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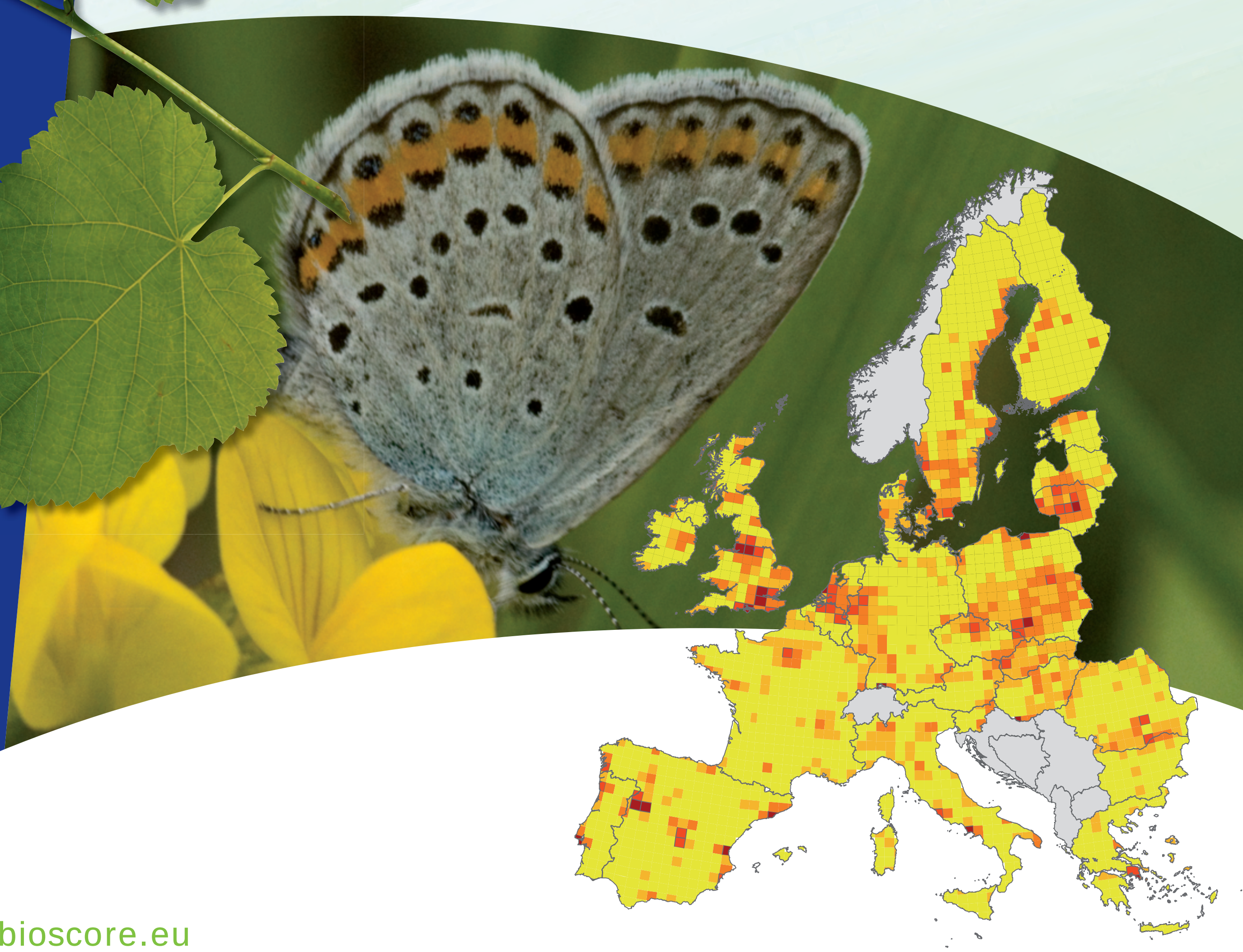
BioScore

A tool to assess the impacts of European Community policies on Europe's biodiversity



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BioScore:

A tool to assess the impacts of European Community policies on Europe's biodiversity

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Preface

The current report presents the results of three years of labour by a team of some 20 experts from nine institutes and organizations in Europe. The BioScore project (in full: Biodiversity impact assessment using species sensitivity scores) responded to a call of the European Commission's Sixth Framework Programme for Research and Technological Development to develop a cost-effective tool that is able to assess the impacts of Community policies on biodiversity. This tool complements the set of EU headline biodiversity indicators as well as European monitoring frameworks.

Chapter 1 describes the policy background of the project and how BioScore can contribute to the policy cycle.

Chapter 2 describes the BioScore database and tool, the method that was used to develop it, the underlying data and a technical description of the database.

Chapter 3 looks into the application of the tool for biodiversity impact assessments and takes you by the hand for actually using BioScore.

Chapter 4 includes the methods and results of four case studies that were carried out as part of the project to test to what extent BioScore can actually achieve what it was supposed to achieve. It includes a case study on the historical impacts of afforestation in Italy, one on the historical impacts of improved air quality in the Netherlands, one on improved water quality in Norway, and a prospective case study on forecasted impacts of biofuel production at the European scale.

Chapter 5 provides an indication of the interdependencies between the BioScore tool and European biodiversity monitoring programmes and their related data flows.

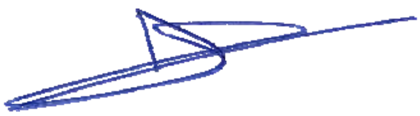
Chapter 6 lists conclusions and recommendations based on the experiences of the project implementation.

Some of the annexes are included in the current report; others – providing technical detail or raw data – are available for download from the BioScore website.

The BioScore tool in its current version, with its possibilities as well as its deficiencies, is available for you to test and apply. The BioScore team is eager to continue further developing the tool and would be pleased to receive your user feedback via the online contact. You can download and try the tool for yourself at www.bioscore.eu.

I am very grateful for the effective and constructive way in which the project partners have worked together as a true team. The team provided a good blend of ecologists, data providers, modellers, geographers, and policy background from all over Europe. Also, the team had great access to knowledge and data on many European species, ranging from all vertebrate groups to butterflies, dragonflies, vascular plants and aquatic macroinvertebrates. A word of thanks goes also to the project's steering group, with representatives from European end users and policymakers. They greatly helped in testing the tool and in ensuring its policy relevance. It is the team's hope that the tool will indeed help policymakers at all levels make decisions to the benefit of Europe's precious biodiversity.

Happy reading!



Ben Delbaere
BioScore coordinator

Executive summary

Every human activity in some way or another has an impact on a part of the world's biodiversity. This impact can be very direct, local but insignificant, such as swatting a mosquito, or can be global and very important, though perhaps indirect and spread out over many years, for example the gradual impact of global warming. Most of the large-scale impacts on biodiversity are driven by policy decisions, either at local, regional, European or global levels. Such policy decisions, available in many forms and types, can be designed to improve conditions for biodiversity. Examples include policies to improve air, water or soil quality or even policies that are directly targeted at biodiversity conservation through species protection or protected areas. Other policies may be developed for other purposes and may have an adverse impact on biodiversity through their – intended or unintended – effects on certain environmental variables. Such policies may for example be in place to develop Europe's transportation infrastructure, which will have effects in terms of land-use change, noise, visual disturbance or pollution.

It is often very difficult to predict the specific consequences of given policy measures on biodiversity. A range of reasons, such as lack of knowledge on dose-response relations, the complexity of biodiversity, or time lags in effects, make it hard to understand and quantify policy impacts on biodiversity. Processes are in place at the European level to overcome some of these shortcomings. Scientific research is supported and carried out at many levels, a set of policy-relevant biodiversity indicators has been agreed and documented, efforts are ongoing to streamline biodiversity monitoring, and a range of scenarios have been developed to reflect on possible future developments.

The BioScore project contributes to filling the knowledge gaps by – for the first time at the European level – bringing together data on ecological preferences of more than 1,000 species of birds, mammals, reptiles, amphibians, freshwater fish, butterflies, dragonflies, aquatic macroinvertebrates and vascular plants in Europe for over 30 environmental variables. These data are stored in a database that also contains data on the distribution of these species in Europe.

This database forms the backbone of the BioScore tool. This tool allows users to carry out quick scoping assessments that respond to basic 'What if …?' questions. It enables the user to, based on assumptions in relation to policy measures, virtually change a selected environmental variable (e.g. area of broad-leaved forest in Europe), either positively or negatively. On the basis of this changing variable the database is queried and information is provided on the potential impacts on biodiversity of that change. The tool provides aggregated information in the form of one value or colour for the entire European continent. However, it also shows disaggregated information in terms of relative number of species per taxonomic group that are potentially positively or negatively affected. The general figure can also be refined geographically, providing information at the level of biogeographical regions (BGR) or individual countries. In addition, a figure is presented on the potential impact on species that are included in European Red Lists or in the annexes of the EC Habitats or Birds Directives, which provides policymakers with extra information for their decisions.

We have tested the BioScore database by looking at four specific cases in Europe. We analysed the historic impact of afforestation on mammals in Italy; the effect of improved air quality on vascular plants in the Netherlands; the consequences of improved water quality on freshwater fish and aquatic macroinvertebrates in Norway; and we looked at the potential impact of some scenarios of land-use change in Europe caused by policy decisions on biofuel production. Although the specific conclusions for each of these cases vary, in general terms they demonstrate that the BioScore database is able to carry out biodiversity impact assessments at finer resolution and for specific policy measures. The case studies also demonstrate that results are based on a range of assumptions and should therefore be interpreted carefully and in terms of providing general indications, rather than predicting actual impacts.

