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A spatial assessment of ecosystem services in Europe: Methods, case studies and policy analysis - phase 2

Synthesis report

Joachim Maes, Jennifer Hauck, Maria Luisa Paracchini, Outi Ratamäki, Mette Termansen, Marta Perez-Soba, Leena Kopperoinen, Katri Rankinen, Jan Philipp Schägner, Peter Henrys, Iwona Cisowska, Marianne Zandersen, Kurt Jax, Alessandra La Notte, Niko Leikola, Eija Pouta, Simon Smart, Berit Hasler, Tuija Lankia, Hans Estrup Andersen, Carlo Lavalle, Tommer Vermaas, Mohammed Hussen Alemu, Paul Scholefield, Filipe Batista, Richard Pywell, Mike Hutchins, Morten Blemmer, Anders Fonnesbech-Wulff, Adam J. Vanbergen, Bernd Münier, Claudia Baranzelli, David Roy, Vincent Thieu, Grazia Zulian, Mikko Kuussaari, Hans Thodsen, Eeva-Liisa Alanen, Benis Egoh, Peter Borgen Sørensen, Leon Braat, Giovanni Bidoglio

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Contents

Summary

Mainstreaming ecosystem services in EU decision making processes requires a solid conceptual and methodological framework for mapping and assessing ecosystem services that serve the multiple objectives addressed by policies. The PRESS-2 study (PEER Research on EcoSystem Services – Phase 2) provides such an analytical framework which enables the operationalization of the present scientific knowledge base of environmental data and models for application by the EU and Member States for mapping and assessment of ecosystem services. This study is structured along three strands of work: policy and scenario analysis, mapping and valuation. Linking maps of ecosystem services supply to monetary valuation allows an analysis of the expected impact of policy measures on benefits derived from ecosystem services.

The first case study looks at water purification and demonstrates the three-step assessment cycle, investigating the impacts of agricultural and water policy scenarios on the capacity of ecosystems to purify water and on the benefits that are derived from improved water quality at different spatial scales. In general, the conclusion is that greening the CAP, would improve water quality and increase the benefits to society as measured via monetary valuation. Yet, reduction rates differed between the different levels (EU and basin scale) suggesting that the assessment of policy measures is scale-dependent, which, in turn, justifies our multi-scale assessment approach.

The second case study (recreation) presents evidence that millions of people visited forests several times per year and they expressed their willingness to pay to continue doing so. The visitor statistics that are used in this study confirm the usefulness of the ROS approach (Recreation Opportunity Spectrum) to identify areas in terms of their accessibility and potential to provide recreation services. In addition, PRESS-2 presents a spatial analysis of city population density and green urban areas.

The third case study regards pollination. Pollination services offered by insects such as wild bees and bumblebees are essential to maintain crop production, in particular of fruits and vegetables. PRESS-2 demonstrates that the coverage and resolution of current datasets are already sufficient to map the potential of ecosystems to provide this ecosystem service. However, future research should contribute to better ecological observations of key pollinator species to include important drivers of pollinators abundance in modelling and mapping approaches.

Europe has ambitious biodiversity and ecosystem services targets. Much of the ambition incorporated in the targets rests on the premise that ecosystem services are dependent on biodiversity for which there is indeed a substantial amount of evidence. Achieving biodiversity targets requires prioritizing investments and making them cost effective based on a sound knowledge base and assessment methods, which PRESS has contributed to. Our approaches show that the inclusion of the ecosystem services concept into policies would allow a systematic review of the consequences of policy measures for services beyond conventional environmental assessments. In order to be able to react and adapt to new circumstances, consequences of policies must be continuously monitored and flexible in design. Therefore, it is necessary to quantify goals and determine baseline levels describing what the situation was before the measure against which progress is verifiable. However, research is only one element of the necessary efforts to restore natural ecosystems and to preserve biodiversity in Europe. Therefore, the PRESS-2 team reiterates the conclusion of the first report and calls for a broad collaboration of all stakeholders involved, including researchers, policy makers, stakeholder groups and citizens, in an integrated ecosystem services approach.

1. Introduction

The policy context

The concept of ecosystem services (ESS) is now integrated in current biodiversity policies at global and European level (CBD 2010; EC 2011a). The policies describe how ecosystems and biodiversity are to be incorporated into public and business decision making, and indicate where natural resources are currently undervalued, and sometimes neglected. The inclusion of ESS into biodiversity policies is largely the result of the Millennium Ecosystem Assessment (MA 2005) and the TEEB initiative (The Economics of Ecosystems and Biodiversity 2010a,b). These studies have led to political acknowledgement (at the level of the United Nations) of the concept of ESS and advocate for a better understanding of the links between biodiversity, ecosystem functions, ecosystem services, their benefits and associated social and economic values as part of human well-being.

In particular, the EU Biodiversity Strategy to 2020 (EC 2011a) integrates the sustainable use of ecosystem services as underpinning element of human economies which complements the non-utilitarian conservation approach to biodiversity, thus contributing to the Europe 2020 targets[1], in particular through the "resource efficiency" flagship initiative[2]. This initiative aims at building smart, sustainable and inclusive growth for Europe. It establishes resource efficiency as the guiding principle for EU policies on energy, transport, climate change, industry, commodities, agriculture, fisheries, biodiversity and regional development. In addition, the ecosystem service concept has been identified as one of the pillars of the assessment of impacts in the preparation of the 2012 European Commission's Blueprint to Safeguard Europe's Water Resources (EC 2012). Furthermore, restoring and preserving ecosystem services is one of six priorities identified by the rural development pillar in the new proposal for the EU's Common Agricultural Policy (EC 2011i). Importantly, the EU's regional and cohesion policy now recognizes the importance of investing in natural ecosystems as a source of economic development aligning regional development targets with the Europe 2020 agenda (EC 2011j).

Much of the ambition incorporated in the targets and actions of the EU Biodiversity Strategy to 2020 rests on the premise that ecosystem services are dependent on biodiversity. And there is indeed a substantial amount of evidence demonstrating the dependency of "specific" ecosystem services on "specific" aspects of biodiversity. However, there is still much to be researched and validated, both at the experimental level and at the field observation and measurement level (see e.g. Cardinale et al., 2012). Much of the discussion on the relationships between biodiversity, ecosystem functions and ecosystem services is confused because the relationships are considered at the level of these so-called container concepts. Attempts to depict such relationships end up as a cloud of dots in a scatter plot. Another part of the confusion stems from the often undisclosed assumption that biodiversity is best represented by species richness, and subsequently sufficiently represented by aboveground species only, and then mostly vertebrates.

In Braat and Ten Brink (2008) it was suggested that "mean species abundance" of a cross section of species of the ecosystem considered could usefully represent its potential to provide ecosystem services,

1 http://ec.europa.eu/europe2020/targets/eu-targets/index_en.htm

2 http://ec.europa.eu/resource-efficient-europe/

with provisioning services having often only one, and occasionally a few, targeted species above-ground determining the service levels, and the associated economic values. But of course hundreds, if not thousands of species, did their work, usually not recognized, below the surface (insects, nematodes, fungi, bacteria). The regulating services are by definition dependent on the functional dimensions of ecosystems, and thus on the biological diversity of functional traits, and on key species in production and recycling, and in providing structure and spatial heterogeneity. Finally, species richness is of course a very important element of the cultural services, both as visible diversity components in space and through time, and as identifiable carriers of useful information, the common denominator of this class of services. Some of these contentions have been substantiated by now (see Maes et al., 2012), others are still being tested.

When mapping ecosystem services, the definition of the service flow, its source stock and production process, the choice of indicators, and by that the "visualisation" of the aspects of biological diversity of the service producing system will have to become part of the meta-data of the maps (and possibly in the legend). This is a still a major endeavour for most ecosystem services!

In the recent past it has become more evident to policy makers that nature-based solutions for social and economic problems and challenges, e.g. using wetland ecosystems for water purification, flood protection or carbon storage, may indeed be more cost-effective and resource efficient than technical infrastructures for enhancing resilience. Taking into consideration a probable future of decreasing resource availability in Europe and worldwide, the protection of the flow of services provided by ecosystems would contribute to delivering a sustainable, low carbon society and help progress towards the Europe 2020 targets on climate and energy. Assimilation of the ecosystem service concept calls for the economic valuation of ecosystem services and for a transparent incorporation into policy processes and decision-making. This implies placing ecosystems and biodiversity at the centre of sectoral policies, integrating them into the spatial planning of water and land, and making explicit the costs of ecosystem service degradation and biodiversity loss as well as the benefits from conservation and sustainable use of natural resources.

The PRESS study

Mainstreaming natural capital and ecosystem services into policy and decision making requires a scientifically sound knowledge base, which should provide a better understanding of the complex consequences of decision making of the private and public sector at different geographical policy levels. Furthermore, a better understanding is needed of the ecological production functions and their specific relationships with aspects of biodiversity, which are at the basis of ecosystem services. The PRESS (PEER Research on EcoSystem Services) project was conceived during the TEEB meetings in 2009 and started in early 2010 to contribute to this knowledge base by advancing methods to map, assess and valuate ecosystem services at multiple spatial scales[3]. The project has addressed some of the knowledge gaps which stand in the way of performing a spatially-explicit, biophysical, monetary and policy assessment of ecosystem services. The focus has been on Europe, the Member States of the EU and sub-national regions. The starting point was the need to upgrade the knowledge base on land-use mapping to reflect the existing knowledge about ecosystem services and their social and economic values, and to better inform policy design and decision making processes.

3 PEER is the Partnership for European Environmental Research, a network of Institutes which includes Alterra Wageningen UR (the Netherlands), CEH (U.K.), Irstea (France), DCE – Danish Centre for Environment and Energy at Aarhus University (Denmark), SYKE (Finland), Helmoltz Centre for Environmental Research – UFZ (Germany) and the European Commission's JRC-IES

In the PRESS-phase 1 report (Maes et al. 2011) we demonstrated methodologies to map ecosystem services. In particular, this report delivered models for mapping at different spatial scales the role of ecosystems as providers of recreation to citizens and the function of river networks in providing clean water. It demonstrated how the introduction of ecosystem services into biodiversity policy has resulted in synergies and trade-offs with other policies regulating agriculture, fisheries or forestry, each of which has strong impacts on biodiversity and conservation. The report includes an analysis of policy options, which shows that the perception of which services are provided by ecosystems varies according to the respondents, the geographical characteristics of the regions and the scales of decision making. This suggests then the type of assessment that territorial managers need to carry out. Finally, we pointed to the need for the development of hierarchical sets of ecosystem service indicators, following the SEBI-2010 example (Streamlining European Biodiversity Indicators; EEA, 2010), but geographically explicit and linked to the EU Biodiversity Strategy 2011-2020, and in particular the supporting Action 5 (under Target 2) which calls on the EU Member States to map, assess and value ecosystem services on their national territory.

Outline of the PRESS Phase 2 Synthesis report

This Synthesis report contains the results of the second phase of the PRESS project which has extended the mapping and policy analysis with scenarios and monetary valuation.

Water purification (chapter 2) relates to the role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water, and the assimilation and detoxification of compounds through sediment, soil and subsoil processes. In particular, this case study examines how scenarios of land use change (as a result of a change in agricultural policy) and of river and wetland restoration affect the biophysical flow and the monetary value of this service.

Both natural and managed ecosystems provide a source of *outdoor recreation* as people enjoy walking in forests, watching birds in wetlands or hiking and camping in the outdoors. The recreation case study (chapter 3) builds on maps that express the recreation opportunity spectrum which combines recreation potential with accessibility to sites. The case study explores a scenario of expected demographic changes and makes an assessment of the service flows.

Pollination services are mainly delivered by bees and bumblebees when transferring pollen between flower parts increasing the probability of fertilization. Many crops are, to various degrees, dependent on pollination to produce fruits. This case study (chapter 4) quantifies the relative abundance of pollinators and estimates the contribution of ecosystems to crop pollination.

A literature based *policy analysis* (chapter 5) explores how EU policies and their implications at Member State and local level affect the supply of ecosystem services or may lead to trade-offs.

