systems are not suitable for the significant challenges that climate change presents for the Netherlands; they have reduced the ability for natural and spontaneous adaptation.

The paper highlights the examples of climate buffers in four 'typical' Dutch landscapes describing the benefits such buffers provide and the need to expand their coverage. In addition to the adaptation benefits, the paper suggests that green infrastructure can deliver multiple benefits and as such represents a low risk option in the face of the uncertainty surrouding climate change. The international benefits of natural climate buffers are also described

as is the potential beneficial relationship of climate buffers with the Dutch National Ecological Network.

Green infrastructure benefits provided

- improving habitats' resilience to climate change;
- flood protection and attenuation;
- improving water quality;
- providing recreational areas;
- habitat creation;
- providing migration facilities for climate migrants;
- water retention.

Link to the key elements of territorial cohesion, including the environmental dimensions

- **Harmonious development:** the paper indicates the potential economic benefits of increased areas of high-quality recreation and sympathetic waterside development as well as the low risk that natural climate buffers present when compared to engineered measures. In addition, it recognises that climate change will have negative economic and social impacts within Europe and the Netherlands and that increasing natural resilience can support socio-economic development.

- **Inherent features of territories:** the paper makes clear links to the specific types of landscapes and habitats present in the Netherlands and the benefits of expanding these to provide climate buffers. The Netherlands has unique delta, marsh and estuarine habitats, and the paper aims to enhance and restore these by demonstrating the range of benefits they offer.

- **Concentration (overcoming differences in density):** providing areas that attenuate flooding reduces the environmental and health problems related to population concentration, such as water pollution and increased flood risk. The paper also aims to improve the Netherlands' resilience to climate change and reduce the risk to populated areas.

- **Connecting territories:** By highlighting the international importance of climate buffers to migrating bird species and specifically to 'climate migrants' from southern Europe and Africa, the paper explicitly recognises the connected nature of the Dutch territory. This is also considered when describing the Netherlands as the 'drain of Europe' in relation to international water flow.

- **Cooperation:** The paper focuses on what the Netherlands can do to provide climate buffers but also recognises the international element and effect these measure are likely to have.

Further information:

More Nature and Dry Feet, see http://www.eeb.org/?LinkServID=5019A14F-E59D-1888-F461BA0820CA8DF7&showMeta=0.
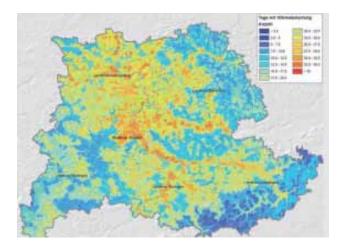
Case study 3: Urban Heat island management in Stuttgart (Germany)

Short description

Stuttgart's centre is situated in the Keuper sink (roughly 240 m above sea level), which is almost completely surrounded by mountain ranges reaching up to 500 m. There is only one opening in the north-east to the wide Neckar valley. This position has a significant influence on such climatic elements as radiation, temperature, humidity, precipitation and especially low winds. Stuttgart's climate is mild with an average annual temperature of about 10 °C (50 °F) and it is one of the warmest places in Germany. The city centre has an annual average of 70 frost days and 40 to 47 summer days. By comparison, in Greater Stuttgart (e.g. the Filder region) there are 91 to 94 frost days and 28 to 32 summer days. Such significantly warmer conditions in metropolitan areas have led to these becoming known as heat islands.

To attenuate heat stress, climate-based planning has been carried out since 1938. At that time, urban climatology became a discipline within the state capital, and a great deal of vital information for precise planning has been generated and planned so as to exploit the role of natural wind patterns and dense vegetation, in order to better reduce problems of overheating and air pollution. Based on a Climate Atlas, a number of planning and zoning regulations are recommended. These aim to preserve open spaces with more or less important climatic activities and to increase the presence of vegetation in densely built-up areas. A series of wind paths have been designated across the city that allow cooler mountain air to flow into the heart of the conurbation. No new building is allowed in an area designated as part of a wind path, especially in the hills around the town. In addition, the felling of trees of a certain size in inner city areas is banned, and as a result, greenery covers more than 60 % of the city. The planning recommendations build on the legislative framework of the German Building Code and other national, regional and locally developed regulations.