Creating a biodiversity impact assessment tool at the European level is a task that is never really finished. Improvements can be made as more scientific knowledge becomes available, more accurate and up-to-date data are collected through harmonized monitoring networks, or when information technology is further developed. Therefore, it should be noted that the current version of the BioScore tool is really a first version, allowing for coarse rapid scoping assessments. It is very encouraging to know of the BioScore team's commitment to continue developing the tool, if further resources become available, and that some key players at the European level have expressed interest in formalizing collaboration agreements.

Now, at the end of three years of work with nine institutions, we can conclude the following:

1. The BioScore tool has provided a unique methodology and basis for assessing the impacts of selected policy-related pressures on biodiversity in Europe.
2. BioScore identified the main environmental pressures related to the Community policies.
3. At present the BioScore database contains information on habitat suitability and sensitivity to environmental pressures for more than 1,000 species. These represent mammals, birds, freshwater fish, benthic macrofauna, reptiles, amphibians, butterflies, dragonflies and vascular plants, covering a large part of Europe's species diversity, thus providing for a good representation of biodiversity.
4. By relating environmental pressures to European Community policies, the BioScore tool can create rapid scoping assessments (indicative at a coarse scale). It can do so either for the pan-European territory, for individual BGRs or for individual countries.
5. The case studies have shown that the database can be applied to more detailed assessments at finer resolutions on different spatial levels.
6. In its current form, BioScore provides the possibility for assessing single-variable and multivariable impacts.
7. The results of the BioScore assessments give an indication of potential impact on biodiversity based on modelled habitat suitability and species sensitivity rather than predicting the actual impact.

The BioScore team has identified the following elements for improvement and is committed to further develop the BioScore tool:

- Interactions and indirect effects are not taken into consideration, which makes it hard to assess relative importance of policy measures in relation to predicted impacts.
- The BioScore tool has proven to be able to assess biodiversity impacts of pressures. However, the tool can be much improved if more recent and fine scale species distribution data become available.
- Improved biodiversity monitoring will provide much higher value to the tool and will allow policymakers to make more reliable assessments.

Introduction

Imagine you are a policymaker in the higher echelons of the European Commission. You know that the Lisbon Strategy aims to make Europe 'the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010'. At the same time you are aware of Europe's commitment to halt the loss of biodiversity by 2010. Your responsibility is to decide on policies for sustainable energy and within a context of high oil prices, the need to reduce CO_2 emissions and the need to ensure affordable food production, you have to decide whether Europe should allocate land for the plantation of fast-growth forest for the production of second- generation biofuels. And, if so, where these should be planted. What current land-use types will need to be converted? Will we only need land that is currently under intensive agricultural use and therefore maybe compete with food production? Shall we use abandoned agricultural land or maybe brown fields or heathlands or wetlands? Which species rely on these forms of land use for their survival, how will they be affected if the land is turned into a short rotation coppice? And how does their possible disappearance, appearance or change in abundance affect Europe's biodiversity as a whole? Will it influence Europe's efforts to reach the 2010 biodiversity target? These and many other factors are relevant if you want to make a balanced decision.

Say you are a policy advisor in a municipality somewhere in Europe and you are asked to give advice to the local government. The advice concerns a proposed change in a spatial development plan requiring that a given part of the municipality's territory would change from 'extensive agriculture' to 'recreational use' to allow the building of a large theme park. Your advice needs to take into account economic, social as well as environmental concerns. As a component in your environmental deliberations you want to know what the possible impact might be of the proposed change on current and potential wildlife and biodiversity. In order to know that, you would need information on the species that are currently present in and depending for their local survival on extensive agricultural practices. You would want information on the sensitivity of these species to a change in the current land use. Some will have no preference, whereas others might be entirely dependent on a particular practice. Also, you would want to know what actually will happen to the environmental conditions if the land-use changes and how this in turn will affect the species present. What species might disappear? Will others enter the area because conditions have become more favourable for them? How much will it matter? Will it concern species of national or international conservation concern?

Assume you are a lepidoptorologist and you want to study the possible change in the distribution pattern of thermophile butterfly species if temperature in Europe increases by 1 degree in 30 years? Or you are a student and you need information for your Master's thesis on the future of plant species restricted to raised peat bogs in the light of decreasing atmospheric nitrogen deposition. Or you are a civil servant in the national offices responsible for Natura 2000 areas and you want to assess the likely impact of the construction of a high-speed railway on mammals in Natura 2000 areas that are less than 5 km away from the proposed route.

In any of the above cases, and thousands of other similar situations, would it not be great to have a tool at your disposal that can give you the answers to your questions with regard to biodiversity impacts of proposed or current practices and measures?

The BioScore tool has been developed to provide you with many of these answers. No, not all of them of course. For that to be possible one would need constantly updated and accurate information on distribution patterns of all species at a very high resolution and one would need very exact information on environmental conditions and the sensitivity of individual species to these conditions and how species interact in response to changes. These are still unanswered scientific and logistical questions.

Also, BioScore is not a crystal ball. It cannot predict the actual impact of given changes in land use or environmental variables on individual species, species groups or biodiversity in its entirety. In the end, nature is very unpredictable and shows unexpected resilience.

Nevertheless, what the BioScore tool does offer is the ability to identify what part of biodiversity is particularly sensitive to given changes in the environment. From such sensitivity one could then derive indications of possible negative or positive impacts on that part of biodiversity, but without a high level of certainty. BioScore can also identify what geographical locations in Europe have the highest or lowest relative numbers of species that are sensitive to a given environmental change. In its current version the tool can do so up to a resolution of individual countries, at its finest. It is also possible to do so at the level of biogeographical regions (BGR) or the whole of Europe. The database underpinning the BioScore tool is able to make more fine-scale assessments, even up to a resolution of 1x1 km. In future, with more accurate data becoming available, it should be possible to provide assessments at any resolution, even an individual parcel of land.

The type of questions that can indeed be answered by the current version of the BioScore tool include questions at the rather coarse European or national scale, such as:

- How many butterfly species are likely to be negatively affected if annual air temperature increases?
- What proportion of plant species in the Continental BGR that are listed in the annexes of the EC Habitats Directive might be negatively affected by a modest increase in nitrogen levels?
- Where in Europe are the countries with the highest proportion of mammal species sensitive to habitat fragmentation?

In more generalized terms, BioScore is meant to provide answers to questions of the format:

‘If your policy measure results in a change of environmental variable X, this is likely to result in an increase of A% of species and a decrease in B% species. Areas with a relatively high proportion of sensitive species are located in locations XYZ.’

For all of the above results of relative number of species, selections of subsets can be made to only show for example species contained in European Red Lists, or species of a certain taxonomic group. When further developed, it will be possible to also select species with a certain economic value or those that contribute to certain ecosystem services.

The BioScore tool includes information on sensitivity of more than 1,000 European species representing mammals, birds, freshwater fish, butterflies, dragonflies, vascular plants and aquatic macroinvertebrates. Although this is a substantial number giving a good indication of overall biodiversity, it is only a fraction of overall biodiversity in Europe, which consists of some 60,000 species for the taxonomic groups considered by BioScore. Also for this reason, the results presented in assessments using BioScore only provide an indication of sensitive species and possible impact and should by no means be treated as a quantification of actual impacts.

The content of this report is structured according to the original objectives of the project, which were to:

- assemble the necessary knowledge base (policy, science, data) for developing the tool;
- build a cost-effective impact assessment tool in the form of a European species database with sensitivity scores;
- apply the tool for the purpose of assessing the impacts of European Union policies on biodiversity;
- apply the tool for analysing the effectiveness of European policy responses;
- apply the tool for modelling European-wide scenarios for selected drivers;
- integrate the knowledge gained from developing and testing the tool on species sensitivities into an existing common monitoring framework as developed in the EuMon project (EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest) to assess the impact of selected pressures on biodiversity;
- propose incentives for a wide uptake of the tool.

1 Policy context and background

The BioScore project is designed to assess possible impacts of European Community policies. This chapter describes what Community policies have been considered and what mechanism and rationale have been adopted to connect policies and policy instruments to impacts on components of biodiversity.

1.1 BioScore conceptual framework

The BioScore project introduces a new element into the cause–effect chain that connects a policy measure to an impact on an element of biodiversity. Biodiversity impact assessments mostly look into the impacts in a deductive way: it is observed that certain species disappear or increase in population size with a given change in the environment. This observation can be extrapolated or broadened by including observations of changes to other species or habitats. From this observation it is then concluded that the observed environmental change causes the change in biodiversity. What is often lacking is the mechanism that causes this change to happen. In the BioScore project we therefore introduced the sensitivity of individual species to a given environmental variable as the connector between a changing environment and a response in terms of a species disappearing, appearing or expanding.