With these three case studies and the policy analysis we aim to illustrate how current knowledge and data on land cover, water resources, ecosystem properties, nutrient dynamics and climate can be combined to estimate biophysical flows of ecosystem services and their associated benefits and social and economic values. It is important to note that when we refer to biodiversity in this report, we do not only mean species richness, but do imply all functional and structural aspects of the biological diversity of the ecosystem discussed. As such, the PRESS project contributes to on-going initiatives that aim to increase our knowledge on ecosystems and to integrate them into the common implementation framework (CIF) of the EU Biodiversity Strategy to 2020.

This Synthesis report of the main results and achievements of this study is accompanied by a Technical report which presents and documents the different approaches and methodologies that have been used and reports extensively on the results.

2 Mapping and assessment of water purification services at multiple spatial scales

Policy messages

Water purification is a crucial ecosystem service as the self-cleaning capacity of wetlands, rivers, streams and lakes results in the provision of clean water for multiple uses. This service averts costs for society, since the treatment of mainly diffuse pollution is difficult using technological solutions only.

The water purification study demonstrates the full assessment cycle by investigating the impacts of agricultural and water policy scenarios on the capacity of ecosystems to purify water and on the benefits that are derived from improved water quality at different spatial scales.

Biodiversity cleans streams: the more biodiversity a river holds, the faster nitrogen is removed from the water (Cardinale, 2011). Although this PRESS study was not able to upscale this experimentally derived observation to the scale of river catchments, biodiversity was considered at ecosystem level, since the high nitrogen removal rates of wetlands are accounted for in the models.

The scenarios of greening of the Common Agricultural Policy, introducing measures to reduce fertilizer application and the restoration of wetlands, resulted in positive effects on water purification services, improved water quality and increased the benefits to society as measured via monetary valuation.

Yet, reduction rates differed between the different levels (EU and basin scale) suggesting that the assessment of policy measures is scale-dependent, which in turn justifies our multi-scale assessment approach.

Introduction

Freshwater aquatic ecosystems, and more specifically the biotic communities in lakes, rivers and floodplains, interacting with the waterlogged soils, have the capacity to retain, process and remove pollutants, sediments and excess nutrients. This water purification service reduces the quantity of pollutants of downstream waters and more importantly to the human settlements in the region, it contributes to the availability of clean water for multiples uses.

In this chapter, we present four case studies which cover different spatial scales to illustrate how benefits from water purification services can be accounted for using nitrogen as a common water quality indicator (Figure 2.1).

The starting point of the assessment is a policy change with a focus on the new Common Agricultural Policy (CAP; EC 2011i) and on a new water policy at EU scale (Blueprint to Safeguard Europe's Water

Resources; EC 2012). A number of specific policy measures (greening measures under the CAP, nitrogen reduction measures and river and wetland restoration) were analysed using scenarios of land use change as a consequence of the policy measures relative to a baseline. Biophysical models were used to estimate how changing land use affected water purification as indicated by nitrogen retention. Finally, the economic value of the improved water quality, due to the nitrogen removal, was assessed via costs saved for downstream water treatment and by willingness to pay for clean water.

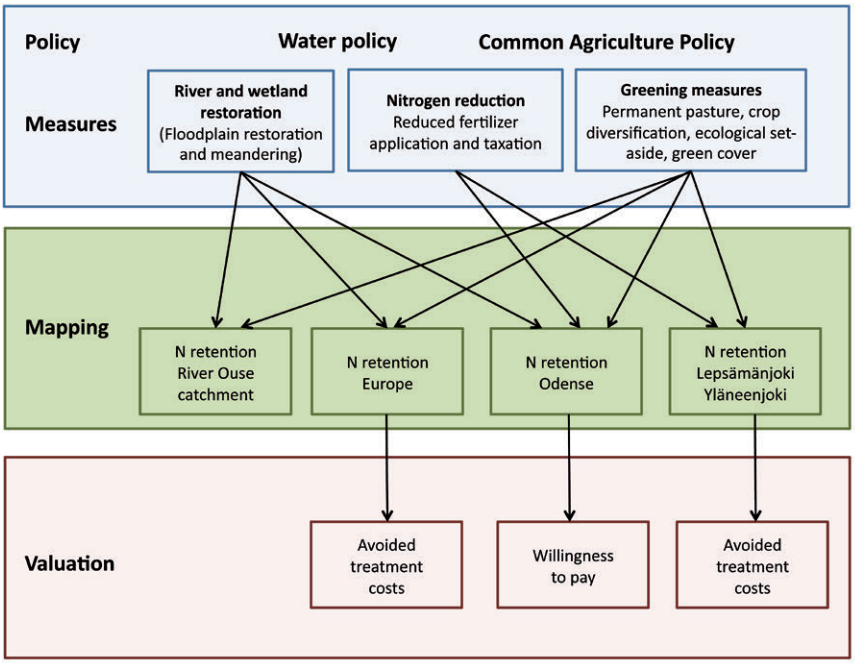


Figure 2.1. Scenario-based approach for the assessment of water purification services at different spatial scales in Europe. Nitrogen (N) was used as a common water-quality metric.

Results

Table 2.1 summarizes the most important results of the study by showing the direction of change of water purification services delivered by the aquatic ecosystems in a range of scenarios of land use change as a consequence of the policy measures. The overall conclusion was that greening the CAP, introducing measures to reduce fertilizer application, and the restoration of wetlands all resulted in increased levels of the water purification services, improved water quality and increased benefits to society as measured via monetary valuation.

Table 2.1. Direction of change in water purification following the implementation of different scenarios in four different case study areas.

Scenarios and measures		Europe	UK Ouse catchment	FI Lepsämänjoki Yläneenjoki catchments	DK Odense catchment
Greening direct payments (CAP)	Permanent grassland	➔	↗		
	Crop rotation/ diversification			↘	
	Ecological set aside (ecological focus areas)		↗	↗	↗
	Green cover			↗	
Reduced fertilizer application				↗	↗
River restoration			➔		
Wetland restoration		↗			↗

➔: change in nitrogen retention less than 5%; ↘: 5% decrease in nitrogen retention; ↗: 5% increase in nitrogen retention

Greening the CAP

The difference in effects between a generic European scenario on greening direct payments relative to the catchment specific scenarios is apparent. At European scale, losses in arable land and certain crops in one area are predicted to be compensated for in other areas, since EU food demand is not expected to change substantially. As a result, the overall change in land use, nitrogen input and nitrogen retention is relatively small. It follows that the benefits (avoided treatment costs) at aggregated EU scale (arising from reduced nitrogen application) were equally small (see Figure 2.2). At the catchment scale, however, the greening measures were predicted to result in increased benefits. Figure 2.3 illustrates this for the Finnish case.

This suggests that local and regional implementation of EU legislation may enable a more rigid enforcement of measures without considering the impacts on other areas, explaining why greening measures result in increased local benefits but may have negative effects on other regions.

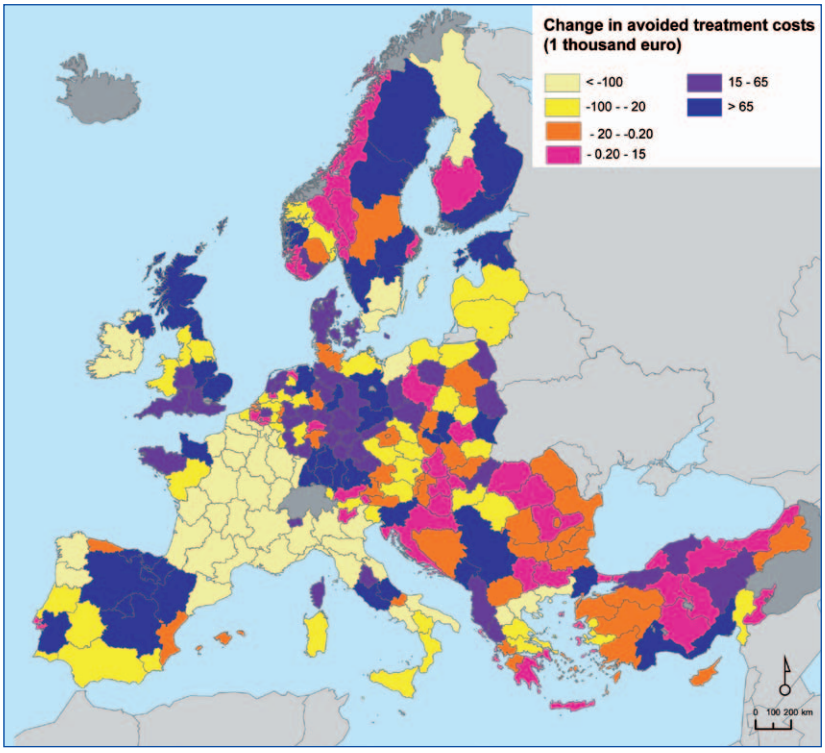


Figure 2.2. Assessment of avoided treatment costs comparing the EU-GREENCAP scenario relative to the EU-BAU (Business as Usual).

(1) The UK study (Table 2.2) includes two measures: an area measure, the Environmentally Sensitive Area scheme and a *pro constraint*, a farm-level compulsory rate of ecological set-aside. They are predicted to have significant beneficial effects as measured by the effectiveness (the ratio between output load for each scenario relative to the baseline).

Table 2.2. Scenario assessment of basin-wide nitrate-N fluxes and concentrations for the river Ouse catchment.

	Diffuse sources (ton year^{-1})	River retention (ton year^{-1})	River retention (%)	Output load (ton year^{-1})	N at outlet (mg l^{-1})	Effectiveness (%)
Baseline	8961	783	8.17	8798	4.67	
Environmentally Sensitive Area	8263	723	8.13	8160	4.33	7.25
20% set-aside	8044	707	8.16	7956	4.22	9.57

(2) The Danish scenarios (Table 2.3) are characterised by significant average reductions in fertilizer application relative to the baseline, in particular in those scenarios that involve taxation of fertilizer. This results in lower nitrogen loads to lakes and to the coastal zone and yields benefits measured by willingness to pay (WTP) to achieve a better ecological status (based on the quality criteria of the Water Framework Directive).

Table 2.3. Changes in average fertiliser application, N-retention and the benefits in terms of water quality improvements predicted for the scenarios of the Danish case study.

Scenario	Fertiliser reduction (kg/ha)	N load to Fjord (ton)	N retention (ton)	P reduction to lakes (kg)	Water quality Fjord	Water quality Lake	WTP Million € year^{-1}
Baseline model		1838		n/a	Poor	Poor	
Low fertilizer tax	79	1479	359	n/a	Moderate	n/a	31.3
High fertilizer tax	101	1404	434	n/a	Moderate	n/a	31.3
Set aside 15%	12	1715	123	342	Poor	Good	34.4
Set aside 25%	24	1570	268	538	Poor	Very Good	27.9
Wetland restoration		1747	91	n/a	Poor	n/a	

(3) The Finnish scenario is based on the greening measures as proposed by the new CAP proposal: ecological set aside area increase up to 10-15% of the total crop area; crop diversification with at least 3 crops cultivated and spring cereals cover <40% of field area; grass cover >10% of field area. This scenario differs from the EU scenario in that it includes an additional measure of 50% of total crop area under wintertime vegetation. The scenario with fertilizer reduction assumes 100% of the area under reduced fertilization with a nitrogen balance decreased to 20 kg N ha-1 and manure spreading allowed only during the growing season. Reduced fertilizer application, vegetation cover during winter, and ecological set aside are predicted to result in additional benefits. Crop diversification is, contrary to general findings, predicted to increase nitrogen application (as a result of case specific conditions) and will invoke costs (Figure 2.3).