Figure A3.2 Urban heat management in Greater Stuttgart

Heat Stress in the Stuttgart Region today: Days with heat stress. © Verband Region Stuttgart.

Cold air down-flow along the ventilation axis left free of buildings at Stuttgart-Vaihingen (City of Stuttgart).

Green infrastructure benefits provided:

- urban heat island management — reducing vulnerability to excess heat in city districts by ensuring an adequate influx of cold air;
- air hygiene by means of fresh air;
- improvement of quality of life — reducing heat stress;
- local recreational areas offer relaxation and recuperation within easy reach;
- areas of vegetation bind carbon dioxide;
the percolation, retention and reformation of groundwater in sealed areas.

Link to the key elements of territorial cohesion, including the environmental dimensions

- Harmonious development: The high percentage of green infrastructure (parks, gardens) and its maintenance and expansion in Stuttgart help to improve the cohabitation of people in densely populated urban conurbations. High air quality and green areas are utilised as goods and services. Thus any limits on urban cold air circulation could be an inhibiting factor on economic growth.

- Inherent features of territories: The state capitals' regulations achieve various benefits to ameliorate living conditions in the dense inner city of Stuttgart while allowing ongoing urban development.

- Concentration (overcoming differences in density): Maintenance and expansion of open green space in Stuttgart like wind paths promote air exchange and are effective climate change adoption measures.

- Connecting territories: The city-wide urban development concept for preservation of areas of relevance for cold air generation strengthens and emphasises the interdependence of urban-rural ties through the ways in which the fresh mountain air of the surrounding districts is channelled into the heat islands of the metropolitan areas.

- Cooperation: Close collaboration between the Office for Environmental Protection (analysis of information, provision of recommendations) and the City Planning and Renewal team means that the recommended green infrastructure solutions are being implemented through spatial planning and development control. Delivering green infrastructure through spatial planning systems.

Further information:

State Capital Stuttgart, 2010. *Climate change — challenge facing urban climatology.*

See http://www.stadtklima-stuttgart.de.

See http://grabs-eu.org.

See http://www.cabe.org.uk/sustainable-places/examples/stuttgart.

Annex 4 Integration of green infrastructure into other policies (examples)

Case study: Combining LIFE funds and CAP subsidies for establishing long-term protection of _Crex Crex_ in Slovenia
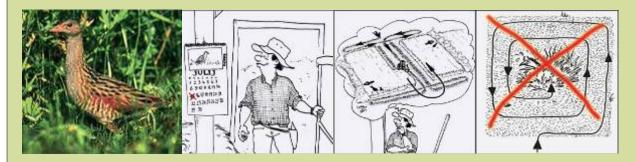
An example of employment of both direct and indirect funding to promote multifunctional farm land, crucial for long-term protection of _C. Crex_ and other bird species in Slovenia.

Short description

LIFE funded a comprehensive survey on habitats of an endangered bird, the Corncrake (_C. Crex_). The acquired specialist knowledge was then used to develop guidelines for direct management of low-input wet meadows. The guidelines were focused on employing specific timing and ways of cutting grass, as well as on leaving particular areas uncut or not cleaned. These measures will allow for the long-term survival of the species.

The LIFE budget was further employed in engagement and education of farmers. Parallel efforts went into recognition of such practices as one of the numerous accreditations for CAP agro-environmental subsidies (Ministry of Agriculture, Forestry and Food of Republic of Slovenia, 2010). Farmers were then instructed on how to apply for these subsidies, ensuring the newly established practices would be continuously encouraged.