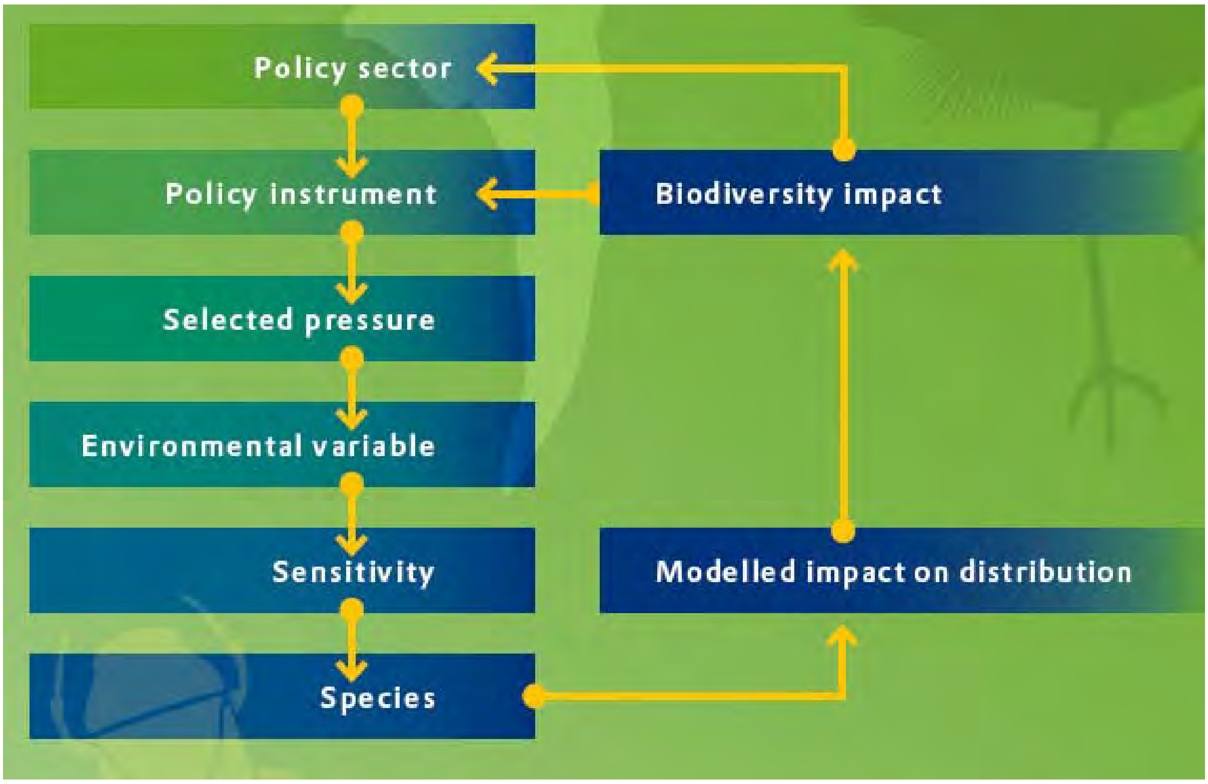


Figure 1: Conceptual model of the BioScore tool.

Figure 1 shows the model applied to this project. It basically consists of six steps, each of which is described in more detail in the following pages and chapters:

1. Identification of policy sectors with a direct or indirect, positive or negative impact on biodiversity and selection of policy instruments that are deployed by the given sector to reach specified policy goals.
2. Identification of environmental variables that may act as pressures on biodiversity.
3. Identification of indicator values for selected species that connect the species' environmental preferences (here called sensitivity scores) to the identified environmental variables.
4. Modelling the potential change in distribution range of (groups of) species based on current distribution patterns, known sensitivity scores and forecast changes in environmental variables.

5. Translating the modelled impact into biodiversity impacts by combining species groups and habitats.
6. Providing feedback to policy sectors in terms of forecast biodiversity impacts based on intended policy measures.

1.2 Identifying policy sectors and instruments

Since its establishment, now over 50 years ago, the European Community has increasingly taken a leading role in developing and implementing policies that affect the entire European Union (EU) territory. For certain sectors, such as agriculture and fisheries, the importance of 'Europe' considerably outweighs that of the individual Member States. For the sectors concerned, the EU has developed a Common Agricultural Policy and a Common Fisheries Policy, respectively. For other sectors, however, the EU only provides for a platform for coordination and harmonization or for general guidance. Member States hold full control over their policies for these sectors. An example is provided by the policy on spatial planning, for which the European Spatial Development Perspective (CEC, 1999) provides the framework for action, but it is not binding on Member States.

The European Community has developed a range of policy instruments that can in general terms be classified according to their legal status. The following descriptions of some of the key instrument types are taken from the Commission web pages on EUR-Lex (2008):

> ***Regulation***
> *Adopted by the Council in conjunction with the European Parliament or by the Commission alone, a regulation is a general measure that is binding in all its parts. Unlike directives, which are addressed to the Member States, and decisions, which are for specified recipients, regulations are addressed to everyone. A regulation is directly applicable, which means that it creates law which takes immediate effect in all the Member States in the same way as a national instrument, without any further action on the part of the national authorities.*
>
> ***Directive***
> *Adopted by the Council in conjunction with the European Parliament or by the Commission alone, a directive is addressed to the Member States. Its main purpose is to align national legislation.*
> *A directive is binding on the Member States as to the result to be achieved but leaves them the choice of the form and method they adopt to realize the Community objectives within the framework of their internal legal order. If a directive has not been transposed into national legislation in a Member State, if it has been transposed incompletely or if there is a delay in transposing it, citizens can directly invoke the directive in question before the national courts.*
>
> ***Decision***
> *Adopted either by the Council, by the Council in conjunction with the European Parliament or by the Commission, a decision is the instrument by which the Community institutions give a ruling on a particular matter. By means of a decision, the institutions can require a Member State or a citizen of the Union to take or refrain from taking a particular action, or confer rights or impose obligations on a Member State or a citizen.*
> *A decision is:*
>
> - *an individual measure, and the persons to whom it is addressed must be specified individually, which distinguishes a decision from a regulation,*
> - *binding in its entirety.*

Other instruments, not legally binding but in most cases with a direct impact on Member State legislation, include recommendations, opinions and Commission communications (COM documents). For a more comprehensive description of these and other policy instruments we refer to the EUR-Lex web pages (EUR-Lex, 2008).

For the purpose of the BioScore project we have focused on those policies and policy instruments that may have direct or indirect impacts on biodiversity. This includes three categories of policies:

- policies that have been specifically developed to protect biodiversity (e.g. the EC Communication 'Halting the loss of biodiversity by 2010 – and beyond. Sustaining ecosystem services for human well-being', COM/2006/0216 final and its Technical Annexes 'EU Action Plan to 2010 and beyond & indicators', SEC(2006) 621);

- policies that aim at more general environmental protection, which may benefit biodiversity (e.g. the Nitrates Directive, 91/676/EEC);
- policies that address other sectors which may have an impact on biodiversity, either positive or negative (e.g. the Thematic Strategy on the urban environment, (COM(2005) 718 final).

At the outset we selected 26 policy instruments from five sectors based on their relevance to biodiversity in general and the aims of the BioScore project in particular. This selection is based on an initial list by the project team that was reviewed and commented upon by the project's Steering Committee at its first meeting in 2006. The full list is included in Table 1.

Table 1: Policy instruments selected for the BioScore project.

Sector	Policy instrument	Official reference
Environment	Sixth Community Environment Action Programme	Decision No. 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme
Biodiversity	Birds Directive	Council Directive 79/409/EC of 2 April 1979 on the conservation of wild birds
Biodiversity	Habitats Directive	Council Directive 92/43/EEC of 1992 on the conservation of natural habitats and of wild fauna and flora
Biodiversity	European Community Biodiversity Strategy	Communication of the European Commission to the Council and to the Parliament on a European Community Biodiversity Strategy (COM (98)42)
Environment	Forest Focus	Regulation (EC) No. 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community
Regional Policy	European Spatial Development Perspective (ESDP)	Commission of the European Communities (1999)
Environment	EU Sustainable Development Strategy	European Union Strategy for Sustainable Development (COM(2001) 264 final) – renewed by European Council DOC 10917/06
Environment	Nitrates Directive	Council Directive 91/676/EEC of 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources
Environment	Water Framework Directive (WFD)	Directive 2000/60EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy
Agriculture and rural development	Common Agricultural Policy	Council Regulation (EC) No. 1782/2003 of 29 September 2003 (consolidated version) establishing common rules for direct support schemes under the Common Agricultural Policy and establishing certain support schemes for farmers and amending Regulations (EEC) No. 2019/93, (EC) No. 1452/2001, (EC) No. 1453/2001, (EC) No. 1454/2001, (EC) 1868/94, (EC) No. 1251/1999, (EC) No. 1254/1999, No. 1156/2006
Environment	Winning the Battle Against Global Climate Change	Communication from the Commission to the Council, European Parliament, the European Economic and Social Committee and the Committee of the regions – Winning the Battle Against Global Climate Change (COM(2005) 0035 final)
Agriculture	Agri-environment measures	Council Regulation (EEC) 2078/92 on agri-environmental measures
Environment	Biodiversity Action Plan for Agriculture	Commission Communication of 27 March 2001 to the Council and the European Parliament: Biodiversity Action Plan for Agriculture (Volume III) (COM(2001) 162 final)
Environment	Urban Waste-Water Directive	Urban Waste-Water Directive 91/271/EEC on standards for the collection, treatment and discharge of urban waste water and waste water from industrial sectors
Health and consumer protection	PPP Directive	Council Directive of 15 July 1991 concerning the placing of plant protection products on the market (91/414/EEC)
Agriculture	Pesticides Directive	Council Directive 79/117/EEC on prohibiting the placing on the market of pesticides containing certain active substances
Agriculture	Thematic strategy on the sustainable use of pesticides	COM (2002) 349 'Towards a thematic strategy on the sustainable use of pesticides'

The selection of the above-listed policy instruments was an essential step in identifying the connection between policies and their instruments on the one hand and environmental pressures and variables on the other.