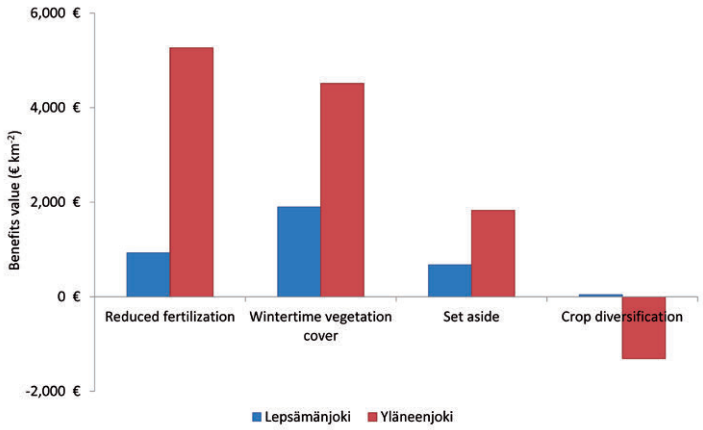


Figure 2.3. Value (€ ha^{-1}) generated by water purification services for four different measures (Finnish case study)

Wetland and floodplain restoration

Biodiversity was not included explicitly in the models used in this study. Yet, more and more it becomes clear that biodiversity positively influences ecosystem functions that are essential to provide ecosystem services. For instance, Cardinale (2011) showed that a higher diversity of the community of algal species increased the nitrogen uptake capacity justifying efforts to protect and conserve aquatic biodiversity. Upscaling parameters that describe the biodiversity-ecosystem function relationships to landscape level in order to make inferences on ecosystem services still requires basic research, which was not possible in this study (Cardinale et al. 2012). However, biodiversity can be considered at ecosystem level as well and in the study we demonstrate that wetland and floodplain restoration are shown to contribute significantly to the reduction of nitrogen in surface waters and decrease the loading to European coastal zones. This was also confirmed by the Danish case study. Additional benefits that are derived from wetland restoration but which were not valuated in this study, are flood protection, increased habitat for species, in particular birds, and enhanced opportunities for particular forms of recreation.

3 Mapping and assessment of outdoor recreation at multiple spatial scales

Policy messages

Recreation in nature (outdoor recreation) is likely one of the most clearly perceived benefits of ecosystems to people. Many people have experienced the sheer enjoyment of walking in forests, seeing beautiful flowers and animals in the outdoors or picnicking with the family on a lakeshore. This is shown by the high visitation rates of forests and natural areas. The visitor statistics that were used in this study confirm the usefulness of the ROS approach (Recreation Opportunity Spectrum) to identify areas in terms of their accessibility and potential to provide recreation services.

Biodiversity is an important variable in the modelling approach. In the recreation study, biodiversity is approximated in an explicit way using spatial data on naturalness but also implicitly by including the Natura2000 network layer.

Millions of people have visited forests several times per year and they expressed their willingness to pay to continue doing so. The magnitude of estimates provided by the case study areas proves that such value may easily be in a range of billions of euros, and may increase if the avoided cost for health care due to recreation restorative and stress reduction capacity is included.

A spatial analysis of city population density and green urban areas is used to bring nature closer to citizens. The analysis can identify where investment in nature will increase the capacity of ecosystems to provide this essential service to people taking into account demographic evolution, urbanization and modes of transport.

Though the issue is not yet addressed in literature under the umbrella of ecosystem services, the restorative and stress reduction capacity of ecosystems would be a major theme for research. It is in fact reported that wilderness and the natural environment in general do have restorative capacities on humans. Accessibility to these areas is therefore important also from this point of view.

Introduction

Cultural ecosystem services are defined as non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experience. In all these forms of cultural services, the essential process is the flow of information from ecosystems, while humans have to invest in obtaining that information through developing accessibility to the ecosystems, and exposing themselves to the information.

This section shows how ecosystems can provide recreation (the re-creating process within humans) as a benefit to citizens. More specifically, the type of recreation addressed here relates to the benefits obtained in daily life, ranging from e.g. the pleasure of reading a newspaper while sitting in the closest green urban area, a bike ride after work, to a day trip to a nature area. All ecosystems are considered to be potential providers of the service, irrespective of their conservation status (biodiversity level), though the type and level of service provision changes accordingly. Tourism and long distance (>100 km) travel were not included in this study, as this would have required a different approach.

The mapping and assessment of recreation services offered by ecosystems was structured along the ecosystem services cascade model (Haines-Young and Potschin 2010; De Groot et al. 2010; Figure 3.1). Firstly, we mapped for different case studies the potential of different ecosystems, including urban ones, to provide recreation. The ROS approach (Recreation Opportunity Spectrum) presented in the first PRESS report (Maes et al. 2011) has been refined and applied at the EU level and at the national level for Finland. A local scale study was carried out on green urban areas, as these are an increasingly important source of recreation given the growing share of human populations in towns and cities. Secondly, we reported on the efforts to assess the number people that recreate in nature by evaluating a number of visitor statistics based on surveys or analysis of existing data. Thirdly, the monetary value of the benefits of the recreation services was estimated based on travel costs. Finally, a scenario of land use change, including demographic projections to 2030, shows how the provision of recreation may consequently change.

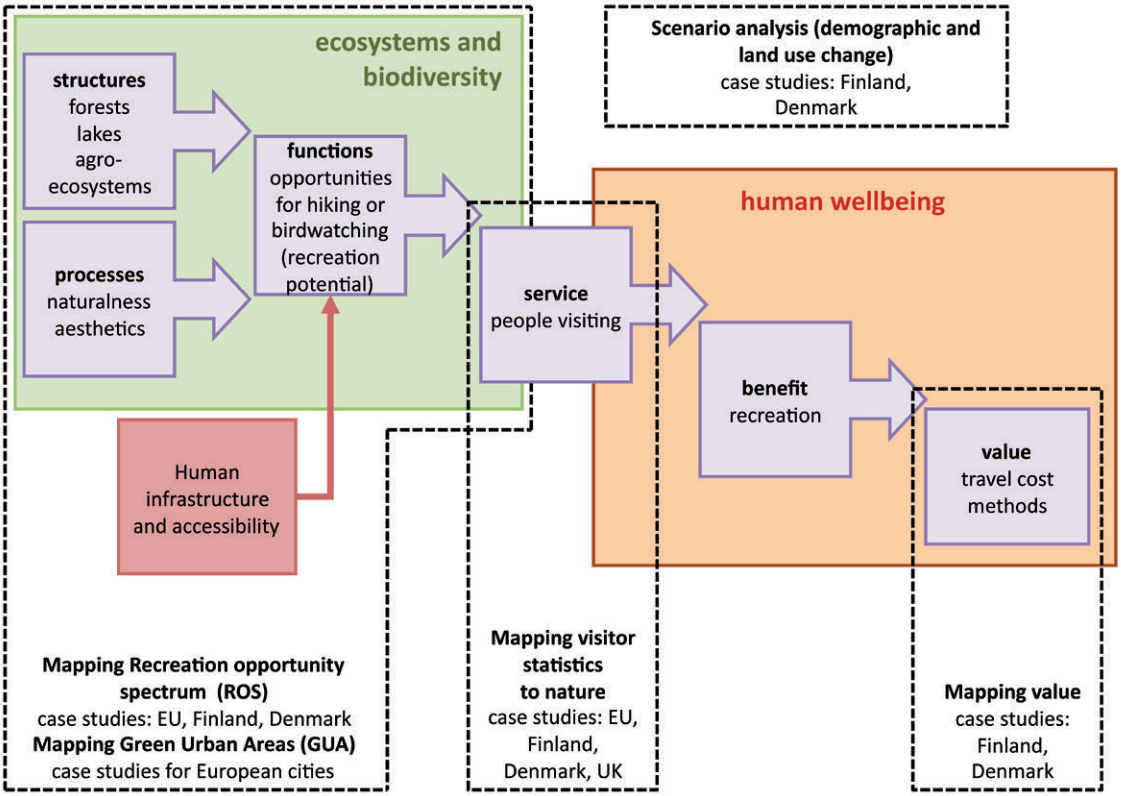


Figure 3.1. Application of the ecosystem services cascade model as an analytical framework to map and assess recreation in nature.

Results

The usefulness of the ROS concept

A first conclusion of this study regards the usefulness of the ROS concept to map the potential of ecosystems to provide recreation (Figure 3.2). The survey data of the different case studies confirm

the assumption that the environments where people like to recreate are linked to the quality of the natural area and the presence of water. In particular the Danish approach concludes that forests which are receiving more than half a million visits per year are those that are categorised in the ROS model with predominantly high recreation opportunity provision while forests categorised as medium recreation opportunity provision received less than half a million visitors.

Another important confirmation of the validity of the ROS model is coming from the analysis of travelled distance. A main assumption in the EU-wide exercise was that all ecosystem types had to be analysed as potential sources for recreation, and not only the most valuable ones in terms of the quality of the natural area and biodiversity. In fact, if someone wants to recreate in nature shortly after work, or bring the children for a stroll, he or she does not have a wide selection of ecosystems available to go to in the limited area surrounding his or her home. It is therefore important to understand what the characteristics of current provision are, to be able to improve it. Results from 23 analysed EU countries show that on average 35% of the population can easily reach sites with a high potential for recreation. Areas with a relatively high degree of naturalness (forests are considered as such) provide multiple ecosystem services (Maes et al. 2011), some of which have positive effects on human health (i.e. air quality regulation).

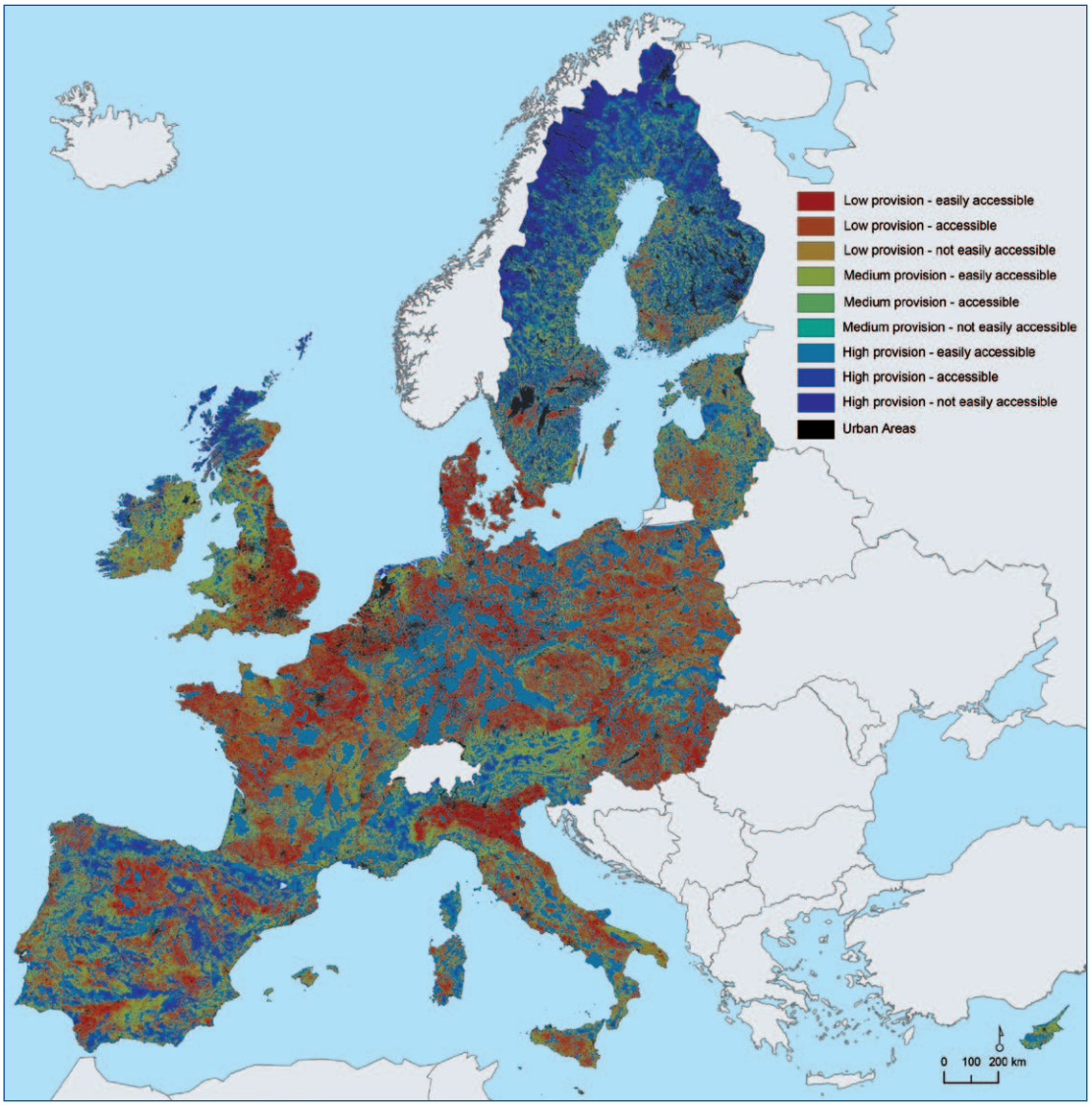


Figure 3.2. The Recreation Opportunity Spectrum (ROS) for Europe classifies ecosystems in three classes of accessibility and three classes of recreation potential.