Figure A4.1 The _Crex Crex_ in Slovenia

Green infrastructure benefits provided

Added benefit of providing a habitat for a specialist species on what would otherwise be crop production land only.
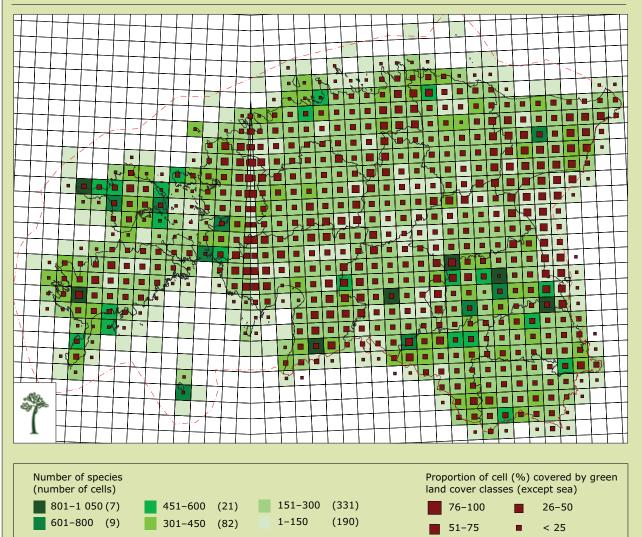
Further information:

BirdLife Slovenia (2010) _LIFE kosec (crex crex)_. See http://www.life-kosec.org/index_en.php?idve=1.

Case study: Distribution of Estonian Biodiversity in 2010

Short description

The maps below are from a map collection on "Distribution of Estonian Biodiversity in 2010", which the Estonian Environment Information Centre Nature Conservation Department compiled from August 2010 to May 2011. The maps show species distribution and the collection includes data from the Estonian main databases and distribution atlases as of September 2010. The maps don't show real species distribution in Estonia but only the part that were entered in databases and distribution atlases. The main goal was to analyse the data from main databases and distribution atlases and compile these in a map collection showing "distribution of Estonian biodiversity in 2010". This was to explore how much or little data that is available in Estonia for public analysis. The databases were: Estonian Environment Register, Estonian Nature Information System (EELIS), Estonian Nature Observation Database, eBiodiversity.

Map A.4.1 Estonian species diversity (data from distribution atlas of Estonian plants are not included) and percentage of natural land cover classes in UTM cells.
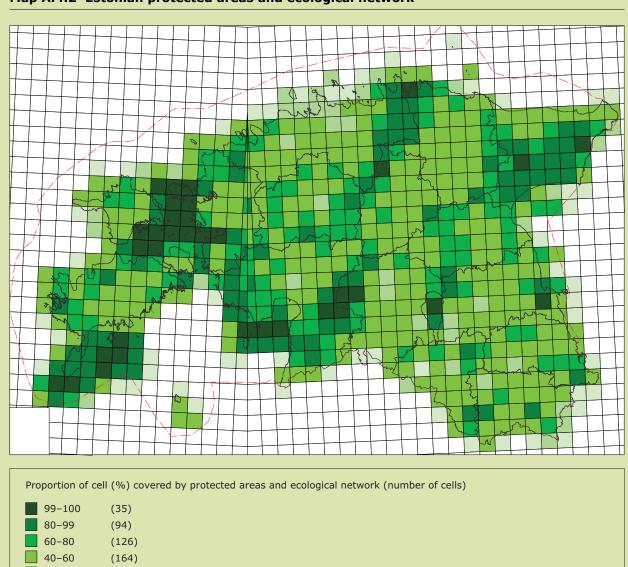

Number of species (number of cells)			Proportion of cell (%) covered by green land cover classes (except sea)	
801–1 050 (7)	451–600 (21)	151–300 (331)	76–100	26–50
601–800 (9)	301–450 (82)	1–150 (190)	51–75	< 25

Source: Estonian Environment Information Centre Nature Conservation Department.