Since the start of the BioScore project in February 2006, a range of new policy instruments has been adopted, such as the Thematic Strategy for Soil Protection (COM(2006) 231). These have, however, not been studies as part of this project. Some specific policies on e.g. biofuels, afforestation or air quality standards have been used as a basis for the analyses in the case studies, but not for the overall identification of environmental pressures. These are described in more detail in the case studies.

1.3 Identifying environmental variables

In order to identify the connection between the selected policy instruments and the environmental variables they impact upon (directly or indirectly), we screened all 26 legislative documents for mention of any environmental variable or pressure on biodiversity. This initial exercise resulted in a list of over 200 terms, ranging from ‘abandonment of high-nature-value farmland’ (EC Biodiversity Communication, 2006) to ‘wind’ (EC Biodiversity Strategy, 1998).

Naturally, this full list showed a large variation in the terms and generated substantial debate in the team. The list contained very specific activities with direct pressures or environmental variables related to them, such as ‘ammonia and nitrous oxide emissions to air’ (Thematic Strategy on Air Pollution 2005). It also contained broader terms such as ‘use of fossil fuels’ (Thematic Strategy on the Urban Environment 2005) or even very general terms such as ‘climate change’ (various instruments).

It became clear that, because of the type of broad policy instruments, the list in itself was too generic and did not provide variables that could be used in modelling exercises. Therefore, the list had to be reduced in length by eliminating duplicates and too generic terms and it had to focus on variables or pressures that could be connected to species preferences or indicator values. An additional selection criterion was the availability of data on indicator values for species in relation to the environmental variables. This is explained in more detail in Chapter 2.

It must be noted that, throughout this exercise the BioScore team repeatedly discussed the meaning of the concepts ‘driver’, ‘pressure’ and ‘environmental variable’. There is no one broadly agreed definition of these terms, and their interpretation depends on the angle from which one looks (i.e. what is considered a pressure in one case might be regarded as a response in another case). This discussion focused on the DPSIR framework (driver, pressure, state, impact, response) which is covered in Section 2.1.1.

For the purpose of the BioScore modelling we adopted the following sequence from policy to impact:

1. Policy sector (e.g. agriculture, forestry, energy, tourism, transportation).
2. Intended activity in the sector (e.g. fertilization, scale enlargement, building of road network, forestation, land abandonment).
3. Consequence of intended activity (e.g. eutrophication, fragmentation of habitats, land-use change).

The list of variables and consequences that was ultimately used for the BioScore tool is presented in Table 2. Section 2.1.2 provides more details on how the policy-related pressures were linked to species-related environmental conditions.

Table 2: List of environmental variables as contained in the BioScore database.

Land-use change	**Pollution**
26 land-use/cover types	Eutrophication Acidification Salinification Pollution (aquatic) Pollution (terrestrial)
Water	**Water-related changes**
Water quality sensitivity Water acidification Water eutrophication – organic pollution Water pollution Water siltation	Soil moisture Permanent water surface Temporary water availability Water quantity/flow Water transparency Bottom substrate changes Shoreline boundary zone changes

Climate change	**Fragmentation**
Climate change	Land fragmentation
Continentality	Water fragmentation
Temperature	
Water temperature	
Disturbance	**Direct pressures**
Land disturbance	Harvesting of crops
Power lines	Hunting
Trampling	Poaching or trapping
	Harvesting of fish
Species interaction	**Management**
Predation	Amount of dead wood
Introduction of non-native species or genotypes	Even aged forest
Disease organisms or parasites	Young felling age of forest
Miscellaneous	
Light	
Flooding	

1.4 Indicator values to connect species to variables

All species on Earth have their preferences with regard to their environment. These preferences can concern any component of the environment, such as soil moisture, winter temperature, altitude, distance to the sea and many others. Also other factors, more directly linked to the functioning of a species, define where a species can and cannot live. Such factors may include dispersal rate, competitiveness, and reproduction strategies. The latter variables, inherent to the species, are in scientific terms referred to as life history traits.

The presence of a species in a certain area is never defined by a single variable but always by a complex combination of many variables, including presence of and interaction with other species. However, a single variable can represent a limiting factor that prevents a species from occurring somewhere. For example, the occurrence of frost may prevent a species from surviving in temperate or cold climatic conditions.

For many species indicator values have been assigned in relation to given environmental variables or to life history traits. Among botanists the Ellenberg indicator values (Ellenberg *et al.*, 1992) are well known and provide a good example of such indicator values. These values indicate, on a scale from 1 to 9, the preference of a vascular plant species in Central Europe for the environmental variables light, temperature, continentality, fertility, moisture, soil pH and salinity. By extrapolation, such values can be called sensitivity scores to indicate whether a species is sensitive to a change in the variable under view. In the current project, we have collected such sensitivity scores for a broad range of species groups (see Chapter 2).

The BioScore rationale is based on the assumption that a sensitivity score is a connector between a changing environmental variable and the presence of a species. For example, if a given variable is expected to show an increase it is assumed that those species with a high sensitivity score for that variable (e.g. preferring low values of the given variable) might be negatively impacted in terms of their survival. At the local level it might mean that the species disappears from its location, at a larger scale it might mean that its distribution range shrinks or otherwise changes.

1.5 BioScore input into policymaking

In general terms the BioScore project has delivered a decision support tool to carry out biodiversity impact assessment of policy-related pressures. In the previous sections we have described how policy sectors and policy instruments formed the basis for identifying environmental pressures and related variables. In addition, the BioScore team has analysed the potential connection to more specific policy processes: the EC Habitats Directive, the EC Communication on Biodiversity, the SEBI2010 process (Streamlining European Biodiversity Indicators for 2010) and the topic of ecosystem services.

1.5.1 The EC Habitats Directive

The EC Habitats Directive (Council Directive 92/43/EEC of 1992 on the conservation of natural habitats and of wild fauna and flora) entered into force in 1992 and provides, together with the EC Birds Directive, the legislative framework for EC action towards biodiversity conservation. A core element of its implementation is the establishment of the Natura 2000 network of protected sites.

We have reviewed the articles of the Habitats Directive and identified the potential linkages between the BioScore tool and the implementation of the Directive. This review was based on one simple question: What can BioScore contribute to the implementation of the Habitats Directive? The outcome of the review is presented in Table 3.

Table 3: Possible contribution of the BioScore tool to the implementation process of the EC Habitats Directive.

Article in Habitats Directive	Possible BioScore contribution	Comment
4. 4) Once a site of Community importance has been adopted in accordance with the procedure laid down in paragraph 2, the Member State concerned shall designate that site as a special area of conservation as soon as possible and within six years at most, establishing priorities in the light of the importance of the sites for the maintenance or restoration, at a favourable conservation status, of a natural habitat type in Annex I or a species in Annex II and for the coherence of Natura 2000, and in the light of the threats of degradation or destruction to which those sites are exposed.	Help identify possible impacts of identified threats of degradation or destruction on habitats or species, notably those listed in the annexes.	Currently only possible on a coarse scale. With improved data and access to distribution range data, detail of analysis will improve.
6. 3) Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives. In the light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public.	BioScore may provide one of the tools for such impact assessments, especially for large-scale projects.	Potentially only possible at larger scale. With further development, site-specific analysis possible.
6. 4) If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted. Where the site concerned hosts a priority natural habitat type and/or a priority species, the only considerations which may be raised are those relating to human health or public safety, to beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasons of overriding public interest.	Based on the ecological preferences of biodiversity to be compensated and on combination of environmental variables of surrounding areas, the data contained in the BioScore tool may help identify possible areas for compensation that could yield biodiversity similar to that which is damaged.	Potentially only possible at larger scale. With further development, site-specific analysis possible.
9. The Commission, acting in accordance with the procedure laid down in Article 21, shall periodically review the contribution of Natura 2000 towards achievement of the objectives set out in Article 2 and 3. In this context, a special area of conservation may be considered for declassification where this is warranted by natural developments noted as a result of the surveillance provided for in Article 11.	BioScore may help assess effectiveness of the Natura 2000 network as a whole or in part in relation to the objectives set out in Art. 2 and 3 (favourable conservation status). However, this is not the primary aim of BioScore.	Availability of boundary data and accurate and up-to-date species distribution/abund-ance data is a condition for success.