Accessibility

The analysis made at country level provides some ideas on how accessibility can be granted. Some countries have an inherent high provision of recreation potential. For instance, in Sweden and Finland the boreal environment is characterised by a high degree of naturalness. In countries where this provision is lower due to intensive agriculture (for instance Germany, United Kingdom, France, Italy) the network of protected areas is a major element in ensuring potential recreation provision. Intensive agriculture mostly takes place in lowlands, where many major European cities are also located and millions of people live. In Italy, a high recreation potential is mostly provided by areas in the hills and mountains, which are further away from millions of citizens than the average distance of close-to-home trips. On the contrary, countries like Germany show a more evenly distributed network of protected areas on the national territory.

Surrounding environment

The fact that the surrounding environment is crucially important is demonstrated by the Finnish survey (Figure 3.3), which shows the importance of the *everyman's right* (the right to have public access to the land). About 80% of close-to-home trips are made to this type of environment. The total number of close-to-home trips accounts for over 500 million trips per year. The Danish survey provides high estimates for trips to nearby forests, estimated at over 26 million per year in the Copenhagen and Frederiksborg regions only (Figure 3.4). The fact that the surroundings are important in recreation analysis highlights the role of urban green areas (Figure 3.5). Also in this case spatial distribution matters, and has the double effect of providing a higher number of residents with recreation potential, and of diminishing visitor pressure on each area. Statistics in the Netherlands show that availability of green urban areas to people living in a 500 m surrounding range from 14 to 56 m^2, with an average around 30 m^2.

Economic valuation

In the Finland case, the analysis of consumer surplus estimates per trip, shows that leisure homes in general and in Northern Finland as a region stand out from the others. Furthermore, the value of a trip to State owned land in Northern Finland is calculated to be almost twice as high as the value of a trip to State owned land in other parts of the country. Trips to *everyman's right area* in Northern Finland provide a consumer surplus that is about 45% higher than trips to the same type of site elsewhere in Finland. The total value of the recreation service is estimated at several hundreds of M€ for the capital city. The Danish study on forests in the Copenhagen and Frederiksborg regions concludes that the willingness to pay for car access ranges from 1 to 12 million € per site. There were 52 forests analysed so the total value is exceeding 50 million € for just one type of ecosystem.

Scenario analysis

The scenario analysis links land use modelling, a population growth scenario and recreation provision. The scenario applied on Finland is a Business as Usual scenario towards 2030. Results show that under current conditions changes are very small. Results of the Danish case indicate that with an increase of 240 000 of the population living in the municipality of Copenhagen over a 20-year period, forests closest to Copenhagen would receive between 106 000 and 1 million additional trips (equivalent to 10-32% increase). Changes in the value of car access show in some locations a reduction of € 134 000 per year while in other locations recreation services would yield as much as € 2.8 million.

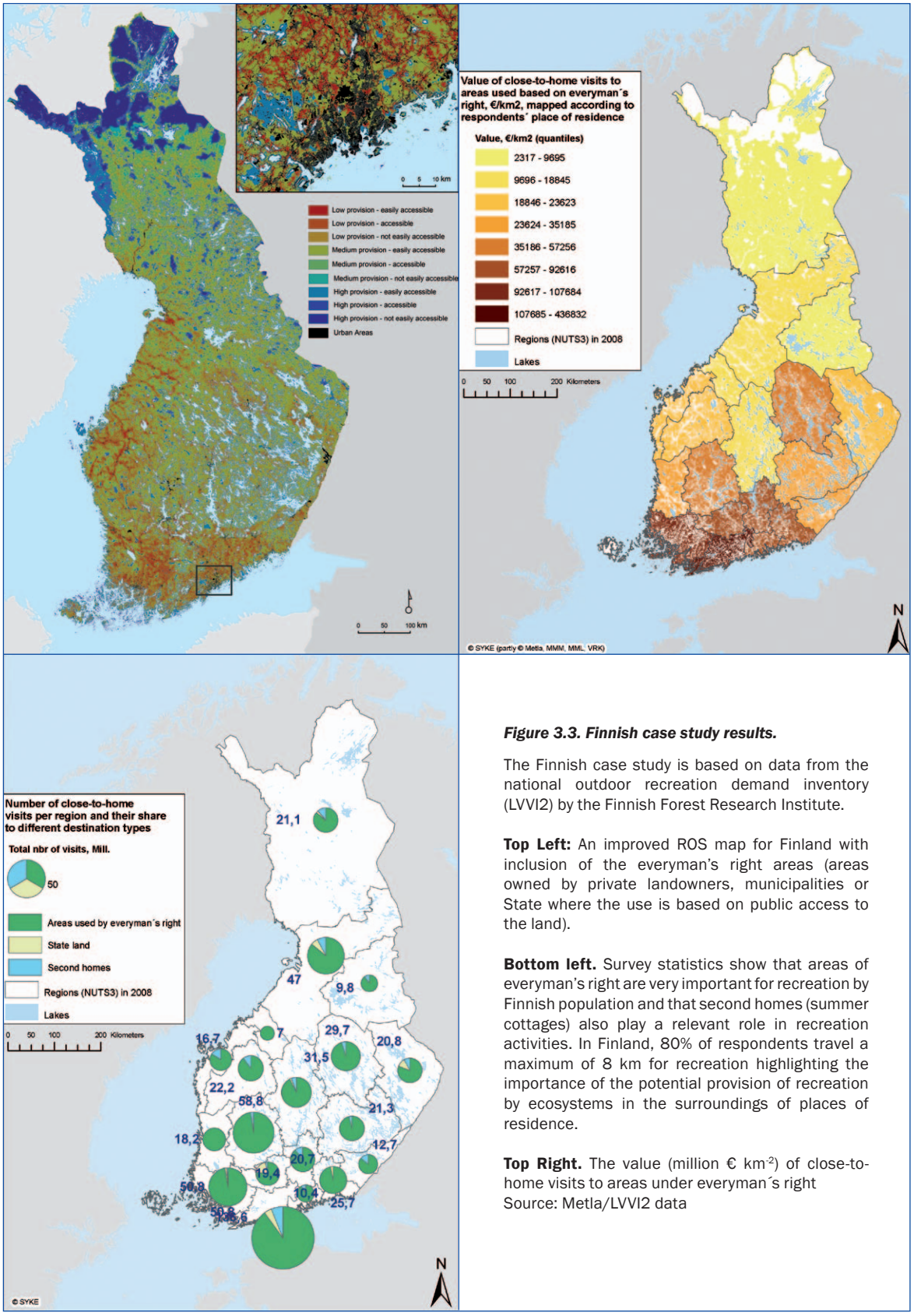


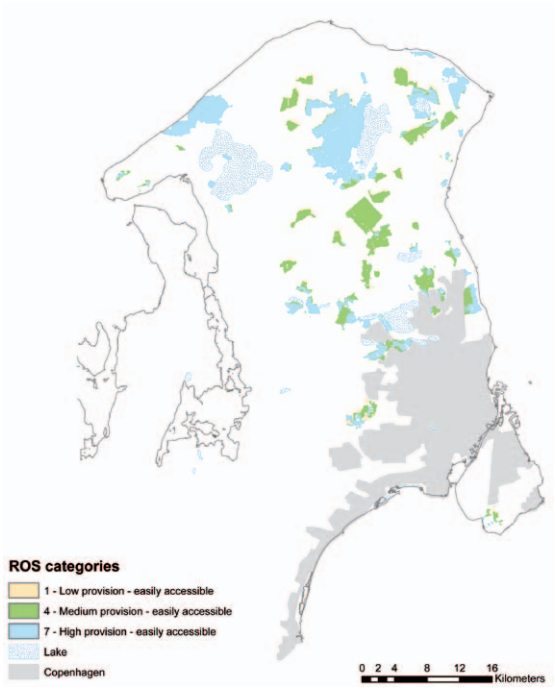
Figure 3.3. Finnish case study results.

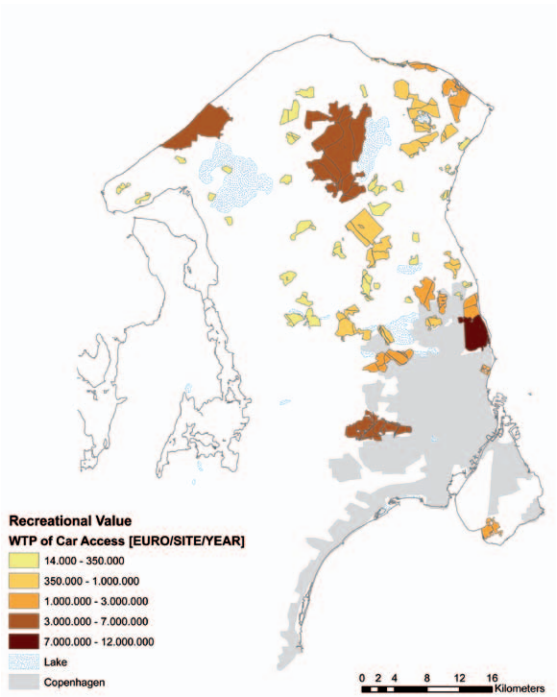
The Finnish case study is based on data from the national outdoor recreation demand inventory (LVVI2) by the Finnish Forest Research Institute.

Top Left: An improved ROS map for Finland with inclusion of the everyman's right areas (areas owned by private landowners, municipalities or State where the use is based on public access to the land).

Bottom left. Survey statistics show that areas of everyman's right are very important for recreation by Finnish population and that second homes (summer cottages) also play a relevant role in recreation activities. In Finland, 80% of respondents travel a maximum of 8 km for recreation highlighting the importance of the potential provision of recreation by ecosystems in the surroundings of places of residence.

Top Right. The value (million € km^{-2}) of close-to-home visits to areas under everyman´s right
Source: Metla/LVVI2 data





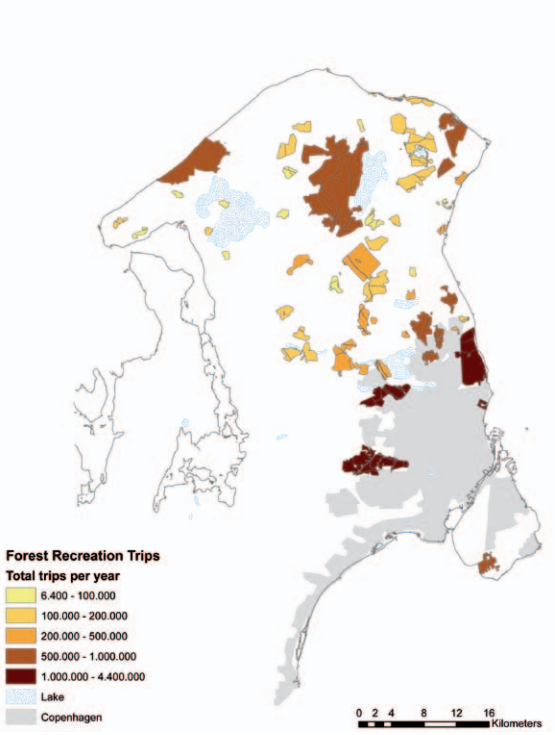


Figure 3.4. Danish case study results.

The Danish case study is based on a national household survey from 1994 used to estimate how many trips per year people make to forests for recreation in the regions of Copenhagen and Frederiksborg (North Zealand), totalling 662 people.

Top Left: ROS categorisation of forest sites included in the case study.

Bottom left. Total number of forest recreation day trips per site. Based on these statistics it is estimated that the total of yearly car trips to the 52 forests amounts to 14.5 million and trips with other means of transport sum to 12.1 million trips. On average, each adult in the region makes 23.5 trips per year to these forests.

Top Right. The willingness to pay for car access to forests (million € per site per year). The most valuable site (Willingness to Pay for car access close to 12 million € per year) is a former royal hunting forest and is today the most visited natural area in Denmark.