The above map show two components:
- Green colour demonstrates number of species in the cell. Number in brackets shows how many cells have that tone.
- Size of brown rectangle shows proportion of cell covered by green land cover classes (% of cell area). Land cover classes are from Corine Land Cover database 2006, but the following areas were eliminated: artificial surfaces, agricultural land, parks and gardens and sea (Sea was eliminated as it covers many of the cells 100% and is hence visible anyway on the map).

The brown rectangles in Map A.4.1 are the largest natural areas from northern coast diagonally to south-west corner and north-east Estonia surrounded by Lake Peipsi from south and the oil shale production area from the north side. The above map does not include data from distribution atlas of plants as the plants' atlas uses another grid and the location coordinates are not available.

Map A.4.2 Estonian protected areas and ecological network

Proportion of cell (%) covered by protected areas and ecological network (number of cells)

■	99–100	(35)
■	80–99	(94)
■	60–80	(126)
■	40–60	(164)
■	20–40	(131)
□	10–20	(38)
□	0.01–10	(52)

Source: Estonian Environment Register (protected areas) and counties planning (ecological network).

The above map shows proportion of cell covered by protected areas and ecological network. Number in brackets shows how many cells that have a tone. The data is from the Estonian Environment Register (protected areas) and counties planning (ecological network). Here it is possible to see the largest natural areas from the northern coast diagonally to the south-west corner and the north-east Estonia surrounded Lake Peipsi from south and the oil shale production area from the north side. Additionally darker cells are on sea areas like Gulf of Pärnu, southern coast of Saaremaa and Väinameri (which is part of the Baltic sea between West-Estonian islands and Estonian mainland). There are large Natura 2000 sites.

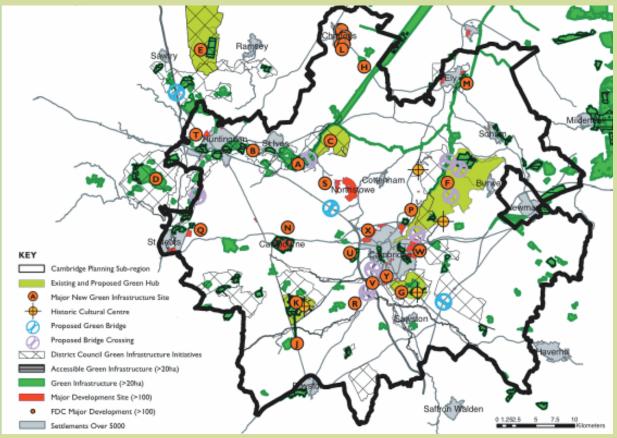**Case study: Green Infrastructure Strategy for Cambridge**

An example of a spatial plan incorporating green infrastructure (for a city/town): main contents, What tools were used for its development? How is it implemented?

Short description

The strategy sets out to bring together existing data on green infrastructure sites and map out existing green space provision, and compares that to the future green space needs of the growing population in the region for the next 20 years. It then identifies key issues in biodiversity, landscape and rights of way and measures, and proposes an implementation strategy to address them. It recommends options for funding and longer-term management and maintenance of any future assets created.

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Further information:

Cambridgeshire Horizons, 2010, *Green Infrastructure strategy*.

See http://www.cambridgeshire.gov.uk/NR/rdonlyres/DFC9B030-E462-47B4-8365-12454D0B01AC/0/GreenInfrastructureStrategy.pdf.

Case study: Green Infrastructure North West (England)

An example of delivering the objectives of EU territorial cohesion using green infrastructure to improve adaptation to climate change and green space provision through spatial planning and knowledge transfer.

Short description

The United Kingdom and England in particular has had a decentralised and regional focus on the delivery of green infrastructure. For instance, the government body of the North West has a series of strategically coordinated activities relevant to green infrastructure that are designed to inform civil society, city and local authorities.

This is managed as part of the region's climate change action plan, supported by the ERDF. The region's process has been to provide an evidence base in the form of a report which highlights the role and importance of green infrastructure in mitigating and adapting to climate change; undertaking specific project examples and the production of a green infrastructure action plan (currently undergoing consultation) for the implementation of green infrastructure within the region.