Article in Habitats Directive	Possible BioScore contribution	Comment
11. Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species.	BioScore may contribute to this surveillance in terms of assessing changes in environmental variables and their impact on species distribution. Implementation of this Article may provide essential input into BioScore in terms of species and habitat distribution data.	Availability of timely and accurate distribution data is an issue.
16. 1) Provided that there is no satisfactory alternative and the derogation is not detrimental to the maintenance of the populations of the species concerned at a favourable conservation status in their natural range, Member States may derogate from the provisions of Articles 12, 13, 14 and 15 (a) and (b): [...] (b) to prevent serious damage, in particular to crops, livestock, forests, fisheries and water and other types of property.	BioScore may identify possible hazard areas for damage by wild species to selected crops, livestock, etc.	Potentially only possible at larger scale. With further development, site-specific analysis possible.
17. 2) The Commission shall prepare a composite report based on the reports referred to in paragraph 1. This report shall include an appropriate evaluation of the progress achieved and, in particular, of the contribution of Natura 2000 to the achievement of the objectives set out in Article 3. A draft of the part of the report covering the information supplied by a Member State shall be forwarded to the Member State in question for verification. After submission to the committee, the final version of the report shall be published by the Commission, not later than two years after receipt of the reports referred to in paragraph 1, and shall be forwarded to the Member States, the European Parliament, the Council and the Economic and Social Committee.	BioScore may contribute to the EC composite report by providing a Europe-wide progress assessment, e.g. by analysing the differences in population status within and outside the Natura 2000 network.	On condition of availability of boundary data, accurate and up-to-date species distribution data. May only be possible at coarse scales or for very large sites.
18. 1) Member States and the Commission shall encourage the necessary research and scientific work having regard to the objectives set out in Article 2 and the obligation referred to in Article 11. They shall exchange information for the purposes of proper coordination of research carried out at Member State and at Community level. 2) Particular attention shall be paid to scientific work necessary for the implementation of Articles 4 and 10, and transboundary cooperative research between Member States shall be encouraged.	-	Implementation of this Article will provide essential input to fine-tune the BioScore results.
22. In implementing the provisions of this Directive, Member States shall: (a) study the desirability of reintroducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such reintroduction contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned.	On the basis of ecological preferences of species and habitat suitability, BioScore may help identify suitable reintroduction areas in Europe.	-

1.5.2 EC Communication on Biodiversity

The key policy framework for the conservation of biodiversity at the European Community level is the EC Communication on Biodiversity of May 2006 (Halting the loss of biodiversity by 2010 – and beyond: Sustaining ecosystem services for human well-being; COM(2006) 216 final). The technical annex to the Communication (SEC(2006) 621) lists about 150 actions at Community or Member State level that jointly aim at achieving the Communication's objectives.

The BioScore team has reviewed these actions in the same way as it did for the articles of the Habitats Directive (Table 4).

Table 4: Possible contribution of BioScore to the EC Communication on Biodiversity.

Action in EC COM Technical Annex	Possible BioScore contribution	Comment
A1.1.4 ACTION: Strengthen effectiveness of Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) in informing decision making (*inter alia*: take stock of effectiveness, produce guidance, tighten legal requirements as appropriate) so as to prevent, minimize and mitigate damages to Natura 2000 sites [2006 onwards].	BioScore may contribute to enhance decision making by assessing the impacts of certain pressures on biodiversity.	-
A2.1.3 ACTION: Define criteria and identify [2006-07] high-nature-value farmland and forest areas (including the Natura 2000 network) threatened with loss of biodiversity (with particular attention to extensive farming and forest/woodland systems at risk of intensification or abandonment, or already abandoned), and design and implement measures to maintain and/or restore conservation status [2007 onwards].	BioScore may help identify areas threatened with loss of biodiversity based on the presence of threatened species.	-
A2.1.15 ACTION: Assess potential impact on biodiversity of plans, programmes and projects for afforestation (or, should the case arise, deforestation); adjust accordingly in order to ensure no overall long-term negative impact on biodiversity.	BioScore may help assess the impacts of afforestation on biodiversity.	Scale dependent due to relatively small changes in land use at European scale. See case study in this report (Section 4.1).
A2.2.1 ACTION: Identify geographical risk areas for factors affecting soil biodiversity (soil sealing, loss of organic matter, soil erosion, etc.) [by 2009].	BioScore may help identify risk areas affecting soil biodiversity.	Requires data on distribution of soil species.
A2.5.1 ACTION: As part of the preliminary flood risk assessment for each river basin, assess the risks and benefits of flooding for biodiversity [within 3 years of adoption of Directive].	BioScore may help identify what species may be positively or negatively affected by flooding and where the specific risk zones are located.	Requires identification of environmental variables related to flooding as well as location maps of potential flood areas.
A4.2.2 ACTION: Implement policies and measures in line with Thematic Strategy for Urban Environment to prevent urban sprawl [2006 onwards].	BioScore may help provide guidance on the impacts of urban sprawl on biodiversity by identifying areas of relatively higher risk for species loss due to this type of land-use change.	Scale dependent given small changes in land use at European scale.
A9.3.1 ACTION: All climate change adaptation and mitigation measures assessed to prevent negative impacts or, where prevention is not possible, to minimize, mitigate and/or compensate for negative impacts and, wherever possible, provide positive benefits to biodiversity.	BioScore may help assess the effectiveness/impact of climate change policies on biodiversity in terms of identifying sensitive species and where they occur.	-
A9.4.2. ACTION: Assess [by 2008], on the basis of available scientific evidence, and substantially strengthen [by 2010] *coherence, connectivity and resilience of the protected areas network* (Natura 2000 and non-Natura protected areas) in order to *maintain favourable*	BioScore may help assess the impacts of fragmentation on components of biodiversity and provide	-

Action in EC COM Technical Annex	Possible BioScore contribution	Comment
conservation status of species and habitats in the face of climate change by applying, as appropriate, tools which may include flyways, buffer zones, corridors and stepping stones (including as appropriate to neighbouring and third countries), as well as actions in support of biodiversity in the wider environment.	advice for development of buffer zones, corridors and stepping stones.	
A9.4.3 ACTION: Make a preliminary assessment of habitats and species in the EU most at risk from climate change [by 2007], detailed assessment and appropriate adaptation measures prepared [by 2009], commence implementation [by 2010].	BioScore can identify which species in the EU are sensitive to aspects of climate change, both positively and negatively.	-
A10.1.1 ACTION: Subject to funding being found from existing financial resources, establish an EU mechanism for independent, authoritative research based advice to inform implementation and further policy development.	BioScore is a tool to help decision making and therefore should be an element of such a mechanism.	-
A10.1.2 ACTION: Identify ways and means to strengthen independent scientific advice to global policymaking, *inter alia* by actively contributing to CBD consideration of the 2007 evaluation of the Millennium Ecosystem Assessment, and the ongoing consultations on the need for improved International Mechanisms on Scientific Expertise on Biodiversity.	BioScore is a tool to help decision making and therefore should be an element of such a science–policy process.	-
A10.1.5 ACTION: Develop and apply tools to measure, anticipate and improve effectiveness of most important policy instruments for conservation and sustainable use of biodiversity [2006 onwards].	BioScore is designed to assess the effectiveness of selected policy instruments on biodiversity.	-
B2.2.2 ACTION: Screen all new legislative and policy proposals at EU and MS levels for potential significant impacts on biodiversity in general and on ecosystem goods and services in particular, and ensure effective treatment of biodiversity concerns in policy impact assessments, in particular to ensure the maintenance of ecosystem goods and services [2006 onwards].	BioScore is a tool that can assess the impacts of policy measures on biodiversity and should be used in the development of new proposals.	-
C1.4.1 ACTION: Submit to Council and Parliament in 2009 a concise mid-term evaluation of progress towards the 2010 targets (to end 2008) and make any essential adjustments in actions to meet targets.	BioScore may contribute selected assessments to the SEBI-based reporting.	-

1.5.3 *Streamlining European Biodiversity Indicators for 2010*

The SEBI2010 process (Streamlining European Biodiversity Indicators for 2010) supports the EC Communication on Biodiversity by developing and documenting indicators that may help reporting on progress in achieving the 2010 target (EEA, 2007a). It has identified 26 indicators, in line with the global set of headline indicators as developed in the framework of the Convention on Biological Diversity (CBD) and the EU headline biodiversity indicators.

In line with the analysis for the Habitats Directive and the EC Communication on Biodiversity, the BioScore team reviewed its potential contribution to the SEBI2010 indicators (Table 5).

Table 5: Possible contribution of BioScore to the SEBI2010 indicators.