It is premature to draw EU-wide conclusions from this study on the value of recreation as ecosystem service. Nevertheless, the magnitude of estimates provided by the case study areas proves that such value may easily be in a range of billions of euros, and may increase if the avoided cost for health care due to recreation restorative and stress reduction capacity is included.

The potential of Green Urban Areas (GUAs) to provide recreation ecosystem services

Surveys clearly show the strong relation between recreational activities and the origin of recreational trips (the places of residence of people recreating). Under this perspective, the role of Green Urban Areas (GUAs) cannot be neglected. GUAs are in fact main sources of recreation provision by ecosystems for populations living in urban centres.

Using *the potential number of people per GUA for the urban zones* as a proxy to value the potential of Green Urban Areas to provide recreation services, Figure 3.5 shows for the city of The Hague, lying at the Dutch coast, that both the green areas situated in the city centre and the dune areas in the urban periphery provide potential recreational services to many people within a 500m distance. Compared to The Hague, recreational services in the city of Amsterdam are provided more by small GUA's in the city centre (Figure 3.6). A second proxy to value the potential of GUA to provide recreation ecosystem services is the *amount of green area per person*. The dune areas in The Hague provide a higher service in terms of area per person than the green areas in the city centre.

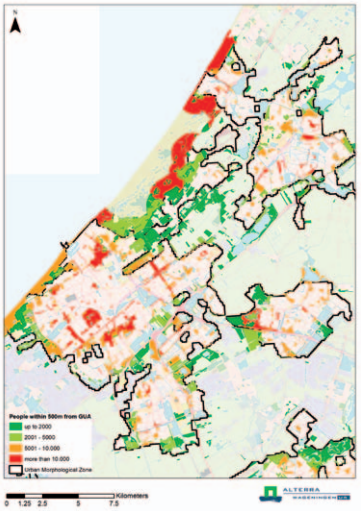


Figure 3.5. *Number of people within 500m of GUAs in the Dutch city of The Hague*

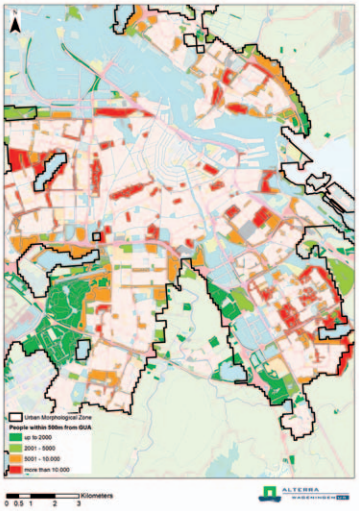


Figure 3.6. *Number of people within 500m of GUAs in the Dutch city of Amsterdam*

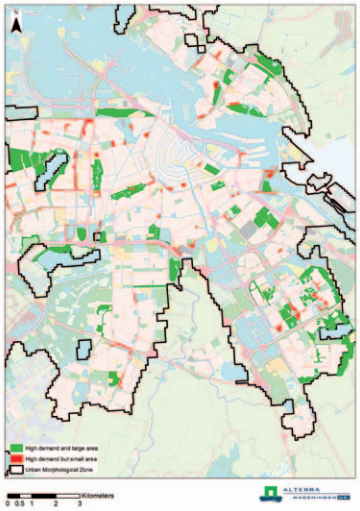


Figure 3.7. *Demand/supply ratios for GUAs in the Dutch city of Amsterdam*

Considering *the number of people within 500 m of a GUA* as the demand for recreation, and the area of that GUA as the supply, a selection of GUAs can be made. In Figure 3.7 the areas with high demand and high supply (thus potentially providing a high amount of green space to many people) are marked in green, high demand and low supply (thus potentially providing a low amount of green space to many people) are marked in red. Compared to Figure 3.6, showing the number of people within 500 m of GUAs, this map provides a different interpretation of recreation provision. Some sites like the dune areas, for example, provide recreation potential to many more residents than the smaller green areas in the city, which may therefore be less congested.

Using of available datasets in a simple and transparent way that can be applied at European level, recreation ecosystem services provided by green urban areas can be analysed effectively. The calculations do not take into account people working only in the cities, relevant in many European city centres. The distance of 500 m was based on the assumption that people will walk to the GUA, while in some countries cycling, or going by car or public transport will be more common.

4. Mapping and stakeholder assessment of pollination services at multiple spatial scales

Policy messages

Pollination services offered by insects such as wild bees and bumblebees are essential to maintain crop production, in particular of fruit and vegetables. PRESS demonstrated that the coverage and resolution of current datasets are already sufficient to map the potential of ecosystems to provide this ecosystem service.

Importantly, this study shows how functional traits of pollinator biodiversity can be used to map pollination potential of ecosystems.

The concept of ecosystem services was expressed to be useful by interviewed stakeholders, but it has opened up new questions about responsibilities and liabilities. Many stakeholders feel they have all the relevant information. Instead, operationalization of scientific information and development of good social practices were identified as key concerns, and they think informal practices and codes of conduct are also an important aspect of pollinator conservation.

However, better ecological observations of key pollinator species are needed to include important drivers of pollinator-abundance in modelling and mapping approaches which were not included in the study, for instance the use of pesticides or the presence of pollinator-supporting habitats in the landscape.

Introduction

The productivity of many agricultural crops, in particular of fruits and vegetables, depends on the presence of pollinating insects. The dependence of several European crops on pollination and the high monetary value associated with crop pollination makes it relevant to society to delineate places where nature has the potential to provide pollination services.

This study presents a mapping approach to assess the relative importance of pollination to European agricultural crops. The approach is based on the evidence that different habitats, but in particular forest edges, grasslands rich in flowers and riparian areas, offer suitable sites to host populations of wild pollinator insects such as solitary bees, bumblebees or hoverflies. Pollination as an ecosystem service was studied in four case studies across Europe.

Results

EU level

At the European scale, a map of pollination potential was produced (Figure 4.1). Spatial data of land cover and land use were transformed into indicators for nesting suitability and floral resource availability. Next, these indicators were combined with climate data to simulate pollinator activity and map the relative pollination abundance at a landscape scale. The mapping method was based on the InVEST model of the Natural Capital Project (Kareiva et al. 2011).

The relative pollinator abundance is modelled to increase from northern to southern Europe corresponding to the modelled temperature-dependent activity rate of bees and bumblebees. Given temperature, pollination potential is expected to be low in areas where the dominant land use is arable land used for production of cereals, such as the east of the United Kingdom, areas in France surrounding the capital, areas in central Spain, the Po plain in Italy, areas in northern Germany, Poland and Slovakia and the along the borders of the Danube in Bulgaria and Romania. These areas are assumed to have low pollinator nesting suitability and to offer limited resources for foraging due to an absence of plants with flowers carrying nectar. At aggregated EU level, 23.6% of the total production of crops which depend on pollination could be assigned to insect pollination. This figure corresponds to a production deficit if no pollination services were offered by insects. This value decreased to 1% if all crop production is considered, including the large share crops that are not dependent on pollination.

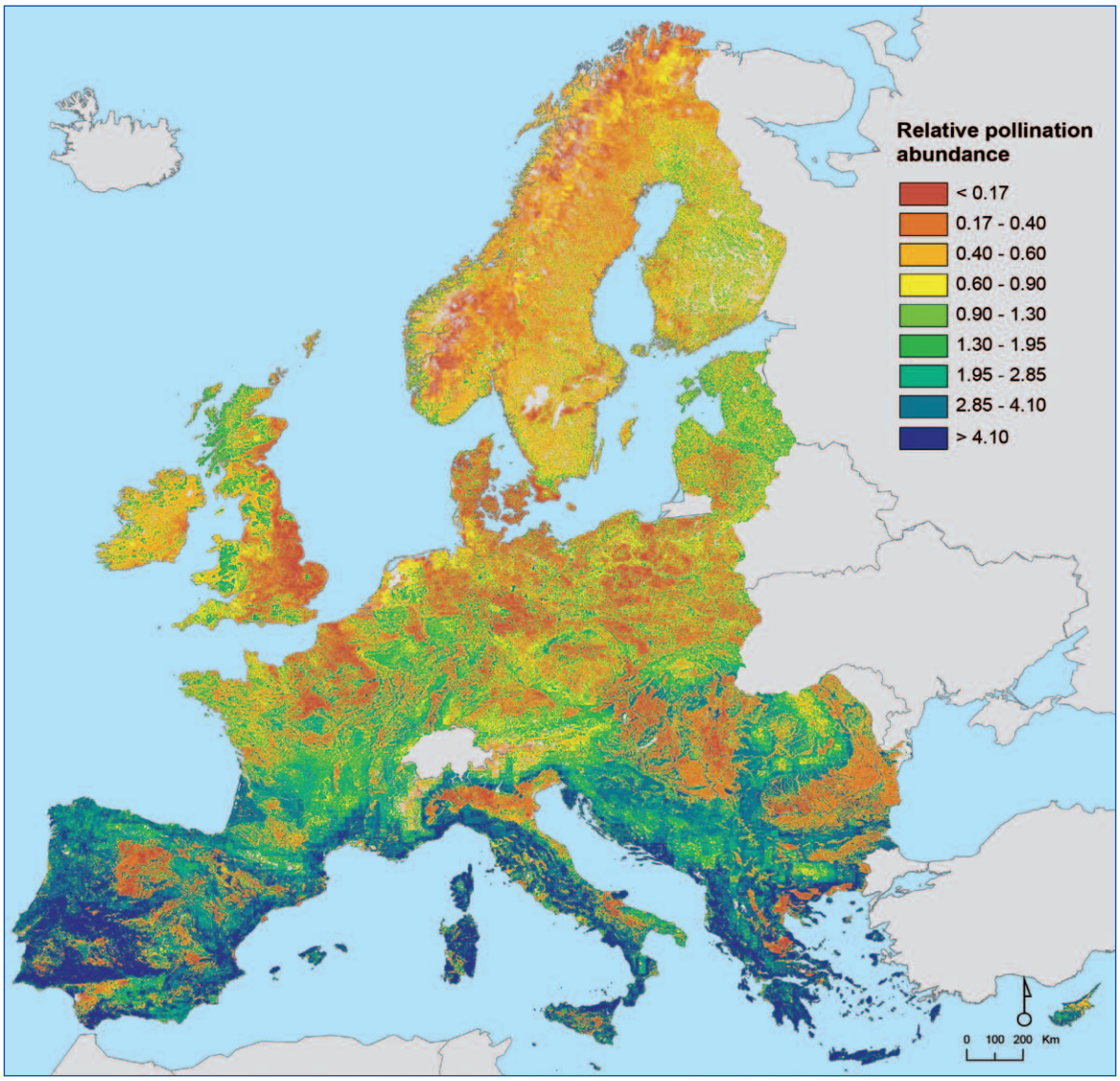


Figure 4.1. Relative pollinator abundance across Europe.

The Finland case

The Finnish case study is based on a similar mapping approach but the spatial scale of assessment was finer. Maps of the relative pollinator abundance at different spatial scales have been compared to maps of pollination demand indicated by the distribution of insect-pollinated crops. The availability of pollination services was generally highest in the north and lowest in the south-east, whereas the demand for insect pollination had just the opposite pattern (Figure 4.2). These patterns are better seen in the scale of the 10 km grid than in the smaller grid sizes and they are largely due to the differences in land cover by forest and arable land between the northern and southern parts. In the northern part cultivated fields tend to be smaller and thereby the distances to forest edges with high pollination availability tend to remain small, whereas in the southern part arable fields constitute much larger cultivated open areas with low availability of pollination services and the distribution of insect-pollinated crops follow the general distribution of arable areas.