The evidence report provides maps of ecosystem services in the region, the aim being to provide an evidence base to provide information on other bodies' decisions. These maps include stakeholder prioritisation of the importance of ecosystem services in the regions. In addition, an action plan is under consultation which describes the possible actions that can be implemented by individuals and organisations from the local to regional scale. Specific case studies are presented to inform the actions and provide exemplars of what can be done.

The green infrastructure action plan consultation document aims to incorporate the public's views to provide further information as to the priority order of the ecosystem services provided by green infrastructure, as well as to describe future development of the programme. A number of the actions require the identification of a suitable **champion** to implement and promote the concept; this is part of an awareness raising exercise to better integrate green infrastructure into relevant decision-making processes. Spatial planning was identified as the most relevant forum to promote green infrastructure, and efforts were made to incorporate green infrastructure and the findings from the evidence into the regional spatial plan.

In addition, Green Infrastructure North West was set up to implement specific projects at both the urban and landscape scale to provide proof of concept and support the integration of green infrastructure.

Green infrastructure benefits provided:

- climate change adaptation
- flood protection and attenuation
- food
- energy
- carbon storage and sequestration.

Subregional areas of ecosystem service provision and their ranking against importance.I Importance is determined by the opinions of a range of organisations from the North-West who participated in the consultation exercise (from left to right, the areas are Merseyside, Cheshire, Cumbria, Greater Manchester and Lancashire). The key is thematic with light blue describing the least 'important' areas and the dark red the most 'important'.

Source: North West Climate Change — Green Infrastructure evidence base

Further information:

North West Climate Change — Green infrastructure evidence base and action plan

See http://www.greeninfrastructurenw.co.uk/climatechange.

Green Infrastructure North West website, for examples of projects:

See http://www.greeninfrastructurenw.co.uk/html/index.php?page=index.

Case study: Wareham Managed Re-alignment (United Kingdom) — Green infrastructure in environmental assessment

An example of delivering the objectives of EU territorial cohesion through green infrastructure and environmental assessment.

Short description:

Environmental assessment in general and EIA/SEA in particular are key tools in ensuring that the environment is incorporated into decision-making in Europe. To date there are very few examples of the application of green infrastructure in assessment. One example is work undertaken for the Environment Agency for England and Wales to provide an approach for incorporating the economic values of green infrastructure related to flood and coastal management into traditional forms of assessment.

These guidelines suggest that, supported by the EIA/SEA, it is possible to provide economic values for the environment that can be incorporated into traditional cost–benefit analyses. The guidance suggests an initial investigation of the economic value information available, followed (where appropriate) by value transfer produced quantified economic information. What this study suggests is that the EIA/SEA can be supplemented where appropriate by the economic valuation of green infrastructure.

This was applied to a flood and coastal erosion project, the Wareham Managed Re-alignment. This study demonstrated certain barriers, specifically uncertainty and complexity, to the use of valuing green infrastructure in assessment. For instance, there was found to be significant uncertainty surrounding the absolute value of the environment due to the uncertain nature of the physical changes and the socio-economic context that determines the value of these. This suggested that absolute values may not be that relevant, rather it would be more feasible to assess the relative magnitude of changes across different options to ascertain which delivered the most ecosystem services. This was carried out within the project and was considered to provide a useful analysis as to which of the options would have the least environmental impact.

In addition, the case study found that decisions had to be made on the cost effectiveness and appropriateness of valuation in the policy context, i.e. whether this level of detail was the one required, and whether the results be suitably '**robust**'.

The project identified some specific policy benefits. For instance, the project provided support for the public expenditure of funds on a scheme which without the inclusion of green infrastructure benefits may appear to have low cost–benefit ratios, thereby removing funding hurdles for projects related to green infrastructure.

Green infrastructure benefits provided:

- focus on flood retention and attenuation;
- adaptation to climate change;
- the full range of ecosystem-services were considered in the valuation exercise as per the Millennium Ecosystem Assessment.