	SEBI2010 indicator	SEBI input into BioScore	BioScore input into SEBI
1	Abundance and distribution of selected species	Actual data provide input into the BioScore tool.	BioScore provides predictions based on selected scenarios.
2	Red List Index for European species	No direct link.	BioScore can be used to model impact on Red List species as a selection.
3	Species of European interest	-	BioScore can be used to model impact on selected species of European interest (e.g. listed in Annexes of Habitats Directive).
4	Ecosystem coverage	Actual data may provide input	-

	SEBI2010 indicator	SEBI input into BioScore	BioScore input into SEBI
		into the BioScore tool for refinement/validation of distribution maps.	
5	Habitats of European interest	Actual data may provide input into the BioScore tool for refinement/validation of distribution maps.	-
6	Livestock genetic diversity	-	-
7	Nationally designated protected areas	Actual data could possibly provide input into the BioScore case study on assessing effectiveness of biodiversity policy measures.	BioScore could possibly provide information on effectiveness of protected areas as policy measure for biodiversity (if trend data are available for selected sites).
8	Sites designated under the EU Habitats and Birds Directives	Actual data could possibly provide input into the BioScore case study on assessing effectiveness of biodiversity policy measures.	BioScore could possibly provide information on effectiveness of protected areas as policy measure for biodiversity (if trend data are available for selected sites).
9	Critical load exceedance for nitrogen	Provides pressure data as input into the BioScore tool.	BioScore may model the possible impacts of CLE on selected species.
10	Invasive alien species in Europe	-	Selection of IA species can be used to model impact on those species using the BioScore tool.
11	Occurrence of temperature-sensitive species	-	Direct link to BioScore. Sensitivity score for temperature used for vascular plants and butterflies to model possible impact of climate change.
12	Marine Trophic Index of European seas	No link to BioScore; marine ecosystems currently not covered.	-
13	Fragmentation of natural and semi-natural areas	Provides pressure data as input into the BioScore tool.	BioScore may model the possible impacts of large-scale fragmentation on selected species.
14	Fragmentation of river systems	May provide pressure data as input into the BioScore tool.	BioScore may model the possible impacts of river fragmentation on selected freshwater species.
15	Nutrients in transitional, coastal and marine waters	No link to BioScore; marine ecosystems currently not covered.	-
16	Freshwater quality	Provides pressure data as input into the BioScore tool.	BioScore may model the possible impacts of water quality on selected freshwater species.
17	Forest: growing stock, increment and fellings	Provides pressure data as input into the BioScore tool.	BioScore may model the possible impacts of forestry measures on selected species.
18	Forest: dead wood	Provides pressure data as input into the BioScore tool.	BioScore may model the possible impacts of forestry measures on selected species.
19	Agriculture: nitrogen balance	Provides pressure data as input into the BioScore tool.	BioScore may model the possible impacts of nitrogen balance on selected species.
20	Agriculture: area under management practices potentially supporting biodiversity	Provides response data as input into the BioScore tool.	BioScore may model the possible impacts of biodiversity management practices on selected species.
21	Fisheries: European commercial fish stocks	No link to BioScore; marine ecosystems currently not covered.	-
22	Aquaculture: effluent water quality from finfish farms	No link to BioScore; marine ecosystems currently not covered.	-
23	Ecological footprint of European countries	-	-
24	Patent applications based on genetic resources	-	-
25	Financing biodiversity management	Possibly provides response data as input into the BioScore tool.	BioScore may model the possible impact of selected types of financing of biodiversity management on selected species.
26	Public awareness	-	BioScore may provide results that could help raise public awareness on possible biodiversity impacts of policy measures.

2 The BioScore tool and species database

2.1 Methodological framework

2.1.1 Description of the DPSIR framework

The BioScore approach is to a large extent based on the DPSIR model, as developed by the European Environment Agency (EEA) and widely applied in environmental impact assessments. The DPSIR model provides the framework for the sequence of cause–effect relations between driver, pressure, state, impact and response.

Drivers are those processes in society that trigger broad-scale movements and changes. For example the increasing need for mobility of large parts of society in a globalizing world. This mobility is for instance reflected in the sharp increase in air travel for holidays, the growing number of families whose members live in different countries or even continents, or the ease with which international companies trade goods and services all over the world.

Pressures are the immediate and tangible consequences of the given drivers on components of the environment. These can be very diverse and range from immediate and direct consequences to long-term indirect pressures. In the example of mobility one can think of the expansion of transport infrastructure (e.g. more airports, new high-speed railways, or adding lanes to existing motorways) or the impact of pollution (such as noise, fine dust, CO_2, visual disturbance).

When considering biodiversity, **state** refers to the current situation of biodiversity, before a pressure has an impact. There are numerous efforts to try to measure the state of biodiversity, ranging from species numbers within a given area to a biodiversity index that is composed of multiple factors. Where possible, the state of biodiversity in the DPSIR model is related to the drivers and pressures under view. In our example of mobility it could concern the extent of semi-natural habitats or the presence or abundance of species that are protected according to European Union (EU) legislation.

The **impact** is the modelled or observed change of the state over a given time. The same indicators can be used to measure the change. For instance, again in the given example of transportation, the impact might be measured in terms of the extent of semi-natural habitats that will be directly lost or fragmented due to the construction of a motorway. An impact might also be the change in species composition of a given area due to changing environmental conditions.

Response is used here to refer to the reaction by policymakers, citizens, companies or other stakeholders to the observed or modelled changes in biodiversity caused by a driver–pressure combination. Usually the responses, in terms of policy feedback, are in terms of policy measures that try to reduce or compensate for the identified impacts. In the case of mobility as a driver, possible responses may include the construction of ecoducts to reconnect fragmented habitats, the development of aircraft that are less noisy and less polluting, or the location of a railway in an alternative area.

For all of the above steps indicators have been developed by many organizations and networks to allow measuring and communicating the cause–effect relationships as described by the DPSIR model. For biodiversity in Europe, in particular the SEBI2010 process (Streamlining European Biodiversity Indicators for 2010), as led by the EEA, ECNC and the United Nations Environment Programme (UNEP), provides a key framework. The SEBI2010 initiative has identified and described 26 indicators that together will allow policymakers to understand the state of affairs with regard to biodiversity and the pressures impacting on it (EEA, 2007a).

Chapter 1 described how BioScore starts from European Community policy instruments. Hence the DPSIR framework provides a very useful model to frame the biodiversity impact assessment as aimed for by the BioScore tool. However, from the outset the BioScore team identified a missing link in the DPSIR model with regard to the mechanism that relates the pressures to impacts on biodiversity. In many cases when effects on biodiversity are observed when a certain pressure is occurring, it is taken for granted that this pressure indeed causes the effect. It is not always clear exactly what environmental change is causing the biodiversity impact. For example, when a population of Flamingos disappears after hotels and apartment blocks have been built in the vicinity of the salt ponds in which they used to breed, one can wonder why it is they left. Is it because the flight route between nesting place and feeding area is blocked by high buildings? Is it because the water table in the pond has gone down or because more people walk around the pond, with dogs?

For this mechanism to be understood it is important to know something about the preferences of species in relation to environmental variables, as well as about their sensitivity to a change in these variables. This is where BioScore comes in. BioScore has added the notion of sensitivity or ecological preference or habitat suitability in between the steps of pressure on the one side and impact on the other. By identifying sensitivity scores of species to as many environmental variables as possible, the BioScore tool is able to assess a wide range of cause–effect relations across Europe.

2.1.2 Environmental pressures

A key component of the BioScore approach was to identify the linkages between individual species and their preference or sensitivity to environmental variables or the change in these. We have approached this linkage from two directions: one starting from the policy angle, as described in the previous chapter; and a second one starting from the species angle. In the second case, we collected publications and online resources that contain indicator values for species-pressure relations (see next paragraph). This resulted in a wide range of variables, some of which concern life history traits (e.g. dispersal capacity), and others distribution scales (e.g. country or biogeographical region, BGR). A total of 35 variables, for which species-related data were found, have been listed (Annex 1).

A pragmatic and iterative process was followed to connect the environmental pressures that came out of the policy review with Annex 1. In order for the tool to become operational, we compiled a list of 39 variables that resulted from the connecting exercise and that provided a practical way of querying the BioScore database. This list is presented in Table 2.

2.1.3 Focal species

The focal species concept was first proposed by Lambeck (1997, 1999) in an effort to provide a scientific basis for landscape restoration. The basic idea is that of identifying a set of species whose management and conservation can potentially be effective also for most of the other species that are present in the same landscape. Although the concept of focal species has been widely criticized (e.g. Lindenmayer *et al.*, 2002), the approach has a number of advantages and it has been used in many different applications worldwide (Noss *et al.*, 1997; Miller *et al.*, 1999; Foreman *et al.*, 2000; Bani *et al.*, 2002).

The focal species approach becomes particularly important when the number of species to be considered is extremely high and, thus, when it is not possible for practical reasons to consider all the species in a management and/or conservation plan. In the BioScore project we have considered a very large study area (Europe) inside which a large number of species are present. The Fauna Europaea databank (www.faunaeur.org) reports for Europe 1,795 species of vertebrates (Chordata) and many hundreds of thousands of species for invertebrates (e.g. just considering the Italian peninsula, more than 55,000 species; www.faunaitalia.it/checklist/introduction.html); the Flora Europaea databank (http://rbg-web2.rbge.org.uk/FE/fe.html) reports more than 15,500 species of vascular plants (excluding the extremely rich Turkish flora).

Due to the large number of species in Europe, it is obviously impossible to work with the entire number of biota occurring in the EU. Therefore, we needed a criterion to reduce the number of species to be considered by selecting a set of focal species and considering the taxa for which the BioScore consortium have proven expertise or access to public databases. In particular, we considered mammals, reptiles, amphibians, birds, butterflies, dragonflies, vascular plants, freshwater fish, and aquatic macrobenthos (benthic organisms larger than 1 millimetre).