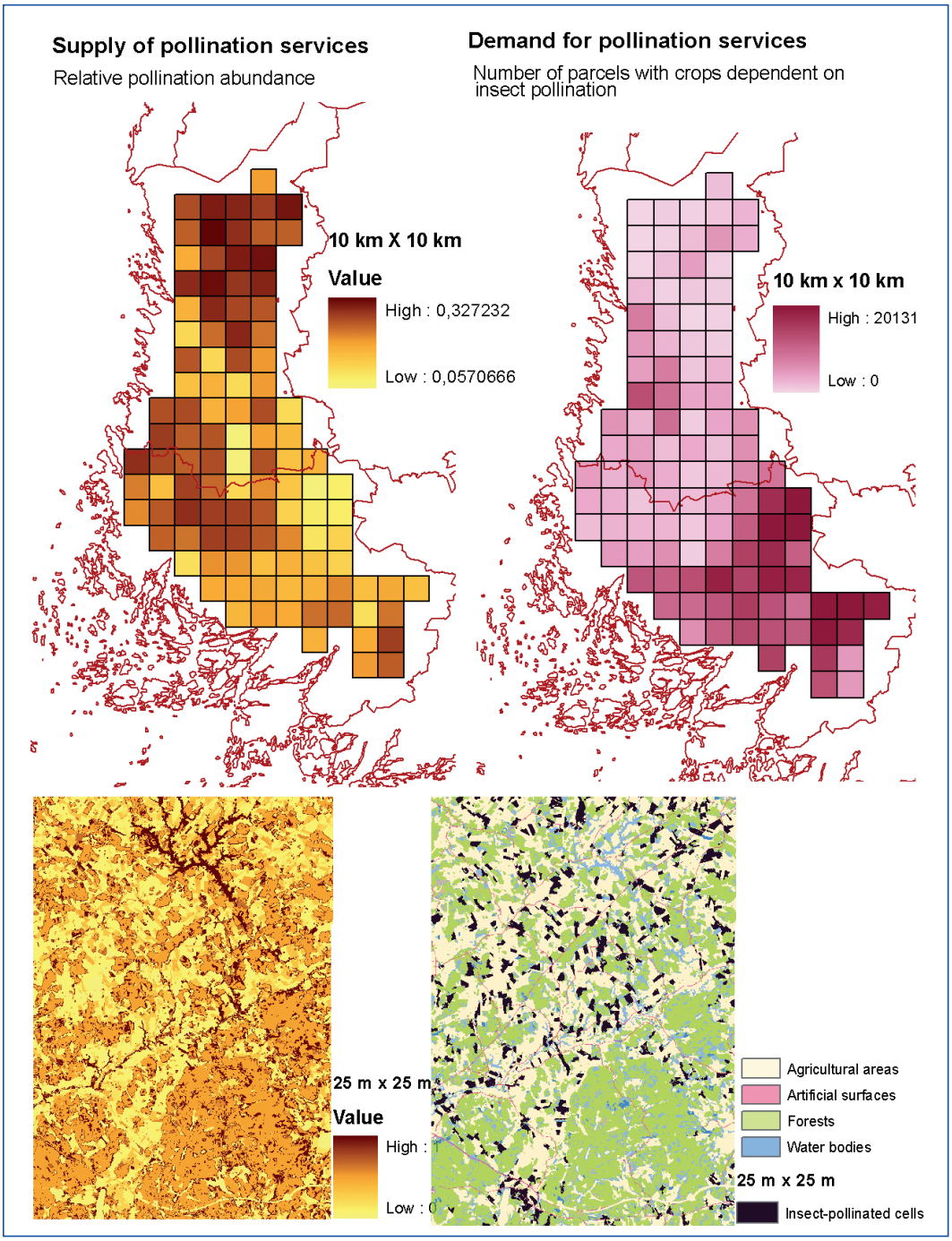


Figure 4.2. Finnish case study on pollination with maps showing the supply and demand

The Finnish high resolution maps (grid size of 25 m) are useful in the local planning of the implementation of agri-environmental measures, because they can help identify localities where pollination demand is high but pollination services are scarce, and where practical mitigation measures are needed. These maps also illustrate that even small patches of woodland in the middle of large field parcels can potentially act as important pollinator source habitats in agricultural landscapes. This stresses again the importance of green infrastructure elements as a way of providing multiple services, including pollination.

The case study shows that mapping pollination is very sensitive to scale. The Rekijoki river valley has the largest existing aggregation of species-rich semi-natural grasslands in Finland. It represents a nationally unique area with a high conservation priority and is a national pollinator insect hotspot with several threatened species. This is easily visible in the 25 m and 500 m grid maps. However, in the 10 km grid map this area receives a lower than average value in the availability of pollination services, because the areas surrounding the river valley are relatively intensively cultivated arable areas with generally a low pollination service level. This example highlights that, whereas the availability of pollination services for cultivated crops may be optimal in landscapes with relatively even distribution of suitable bumblebee habitat (in the northern areas of the Finnish case study area), this does not mean that these same landscapes would be best for conservation of pollinator insect diversity.

The UK case

The UK case study maps two sets of indicators for pollination services using empirical data of the richness of nectar-carrying plants, of insect-pollinated crops and of crop pollinator richness across the British landscape. A main result of the UK study is that much of the insect-pollinated crops grown in Great Britain are planted in the south and east of Britain, whereas their wild flower resources follow a tendency towards the south and west. More detailed analyses of single insect-pollinated crop species (oil-seed rape and field bean, Figure 4.3) or groups of ecologically similar species (fruit trees and berries) suggest that there is potential for spatial mismatches between crops and their wild pollinators at least in certain regions of the country.

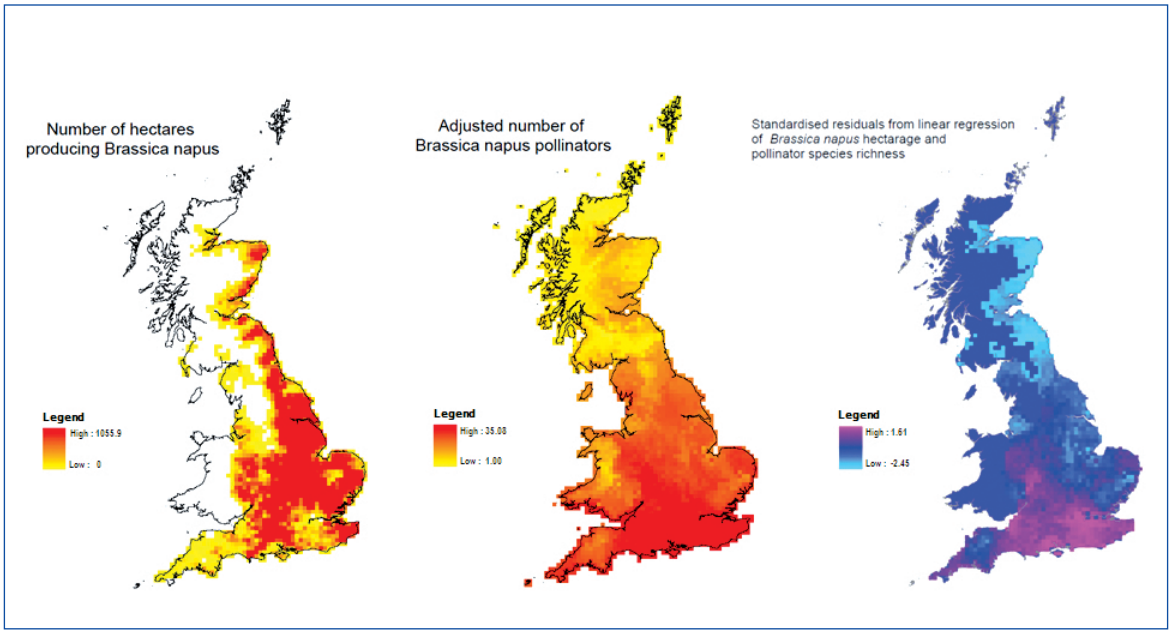


Figure 4.3. Distribution of oil seed rape crops, the species richness of its wild pollinators, and the potential for pollination mismatches. Pink shades indicate high overlap between crops and pollinator richness and light blue shades show low overlap. Dark blue indicates areas where no crop are grown.

A difference between the UK and European level case studies was that the UK study has produced a map on pollinator species richness (based on real species distribution data), whereas the European mapping has estimated relative pollinator abundance. While it seems reasonable that pollinator abundance is more important than species richness for the supply of effective pollination services, diverse pollinator communities may, however, provide a degree of redundancy or functional complementarity in the pollination system. Such diversity may therefore underpin service resilience in the face of environmental changes that extirpate species.

Stakeholder views

From interviews conducted as part of the policy analysis it became evident that the stakeholders at regional and local levels focused more their attention on managed bees instead of wild pollinators. However, it remains to be seen if the commercialization of pollination services creates more interest in wild pollinators. Most of the stakeholders, when asked about the drivers behind pollinator loss, quoted the market economy as a key driver. Perceptions were targeted at the socio-economic arena rather than ecologic drivers or pressures. On the other hand this is concordant with the fact that economic instruments, e.g. the agri-environment support, were seen as suitable tools for steering the situation. Market economy and economic instruments were seen to be the two most important determinants of crop cultivation and the measures and practices used.

The concept of ecosystem services was expressed to be useful by the stakeholders, but on the other hand it has opened up new questions about responsibilities and liabilities. Especially the relations between different policies and also the responsibilities of different stakeholders in the agricultural business need to be clarified and analysed. Many stakeholders hold the opinion that they don't lack any relevant information. Instead, the operationalization of the scientific information and development of good social practices were identified as key concerns. Based on the stakeholder interviews it can be concluded that, in addition to scientific knowledge and formal administrative tools, informal practices and codes of conduct are important aspects of pollinator conservation.

More attention should apparently be paid to investigating the role of informal institutions and practices. All of the interviewed people reacted positively to the maps which were shown during the discussions. The method of valuing the landscape from the perspective of pollinators seemed to raise the stakeholders' interest. Yet they were also critical and suspicious about the application of these kinds of maps (fear of bureaucracy or further control). Trust is a highly important issue when developing practices and measures at the local level. When discussing pollination in the context of land use planning in administration, the opinions did not give rise to optimism. Pollination as an ecosystem service takes place at smaller geographical scales than the current land use planning processes.

5. The impacts of EU policies on ecosystem services

Policy messages

Mapping, assessment and valuation of ecosystem services are necessary but not sufficient steps in achieving the ecosystem services targets of the EU Biodiversity Strategy. Following the TEEB procedure (TEEB 2010b), capturing the value for society requires a thorough understanding of the impacts of current policies on the ecosystems and more specifically on the mechanisms that determine the levels of the various ecosystem services. To know better means to be able to manage better, and possibly more cost-effectively. Therefore, in this last section of the PRESS-2 report, we discuss the state of knowledge and understanding of the effects of EU policies on ecosystem services.

A great number of EU policies influence ecosystems and the services they provide directly or via social and economic drivers of change, though many of them still do so mostly implicitly and unintentionally. International trade, agriculture, land use policies and nature conservation together create a complex and still only partly understood mixture of policies.

Including the ecosystem services concept into all social and economic policies would allow for a systematic review of the consequences of measures for services beyond conventional environmental assessments. It would also help in identifying and including services such as pollination, which are otherwise easily ignored.

Yet, even the most detailed literature review will not yield enough information to cover all synergies and trade-offs of measures, because they are also highly dependent on site-specific factors such as soils, climate, slopes and management history.

An important aspect in designing the implementation of the Biodiversity Strategy is that it is people at the local level that are often involved in actually implementing policy measures and sometimes have the most relevant knowledge.

However, even when local knowledge is included, this is no guarantee that policy measures achieve what it is being developed for. In order to be able to react and adapt to new circumstances consequences of policies must be continuously monitored and flexible in design. Therefore, it is necessary to quantify goals and determine baseline levels describing what the situation was before the measure against which progress is verifiable.

Introduction

The first phase of the PRESS study (Maes et al. 2011) revealed that many Ecosystem Services (ESS) are both targeted and affected by existing policies, even if ESS were not described explicitly as such. Examples are agricultural policies, water policies, forest policies, and of course biodiversity and conservation policies. However, Maes et al. (2011) also showed that the impacts of EU policies on ecosystem services in general need to be examined in some depth, as many of these policies represent complex frameworks, with multiple goals and measures that affect the services in different ways. This section provides a start of such an analysis from a twofold perspective.