Location plan and map and key of existing habitats and flood compartments. Contains Environment Agency information © Environment Agency and database right.

Source: Eftec, 2010.

Further information:

Defra, 2009, *An introductory guide to valuing ecosystem services*. (Case study from page 49).

See http://www.defra.gov.uk/environment/policy/natural-environ/documents/eco-valuing.pdf.

Eftec, 2010,
Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects.

See http://publications.environment-agency.gov.uk/pdf/GEHO0310BSFH-e-e.pdf.

Slootweg, R. and van Beukering, P., 2008, *Valuation of Ecosystem Services and Strategic Environmental Assessment. Lessons from Influential Cases*.

See http://www.cbd.int/impact/case-studies/cs-impact-nl-sea-valuation-en.pdf.

Annex 5 Abbreviations

CAP	Common Agricultural Policy
CBD	Conference of the Parties of the Convention on Biological Diversity
CDDA	Common Database on Designated Areas
CEP	Collingwood Environmental Planning
CHP	Combined heat and power
COP	Conference of the Parties
CORILIS	Methodology developed for land cover data generalisation and analysis
Corine	Coordination of information on the environment
CTRL	Channel Tunnel Rail Link
DG	Directorate-General
EC	European Commission
ECOTONE	Transition area between two adjacent but different plant communities, such as forest and grassland
ECRINS	European catchments and Rivers Network System
EEA	European Environment Agency
EEAC	European Environment and Sustainable Development Advisory Councils
EEB	European Environmental Bureau
EIA	Environmental Impact Assessment
EIB	European Investment Bank
Eionet	European Environment Information and Observation Network
EnZs	Environmental Zones
EPA	Environmental Protection Agency
ERDF	European Regional Development Fund
ES	Ecosystem services

ESD	European Spatial Development
ESDP	European Spatial Development Perspective
ESF	European Social Fund
ESPON	European Spatial Planning Observation Network
ETC-LUSI	European Topic Centre on Land Use and Spatial Information
EU	European Union
FGCC	Florida Greenways Coordinating Council
FTSP	Fast Track Service Precursor
GBLI	Green Background Landscape Index
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIA	Green Infrastructure Assessment
GIS	Geographical Information System
HNV	High Nature Value
IAS	Invasive Alien Species
ICW	Integrated Constructed Wetland
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale
JRC	Joint Research Centre
LARCH	Landscape Assessment using Rules for Configuration of Habitat
LIFE	European Union's funding instrument for the environment
LUZ	Large urban Zone
MEA	Millennium Ecosystem Assessment
MEFF	Effective Mesh Size
N2000	Natura 2000
NEN	National Ecological Network
NGO	Non-governmental organisation
NLEP	Net Landscape Ecological Potential
NUTS	Nomenclature of Units for Territorial Statistics
PEBLDS	Pan-European Biological and Landscape Diversity Strategy

PEEN	Pan-European Ecological Network
PESERA	Pan-European Soil Erosion Risk Assessment
PLUREL	Peri-urban Land Use Relationships — Strategies and Sustainability Assessment Tools for Urban-Rural Linkages
PM_{10}	Particulate matter < 10 μm
RBMP	River Basin Management Plan
REC	Regional Environmental Characterisation
SEA	Strategic Environmental Assessment
SEI	Stockholm Environment Institute
STELLA	STELLA is a flexible computer modelling package with an easy, intuitive interface that allows users to construct dynamic models that realistically simulate biological systems
SOER	'State of the environment' report
TEN	Transport, Energy and Telecommunication
TEN-T	Trans-European Transport Network
TEEB	The Economics of Ecosystems and Biodiversity
UBA-AT	Umweltbundesamt (Environment Agency Austria)
US EPA	United States Environmental Protection Agency
UMZ	Urban Morphological Zone
UNDP	United Nations Development Programme
WISE	Water Information System for Europe

European Environment Agency

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