Among the many possible alternatives, we followed the selection criteria proposed by Maes and Van Dyck (2005), who analysed the efficacy of a threatened butterfly indicator species in Belgium considering 624 species from 20 different taxonomic groups. The aim of the work was to find a group of species that can work as an 'umbrella' to deal with vulnerability, fragmentation, eutrophication, etc. in conservation planning and evaluation. The approach developed by the authors was therefore particularly well suited for the development of the BioScore tool. In particular, for each species group considered we retained only species for which enough information was available on potential effects with regard to the selected environmental pressures. This information was gathered from a large number of books, published literature, expert judgement questionnaires, and existing databases (see paragraphs below for an overview on the datasets considered). Subsequently, in the analyses we retained only those species with an intermediately rare distribution. For species groups, such as butterflies, where relatively detailed distribution maps are available on the scale of Europe, species were retained when they occurred in 10–20% of the surface area in at least one of the BGRs in Europe, following the classification defined by the EEA (Alpine, Anatolian, Arctic, Atlantic, Black sea, Boreal, Continental, Macaronesia, Mediterranean, Pannonian, Steppic; Figure 2) (EEA, 2006a). For taxa for which no detailed distribution information was available (as was the case for most species at the beginning of the BioScore project), we selected only species that are present in a specific BGR without covering the entire European territory. For these species we focused particularly on species included in the Birds or Habitats Directive whenever possible.

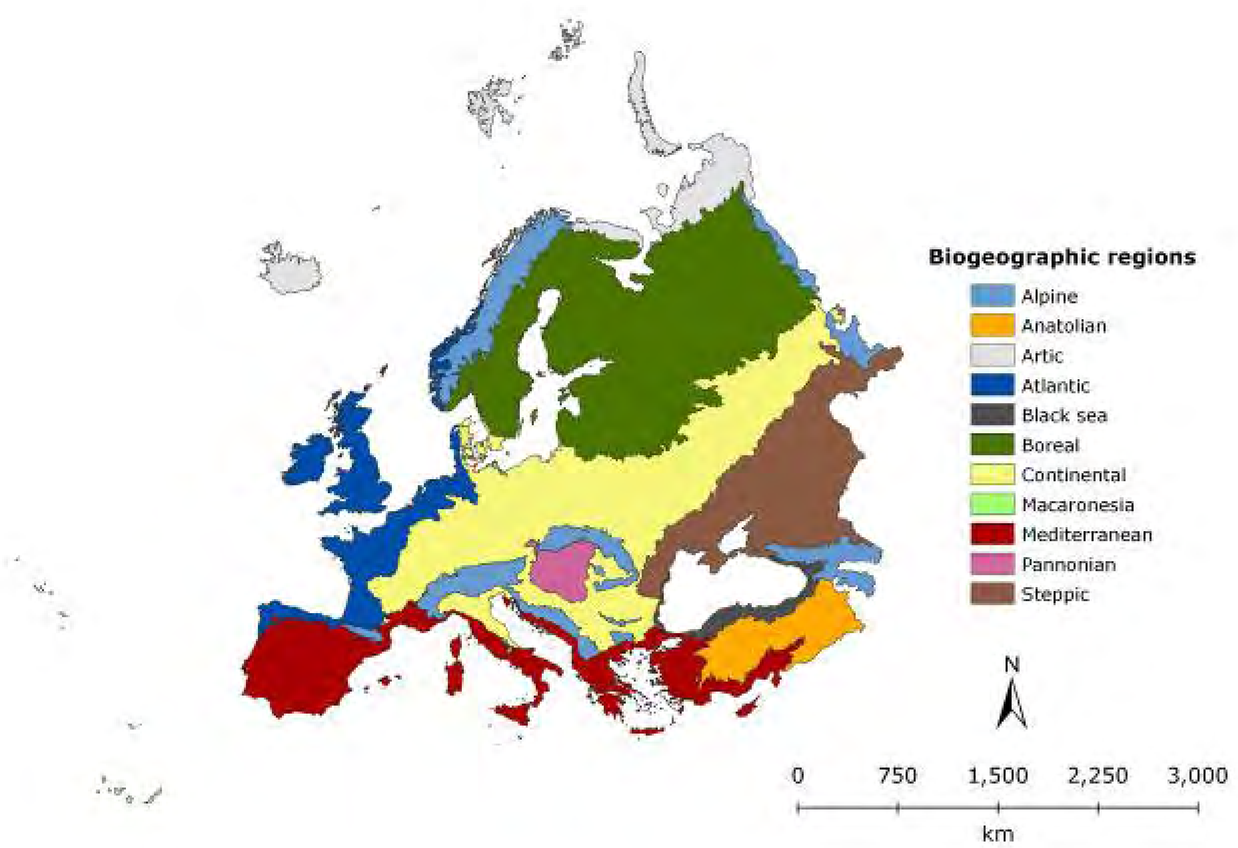


Figure 2: BGRs in Europe as defined by the EEA (2006a).

For the selection of vascular plants, with more than 15,500 species occurring in Europe, we used the 'target species approach' as developed by Ozinga and Schaminée (2005) to reduce this large number to a meaningful subset. According to the authors, target species are defined as species of European importance which fulfil at least one of the following criteria:

- legal protection: European legislation imposes specific measures on its contracting parties;
- threat: survival in the near future is threatened on the global level;
- geographical distribution (endemism): global distribution is small and restricted to Europe or highly characteristic for Europe.

Following these selection criteria we retained a set of 1,092 species (among mammals, reptiles, amphibians, birds, butterflies, dragonflies, vascular plants and freshwater fish) and 133 aquatic macrobenthos families (Table 6). The complete list of species considered (families for aquatic macrobenthos) is provided in Annex 2.

The BioScore consortium, considering future analyses and possible improvements of the currently available dataset, considers expanding the list of species to include threatened plants, host plants for butterflies, and a higher number of terrestrial mammals, reptiles and amphibians as soon as new data become available. The international projects Global Mammal Assessment, Global Reptiles Assessment, and Global Amphibians Assessment are expected to make such data available soon.

Table 6: Species included in the BioScore database.

	Total number	Number with data	Retained number
Mammals	295	60	60
Reptiles	217	30	28
Amphibians	88	20	20
Birds	526	478	179
Butterflies	576	152	77
Dragonflies	130		122
Vascular plants	15974	3000	390
Freshwater fish	450	216	216

Table 6 shows the number of species occurring in Europe (Total number), those for which enough data are available to be included in the BioScore database (Number with data), and those included in the final version of the database (Retained number). Aquatic macrobenthos is not included in the table because we considered only the family level (133 families are included in BioScore).

2.1.4 Sensitivity scores

A number of models have been developed to predict consequences on biodiversity of ongoing human-driven processes under likely scenarios. These predict either local biodiversity losses or changes in species distribution areas (e.g. Bakkenes *et al.*, 2002, 2006; Thomas *et al.*, 2004; Thuiller *et al.*, 2005; Scholze *et al.*, 2006). Most of these models rely on species-specific information, the so-called ecological requirements or ecological signatures of species. Depending on how the species' ecological signatures are obtained, it is possible to distinguish between deductive and inductive models (Corsi *et al.*, 2000). Inductive models, of which there are numerous applications, determine ecological requirements of species by combining species occurrence data with values of concurrent environmental variables using a variety of statistical procedures (Guisan & Zimmermann, 2000; Elith *et al.*, 2006). Deductive models represent an alternative approach where expert knowledge and/or published data are used to determine the ecological signature of species (e.g. Maiorano *et al.*, 2006). In both cases, the derived ecological signatures are used in Habitat Suitability Index analyses or equivalent procedures (e.g. Corsi *et al.*, 2000; Hirzel *et al.*, 2002; Titeux *et al.*, 2004; Guisan & Thuiller, 2005; Hickling *et al.*, 2006; Heikkinen *et al.*, 2007) to predict species suitability, their presence in the area under study or their incidence under particular scenarios of future environmental conditions (e.g. Rounsevell *et al.*, 2006; Spangenberg, 2007). Deductive models, being more general, have the power to forecast potential species occurrences over large areas, encompassing much ecological variability across the study area (e.g. the scale of Europe), even when few or no data on species occurrences are available. This makes them especially suitable for human/policy impact assessment (Corsi *et al.*, 2000; Boitani *et al.*, 2008).

Although knowledge of species signatures should be based on direct measurements over a representative sample of survey sites or experimental units, this can be very time consuming, particularly over extensive study areas or for large numbers of species. Hence, the use of sensitivity scores may form a valid alternative for predicting policy impacts on biodiversity in a cost-effective way. Sensitivity scores typically link environmental pressures, i.e. consequences of policy measures, directly to the ecology of the species and therefore have the advantage of being relatively simple and user-friendly. They have the benefit of simplifying values for a given attribute (e.g. dispersal distance) among species, by arbitrarily placing species into classes according to their tolerance levels for specific environmental pressures (e.g. degree of habitat fragmentation). Sensitivity scores have been widely applied in a number of research fields, particularly medicine (e.g. Carnes *et al.*, 2006; Pancorbo-Hidalgo *et al.*, 2006; Suzuki *et al.*, 2006), but have not been extensively used in environmental studies focusing on habitats (Angelidis & Kamizoulis, 2005), or species and communities, with the exception of indexes for quality assessments of water courses based on aquatic macrobenthos organisms (Hansen & Urban, 1992; Tucker & Evans, 1997; Delbaere & Nieto Serradilla, 2005; Horrigan *et al.*, 2005; Scholes & Biggs, 2005; Santelmann *et al.*, 2006).