The first perspective looks at the impact of a set of EU policies on ecosystem services and more precisely at some of the measures that the policies suggest. More precisly, the effect of green infrastructure on the provision of ESS is discussed. The green infrastructure approach advocated by the EU (European Environmental Agency (EEA) 2011) is not a measure as such, but rather a strategy on the policy level[1]. It is nevertheless included in the analysis on behalf of its relevance for biodiversity conservation and because the approach is closely linked to the other measures discussed in this chapter. These other measures comprise measures of new or future policies, namely the greening options of the future CAP, as well as wetland restoration, a measure considered for the Blueprint to Safeguard Europe's Water Resources[2]. The second perspective of our analysis provides insights into how a specific ecosystem service, pollination, is affected by different EU policies. Both analyses are based on literature reviews, which are not exhaustive.

Results

In Table 5.1 an overview is presented of the effects of policy measures which are part of the EU regulatory policies and frameworks. The scores are explained in the next few pages describing each of the policy columns. The table summarizes the results of a literature survey.

Table 5.1. Effect of policy measures on ecosystem services based on scientific literature.

Class of Eco-system Services	Ecosystem service	Green infrastructure in urban areas	Ecological set aside/ ecological focus areas		Maintenance of permanent grassland		Crop rotation Diversi-fication	Wetland resto-ration
			Fallow land	Buffer strips	Intensive use	Extensive use		
P	Biomass for energy & biofuels		⇔	⇔	–	–		
P	Crop production		–	–		–	–	
P	Livestock				+	+		
P	Wild food (fish, berries, game, mushrooms)							+
R	Climate regulation	+	+		–	+	+	⇔
R	Regulation of water flows	+		+	–	+		+
R	Water purification	+	⇔	+	–	+	⇔	+
R	Air purification	+		+				
R	Soil fertility		⇔				+	
R	Erosion control and prevention		⇔	+				+
R	Pollination			+		+	+	
R	Pest control			⇔			+	
H	Habitat provision and connection	⇔	+	+		+	+	+
C	Recreation	+				+		+
C	Aesthetic information	+	⇔	+		+	+	+
C	Cultural & inspira-tional services	+		+		+		
	Additional trade-offs	Allergens Invasive alien species Energy for maintenance Low conservation opportunities	Bare soils in fallow land change the direction of the effects and increase erosion and leaching of pollutants			Extensive grasslands used for livestock production, have lowstocking densities		High recreation rate disturbs animal breeding and nesting

+: Policy measure is expected to enhance the provision of ecosystem services
–: Policy measure is expected to decrease the provision of ecosystem services
⇔: Policy measure is expected to result in positive, negative or neutral effect depending on particular management approaches

1 http://ec.europa.eu/environment/nature/ecosystems/index_en.htm.

2 http://ec.europa.eu/environment/water/blueprint/index_en.htm.

Green infrastructure

Green infrastructure can be defined as a strategically planned and delivered network of high quality green spaces and other environmental features[3]. Table 5.2 lists the elements that make up green infrastructure.

Table 5.2. Elements that make up green infrastructure (Mazza et al. 2011).

Green Infrastructure element (privately or publically owned):	Includes:
Core areas	Areas of high biodiversity importance, including large areas of healthy and functioning ecosystems with minimal intervention required, and smaller areas that require management; such as Natura 2000 areas and other protected areas (e.g. IUCN categories I, II and IV) or wilderness zones. All ecosystem types could be part of such core areas: woodland, rivers & riparian areas, lakes and ponds, wet- and peatlands, coastal and upland/mountain areas, heath- and grassland.
Restoration zones	Reforestation zones, new areas of habitat for specific species or restored ecosystems for service provision.
Sustainable use/Ecosystem Service Zones	Areas that are managed sustainably for economic purposes, whilst maintaining healthy ecosystems and proving a range of ecosystem service benefits (e.g. multi-use forests and High Nature Value farming systems). Such areas help maintain the permeability of the land-/river-/townscape (i.e. enable species to exist in the wider landscape and move between core areas)
Green urban and peri-urban areas	Parks, gardens, urban forests, orchards, green walls, green roofs, sustainable urban drainage systems.
Natural connectivity features	Ecological corridors (containing landscape elements such as hedgerows, wildlife strips, stone walls), stepping stones (i.e. patches of habitat that enable species to move between core areas), riparian river vegetation, etc.
Artificial connectivity features	Features that are designed specifically to assist species movement, such as green bridges (i.e. bridges that are covered by an appropriate habitat to encourage the movement of animals across them), tunnels and fish passes.

In the context of urban planning and urban ecology, there is a vast body of literature about the potential benefits of urban green space (or urban green infrastructure) designed to provide ecosystem services. Managers and planners in cities are increasingly concerned about climate change and resulting consequences such as flooding or extreme heat events. Biological carbon sequestration in urban tree cover and soils has been suggested as a potential tool for climate change mitigation. There is the direct removal of carbon dioxide from the atmosphere and the cooling effects of vegetation through shading and transpiration, thus may reduce energy use for air conditioning. Another service of urban tree cover is the improvement of air quality and thereby of human health as trees intercept the transport of air pollutants. The services of urban green infrastructure also include the regulation of urban water quality and quantity. The removal of pollutants by urban streams can be increased by adding coarse woody debris, constructing in-channel gravel beds, and increasing the width of vegetation buffer zones and

3 http://ec.europa.eu/environment/nature/ecosystems/index_en.htm.

tree cover. Vegetated landscapes such as green roofs and rain gardens can be used to reduce both the amount of urban stormwater runoff and its pollution load. Apart from these regulating services, there are a number of cultural services urban forests and parks provide e.g. outdoor recreation, nature observation, photography, boating, swimming and fishing. Most of these services come at a cost. Potential disservices listed are the increase of allergens, the promotion of invasive plants, host pathogens or pests.

Next to urban green infrastructure there is of course rural green infrastructure. According to the EEA (2011), agri-environment measures make a major contribution to green infrastructure. Measures discussed for the amendment of the Common Agricultural Policy (CAP) in 2013 could also help to support the green infrastructure approach and therefore contribute to sustainable ecosystem services provision.

Greening the CAP

The greening option in the CAP is characterized by greening of direct payments (Pillar 1), i.e. 30 % of direct support will be made conditional to "greening". This means that farmers must engage in environmentally supportive practices which will be defined in legislation and which will be verifiable. The impact will be to shift the agricultural sector in a more sustainable direction, with farmers receiving payments to deliver public goods (and services) to their fellow citizens (European Commission 2011c). Concrete measures discussed are ecological set-aside, buffer strips, the maintenance of permanent grassland and crop rotation/diversification.

Ecological set aside/ecological focus areas

Ecological set-aside/ecological focus areas are a fixed percentage of the farm land put to an environmental use rather than agricultural production. The fallowing of land has been a traditional practice, but this set-aside decreased. It was re-introduced in 1988 as a voluntary and in 1992 as an obligatory supply control mechanism within EU agricultural regulations. While the primary aim of the policy was to control the supply of agricultural production, a wider role for set-aside in relation to environmental protection was recognized in the 2003 CAP reform.

Where set-aside land is allowed to naturally regenerate, a patchy habitat containing many broad-leaved plants develops and this has been shown to provide good breeding and feeding habitat for many birds. Crop stubbles and weed seeds benefit wintering birds. The other major form of management involves sowing it with a grass mixture. The resulting dense grassland is attractive to a variety of small mammals. Non-rotational set-aside generally develops a greater abundance of invertebrates than other in-field arable habitats, but access for birds may be constrained by the density of the vegetation. The main benefit set-aside has for water quality is the reduction of inputs of fertilizers or pesticides to farmland. Keeping an adequate soil cover is hence a key factor for retaining the beneficial effects of set-aside in this respect. Set-aside does also play a role in erosion control. There is lowering of the average soil erosion rate of the remaining arable fields when set-aside is introduced. This is due to the fact that farmers tend to take the steepest fields out of production. Some studies also see a positive effect in terms of climate change adaptation. In terms of cultural services, set-aside can be seen as introducing diversity into the landscape and improving its amenity value. It can also introduce colour into landscape, for example through flowers (e.g. poppies) and butterflies in species-rich field margins or naturally regenerating wildflower grassland.

Buffer strips

Permanent vegetated buffers, including vegetative filter strips, riparian buffers, and grassed waterways, are installed in many areas to filter sediments from retained waters and deter sediment transport to water bodies and ground water. Along with reducing sediment transport, the filters also help trap sediment bound nutrients as well as pollutants such as pesticides. Apart from water purification, vegetative buffers

can filter airstreams of particulates by removing dust, gas, and microbial constituents. When planted in strategic designs, shelterbelts can effectively mitigate odor. Buffer strips provide habitats and connect existing habitats to facilitate species migration. Vegetation along rivers provides habitat for a wide range of wildlife including woodpeckers, ducks, shorebirds and deer. However, while strips can serve as barriers to the movement of weeds and pests they also provide habitats for unwanted species and are a potential source of some crop pests. Apart from being habitat, filter strips can buffer hedges and other ecologically valuable habitats alongside fields from pesticide drift and fertilizers. Vegetated buffer strips surrounding cultivated fields decrease soil erosion. Depending on their appearance, buffer strips can also contribute to the recreational appeal of landscapes by breaking up monocultures or increasing the aesthetics of stream courses. As traditional features in some landscapes, field margins may have heritage values and give a sense of place or are used for recreation, e.g. by using them as jumps for horses during fox hunting or to enhance game bird populations. While all vegetation of buffer strips can potentially be used as raw material, agroforestry buffers are systems of land use especially planted for the production of harvestable trees or shrubs.

Maintenance of permanent grassland

Managed permanent grassland or permanent pasture (as opposed to natural, non-managed grasslands, terms usually used interchangeably, is according to the Commission Regulation (EC) No 1120/2009, art. 2(c) "land used to grow grasses or other herbaceous forage that has not been included in crop rotation of the holding for five years or longer." The value of permanent pasture for the environment has long been recognized and this led to the introduction of a safeguard being put in place under the 2003 CAP Reform to encourage the maintenance of existing permanent pasture to avoid a massive conversion into arable land, given its positive environmental effect.

The services provided beyond animal production are dependent on the type of grassland and on its management. Extensively used grasslands are often associated with rare or traditional livestock breeds, which in turn are valued as providing aesthetic, cultural and historical benefits, as well as genetic resources for future breeding programmes. Further, extensively used grasslands are among the most species-rich habitats in Europe. Because of this they have the potential to enhance pollination services and hence primary production. Today, extensively used grasslands have a great value for recreation and tourism as people are attracted by the birds, diverse plant life and open-air landscapes of grasslands. Further, extensively used grasslands have contributed considerably to the development of ecological knowledge and are testing grounds for key ecological concepts. Conversion of arable land into pasture is very efficient in reducing nitrate leaching. Hay from extensive grasslands might also provide an alternative source of fuel. Grasslands store approximately 34% of the global stock of carbon but unlike trees, where above-ground vegetation is the primary source of carbon storage, most of the grassland carbon stocks are in the soil. However, whether grassland is rather a sink or a source depends again on its management. There are also some considerable trade-offs. Increasing demands for agricultural products and biofuels compete strongly with the maintenances of grasslands. Another trade-off can be found between livestock production and other ESS.

Crop rotation/diversification

Agricultural intensification and associated monocultures are known for their negative impact on a range of ESS. Crop rotation/diversification is thus considered as one measure for a more sustainable agriculture in the future. The European Commission (2011b) defines crop rotation as "*planned and ordered succession of different crops on the same field (usually lasting 3-5 years)*". Under the greening option, three crops with the main crop not exceeding 70% of arable and open air horticulture area and the third not less than 5% are suggested. No specific crops can be required or excluded due to the rules

of the WTO, but voluntary growth of leguminous crops should be encouraged. The fact that crops cannot be specified makes the assessment of impacts of crop rotation and diversification difficult as different crops have different effects on ESS.

Increased plant diversity can create biotic barriers against new pests by promoting natural enemy abundance. Overall, herbivore suppression, enemy enhancement, and crop damage suppression effects were significantly stronger on diversified crops than on crops with none or fewer associated plant species. Yet pest-suppressive diversification schemes can have a negative impact on production, in part due to reducing densities of the main crop by replacing it with intercrops or non-crop plants. Other advantages of crop rotation include the increase of wild pollinators, the accumulation of soil organic carbon and even the sequestration of atmospheric CO_2, maintaining and restoring soil fertility, leading to increased yields relative to monocultures and increased yield stability in nitrogen-limited environments without having to employ costly and water-polluting fertilizers. Another benefit that is derived from crop diversification relative to monocultures is the aesthetic value of the landscape.

Blueprint to Safeguard Europe's Water Resources

Although called green infrastructure this concept also has a blue component, which refers to the aquatic and wetland network (rivers and streams, canals, ponds, wetlands, etc.). One focus of the upcoming Blueprint to Safeguard Europe's Water Resources[4] will be on the acceleration of the implementation of water-related green infrastructure measures. One measure currently under evaluation in the context of the Blueprint is wetland restoration.

Since evidence is growing that rising investments in technical and structural measures have not been accompanied by reduced flood damages, alternative, 'softer' approaches, such as wetland restoration, are discussed and implemented. Wetlands can regulate water outputs from catchments by storing and slowing the flow of floodwaters, providing flood control and thus reducing the public cost of floods. In coastal areas, wetlands such as marshes and other flood plains can reduce coastal erosion and enhance coastal flood protection. The habitat qualities of wetlands attract high numbers of animals and animal species, many of which depend entirely on wetlands. Rivers and associated wetlands provide ecological connections. These do not only include a range of wildlife habitats but also support species dispersal and migration. Shallow depth, large surface area and high shoreline complexity are likely to provide a high biodiversity of birds, benthic invertebrates and macrophytes. As water passes through healthy wetlands, the wetlands function as traps for nutrients, and water is filtered and cleaned. Wetlands further contribute to groundwater recharge and thus play an important role in water supply, providing drinking water as well as water for industrial use and irrigation. There is also a growing understanding of the role of wetlands in sequestering carbon in long-lived pools and thus contributing to climate regulation. Wetlands are important tourism destinations because of their aesthetic value and the high diversity of the animal and plant life they contain. Yet, nature based recreation such as wildlife viewing, hiking, running, cycling, canoeing, horse riding and dog walking can have negative environmental effects, when proper management is missing and visitor numbers are too high and noisy, trails are left, litter is not removed, etc. Wetland ecosystems also provide a range of provisioning services. Fish and fishery products, berries or mushrooms can also be directly harvested from wetlands. While hunting in wetlands is in the developed world rather perceived to be a recreational service, the game can also be counted as provisioning service.

4 http://ec.europa.eu/environment/water/blueprint/index_en.htm

Policy analysis of the pollination service

The International Risk Governance Council (IRGC[5]) "considers that, although pollination is a critical issue that is well acknowledged within the scientific community, it appears to be neglected and insufficiently appreciated by policymakers, industry (particularly the agricultural sector) and the general public. As a result, the IRGC believes that the threats to pollination services and related risks are not adequately taken into account, directly or indirectly, in policies and regulations that may affect pollinators and their habitats." (IRGC, 2009)

A way to identify the policies which have, may have, or should have significance for pollination, is to look at the work which has been done to identify the drivers behind pollinator loss. In research literature these drivers have been identified as: changing land use patterns, agro-chemicals, diseases, invasive species, climate change, fire, overgrazing and introduction of non-native plants. There are numerous policies which affect these drivers. Table 5.3 lists global as well as European policies and key regulatory frameworks at EU scale that affect pollination services by influencing the drivers behind pollination loss, showing that management of the pollination ecosystem service is indeed a complex, multilevel policy issue.

Table 5.3. Key regulatory frameworks that affect pollination services in Europe

Convention on Biological Diversity International Pollinator Initiative	Guidance for improving and developing policies and practices to enhance pollinator conservation and habitat restoration
The Common Agricultural Policy and rural development policies	Key policy that provides a suite of measures that may enhance (or decrease) wild pollination services
Nature directives (Habitats and Birds)	Protection of habitats that host pollinator populations, species conservation
EU Biodiversity Strategy 2020	Overall biodiversity is important for pollinators. Degradation of habitats is one of the drivers behind pollinator loss
Plant Protection Products Directive	Regulates pesticide use and thus of key importance for pollinators
IAS Strategy	Commission is currently working on a dedicated legislative instrument on Invasive Alien Species. This potentially mitigates pollinator loss
Climate change policy	Climate change has many negative effects on pollinators and pollination
Environmental Impact Assessment (EIA) Directive	EIA is an important tool for land use policies, while land use change is a driver of pollinator loss
Forest policies	Forest edges represent essential habitats for wild pollinators
Environmental Liability Directive	Prevent and restore damage to animals, plants, natural habitats and water resources, and damage affecting the land

The directives and regulations in Table 5.3 are considered the most directly relevant policy frameworks for pollination management. The table is elaborated in the next few pages.

5 The International Risk Governance Council (IRGC) is an independent organisation based in Switzerland whose purpose is to identify and propose recommendations for the governance of emerging global risks. To ensure the objectivity of its governance recommendations, the IRGC draws upon international scientific knowledge and expertise from both the public and private sectors in order to develop fact-based risk governance recommendations for policymakers, untainted by vested interests or political considerations.

Convention on Biological Diversity and International Pollinator Initiative

The Convention on Biological Diversity (CBD) has legitimised the global concern for pollinators through prioritising them in the Conservation and Sustainable use of Agricultural Biological Diversity programme in 1996. From the programme resulted an international pollinator workshop which in turn led to "The São Paulo Declaration on Pollinators". This declaration proposed an International Pollinator Initiative (IPI)[6]. The Food and Agriculture Organization (FAO) was invited to facilitate the initiative. A Plan of Action (POA) for the IPI was developed. It outlines guidance for improving and/or developing policies and practices to enhance pollinator conservation and habitat restoration.

European Pollinator Initiative (EPI)

The European Pollinator Initiative (EPI) was formed in 2000 and aims to protect and enhance the biodiversity and economic value of pollinators throughout Europe[7]. The EPI action plan, as well as other Initiatives' Action Plans, contains four elements: assessment, adaptive management, capacity building and mainstreaming. The EPI's main strategy is to integrate and co-ordinate local, national and international activities into a cohesive network to overcome the currently fragmented activities of scientists, end-users and stakeholders.

The Common Agricultural Policy (CAP)

While agriculture provides suitable habitats for many pollinators it can also have negative effects on them. Pollinators require habitats for both foraging for nectar and pollen as well as nesting. Farmland biodiversity has drastically declined in the past few decades due to agricultural intensification and a shift to large-scale monocultures has led to the loss and fragmentation of extensively used grasslands. In addition to this loss of habitats and therefore loss of foraging and nesting sites pollinators are negatively affected by fertilizers or other agro-chemicals use. The diversity of plant and plant production, which is of utmost importance for agricultural production, also depends on the abundance and diversity of pollinators. Agricultural land management has created a rich variety of landscapes and habitats over the centuries, including a mosaic of woodlands, wetlands, and extensive tracts of open country sides.

Even though pollination is not mentioned as one of the priority areas in the CAP, it may have positive effects on pollination through providing and sustaining pollinator-friendly environments and conditions. Pollinators or pollination are not mentioned explicitly and the effects of the measures on pollination turn out to be mixed. Agri-environment schemes are not designed at EU-level but at Member State or even regional levels and can differ widely among Member States. Evaluation of the impact thus becomes very challenging. The preservation of the remaining extensively used grasslands or re-creation of flower-rich grasslands is essential and can contribute greatly to sustain the abundance and diversity of insect pollinators. Knowledge gaps currently impede development of effective management plans that support pollination services and recommend research that combines multiyear, multiscale monitoring of bee abundance and pollination functions in response to habitat modification to restore pollination services in landscapes.

Habitats Directive

The European Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) forms the cornerstone of Europe's nature conservation policy. Especially in

6 http://www.internationalpollinatorsinitiative.org/

7 http://www.europeanpollinatorinitiative.org/

Annex I of the Habitats Directive, several habitat types suitable for pollinators are listed, including some grasslands and wet meadows[8].

Rural development policies

Policies closely coupled to those mentioned so far are rural development policies, as they influence land use and thereby influence the pollination. The essential regulation for rural development on European level is the Council Regulation 1698/2005/EC to support rural development by the European Agricultural Fund for Rural Development (EAFRD).

Birds Directive

The Wild Birds Directive (79/409/EEC, see also 2009/47/EC) was adopted in 1979 and aims to protect and conserve wild bird species naturally occurring in the EU. It may also have a positive effect on pollinators as some bird species, such as hummingbirds, sunbirds, honeycreepers and some parrot species are important pollinators, too. According to the FAO (2008), on a global scale "26 species of hummingbirds, 7 species of sunbirds and 70 species of passerine birds – all of which are known to pollinate plants" are endangered. Many pollinators are also important food sources for higher animals and their loss may threaten predatory bird species (IRGC 2009).

Plant Protection Products Directive

The Plant Protection Products Directive (91/414/EEC) of 15 July 1991, concerning the release of plant protection products, regulates the sale of pesticides and herbicides within the EU. The directive aims to ensure that marketed products do not pose a threat to human, animal and environmental health. The Regulation 396/2005 on pesticide residues in food and feed is closely related. Both Directive 91/414 and Regulation 396/2005 aim at a high level of protection of human health and the environment. As pesticides are known to pose a risk to pollinators these EU policies are likely to benefit pollination, too.

Environmental Impact Assessment Directive (EIA) and rural development policies

The Environmental Impact Assessment (EIA) Directive (Directive 85/337/EEC) was introduced in 1985. The aim of this directive is to provide a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation of public or private projects before authorising their implementation. The EIA is an important tool for land use policies. As pointed out above, changes in land use have been identified as one of the drivers behind pollinator loss due to the accompanying loss of nesting and foraging sites. While land use policies and management are usually implemented more at the Member State than EU level, the EIA is one way to ensure sustainable land use development within the EU.

Forest policies

Another prominent land use within the EU is forestry. It can be assumed that European forests contribute to pollination services, although evidence is still restricted to tropical forests. While forestry policy mainly lies with each Member State there is a common EU forestry strategy, which is currently under review. While in a report from the workshop on the review of the EU forestry strategy (EC, 2011f) pollination

8 Council of the European Communities (1992). Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. OJ L 206, 22/07/1992 P. 0007-0050.

is not mentioned explicitly, a general valuation and payment for non-wood products and services and ecosystem services is suggested.

Environmental Liability Directive

The Environmental Liability Directive (2004/35/EC), based on the "polluter pays principle", was adopted on 30 April 2004 and came into force on 30 April 2007. It establishes a common framework for liability, preventing and remedying damage to animals, plants, natural habitats and water resources, and damage affecting the land. It seeks to ensure that, in the future, environmental damage in the EU is prevented or remedied and that those who cause it are held responsible. This directive may be applicable, directly or indirectly, to loss of pollinators.

Other policies

The above mentioned directives and regulations are the most evident policy frameworks for pollination. However, there are other policy areas, which should also be considered even if the connection has not been empirically verified or is otherwise poorly known. For example, effects of climate change on pollination are highly debated, however, there is lack of empirical evidence about the connection. EU Regulations related to climate change might therefore also be relevant for pollination (EC 2011g). Since agricultural products are part of world economy, also EU trade policy has indirect links to pollinators through creating pressures (e.g. population growth and demand for food supplies), which in turn influence the direct drivers of pollinator loss, e.g. intensifying agriculture.

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Ecosystems are critically important to our well-being and prosperity as they provide us with food, clean air or fresh water and they maintain a livable biosphere. Consequently, ecosystem services are increasingly considered as crucial argument to support decision making in policies that affect the use or the state of natural resources. In particular, new biodiversity policies, which have been adopted at global and EU scales, have set targets to safeguard biodiversity as well as to maintain the supply of ecosystem services. Achieving biodiversity targets requires demonstrating that changes in policies affecting natural resources are beneficial to human well-being through the enhanced flow of ecosystem services. It also requires prioritizing investments and making them cost-effective based on a sound knowledge base and assessment methods. This study has contributed case studies to help exploring how such assessments might be developed at multiple spatial scale, in particular for pollination, recreation and water purification. The spatial assessment of these ecosystem services included maps displaying the potential and actual supply of these services in both biophysical and monetary units. Scenarios were used to estimate changes in the flow of ecosystem services and to estimate benefits that arise from policy changes. Our approaches show that the inclusion of the ecosystem services concept into policies would allow a systematic review of the consequences of policy measures for services beyond conventional environmental assessments.

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