In a broad sense, all ecological characteristics of a species, from survival to successful reproduction, can be represented as a kind of sensitivity score towards changes in variable values. Information such as optimal habitat type, dispersal capacity, minimal area requirements, preferred soil texture, and sensitivity to exploitation pressures, can be applied in habitat modelling when the necessary maps (e.g. land cover, soil) and models (e.g. measures of sensitivity to climate change) are available. In their strict sense, sensitivity scores refer to a simplification of the often wide range of values for a given ecological characteristic by transforming them into arbitrarily chosen classes. Despite the loss of information, data and measures become much easier to handle, and general patterns can be easily derived for large numbers of species over large study areas, even if limited information is available.

Sensitivity to land-use change
We directly linked each species to the different land-use classes (Corine Land Cover; Nunes de Lima, 2005) in which they are known to occur using habitat suitability scores. In this way it was possible to link each species to a change in land use occurring as result of a particular policy. Many different possibilities are available but we adopted the following scheme based on four ranks:

- 0: the species is indifferent to a change or loss in that class of land cover type;
- 1: the species shows little response to a reduction of that class of land cover type;
- 2: the species is moderately sensitive to a loss of that class of land cover type; and
- 3: the species is closely associated to that class of land cover type and highly sensitive to its loss.

Vascular plants
For vascular plants the sensitivity scores are largely derived from Ellenberg indicator values for the flora of Central Europe (Ellenberg *et al.*, 1992). This system of indicator values is probably the most widely used system based on sensitivity scores in ecology and conservation. Although it is largely based on expert judgement, there is strong experimental evidence of its accuracy, with several studies reporting a close correlation between average indicator values and corresponding measurements of environmental variables (Thompson *et al.*, 1993; Schaffers & Sýkora, 2000; Diekmann, 2003; Ozinga *et al.* 2005). The indicator values for Central Europe (Ellenberg *et al.*, 1992) were supplemented with adjusted scores for Great Britain (Hill *et al.*, 1999) and Italy (Pignatti *et al.*, 2001). The starting point for the list of vascular plants was the 'Target Species database' (Ozinga & Schaminée, 2005). The Target Species database was updated according to taxonomy and geographical coverage. The database was integrated in the species checklist within the expert system SynBioSys Europe (Schaminée *et al.*, 2007).

Benthic macroinvertebrates
Benthic macroinvertebrates are used in almost all parts of the world as bioindicators for the level of water pollution caused by oxygen-depleting organic components of effluent (Braukmann & Biss, 2004). Moreover, benthic macroinvertebrate communities of running waters have shown to be seriously affected by acidification and this is the reason why they have been used as 'early-warning' organisms to detect acidification (Otto & Svensson, 1983; Raddum & Fjellheim, 1984). Several biotic indices and scores have been developed to assess water quality. A biotic index or a biotic score takes account of the sensitivity or tolerance of individual species, families or groups to pollution and assigns them a value, the sum of which gives an index of pollution for a site. They are based on the principle that the macroinvertebrate families, which are more susceptible to oxygen depletion, should take a high score, whereas tolerant ones should be assigned a low score. Based on the specific principle and on the availability of the current biotic scores that are used across Europe, scores have been assigned to the respective families of benthic macroinvertebrates, as regards water pollution, and to the respective species, as regards water acidification.

2.2 Data availability

The BioScore tool requires a large amount of data on the ecology and distribution of all the species considered. We collected a large database containing the information on each of the 1092 species using the most updated references available at the moment of data collection. A full list of all the databases and literature collected for the project is available in Annex 3.

Most of the data sources considered in the BioScore database were produced in the late 1990s or later (with some exceptions). They reflect the ecology and distribution of the species considered with the most recent available information. For mammals, reptiles and amphibians, besides considering many different published data sources, we considered three recently completed and/or ongoing worldwide projects (the European Mammal Assessment, the Global Amphibian Assessment, the Global Reptile Assessment). The idea behind the three projects is simple and straightforward: put together into regional workshops the best available species authorities to obtain the most updated data on distribution and ecology of the different species. These three databases are publicly available (the European Mammal Assessment and the Global Amphibian Assessment) or easy to obtain through contact with IUCN (the Global Reptile Assessment) (see Annex 3 for full references).

For dragonflies and butterflies we considered a number of articles (Annex 3) and websites[1] on distribution and ecology, and we further consulted with country-specific experts (Elisa Riservato for Italy; Cosmin O. Manci for Romania; Milen Marinov for Bulgaria; Elena Dyatlova for Ukraine).

For butterflies, the European distribution atlas (Kudrna, 2002) and the new Climatic Risk Atlas of European Butterflies (Settele *et al.*, 2008) hold detailed information on the distribution of butterflies in Europe.

Data on birds were from Hagemeijer & Blair (1997) and Tucker & Evans (1997).

For benthic macroinvertebrates, we considered a number of articles (Armitage *et al.*, 1983; De Pauw & Vanhooren, 1983; Gabriels *et al.*, 2005; Alba-Tercedor & Sánchez-Ortega, 1988; Alba-Tercedor *et al.*, 2002; Davy-Bowker *et al.*, 2005; Bækken & Kjellberg, 2004; Fjellheim & Raddum, 1990; Raddum, 1999; all listed in Annex 3) on scoring systems and ecology, and we further consulted with country-specific experts, especially regarding acidification (Ann Kristin Schartau for Norway, Leonard Sandin for Sweden).

For vascular plants the sensitivity scores are derived from many publications, including Ellenberg *et al.* (1992), Hill *et al.* (1999) and Pignatti *et al.* (2001). Distribution data were derived from the expert system SynBioSys Europe (Schaminée *et al.*, 2007). Within SynBioSys Europe it is possible to show country-based distribution patterns for each individual plant species, based on Flora Europaea and national species lists. For a subset of species more detailed spatial information is available based on distribution maps from the Atlas Florae Europaeae project (Jalas *et al.*, 1972–1999). The Atlas Florae Europaeae uses a 50 x 50 km grid modified from the Military Grid Reference System (MGRS).

Data on the distribution and ecology of freshwater fish have mainly been extracted from a few key sources (Kottelat, 1997; Maitland, 2000; Kottelat & Freyhof, 2007) as well as Fish Base (http://filaman.ifm-geomar.de/Summary/SpeciesSummary), but with a more restrictive definition of species within salmonids (*Salmo*, *Salvelinus* and *Coregonus*) (cf. Elliott, 1994; Savvaitova, 1995; Østbye *et al.*, 2006). Information on threat and sensitivity to environmental pressures has been taken from these general sources as well as Reynolds *et al.* (2002; 2005), Rochet (2000) and other papers on fish life history and population viability.

The entire database can easily be updated as new data become available. At the same time new species can easily be added following the same structure and providing an important improvement for the BioScore tool while maintaining the same level of usability.

[1] Denmark: http://home1.stofanet.dk/erland_refling/index_uk.htm
Sweden: www.petzon.se/dragonfly/english.html
Finland: www.korento.net/species.html#distr
Czech Republic and Slovakia: www.odonata.cz
Poland: www.odonata.pl/systematyka.php
Hungary: http://szitakoto.dyn.hu
Ukraine: http://dragonflyforall.narod.ru/odonata/index_engl.html

2.3 Technical description of the database

2.3.1 Introduction

The core of the BioScore tool is the database that relates species to their sensitivity to environmental changes, including an indication of the suitability of habitats for each species. The database combines separate databases compiled for each species group by different organizations (see Sections 2.1 and 2.2).

The combined database contains information on habitat suitability and sensitivity for a wide variety of environmental variables (see Section 2.1). The suitability and sensitivity scores are used to assess impacts of environmental change by calculating the number and percentage of species that respond to a given change in environmental variables or in land use. These numbers are presented per species group, BGR , country or for all EU25 countries together. Results are also presented per environmental variable and summarized over the variables. In Figure 3 the general set-up of such an assessment is given. By applying the BioScore tool the relevant suitability and sensitivity scores are extracted from the BioScore database and the number and percentage of species sensitive to change in the assigned environmental variables are calculated.

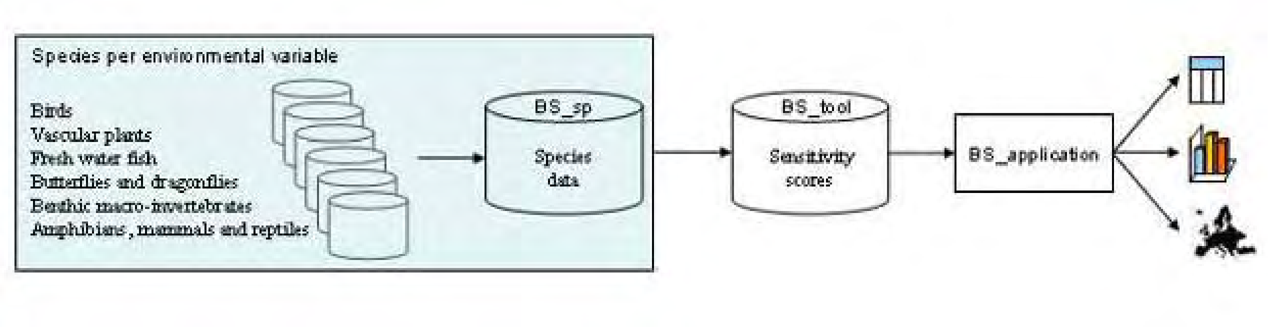


Figure 3: Relation between separate species databases, BioScore database and the BioScore tool.

In this chapter we first briefly describe the BioScore database, then we describe how sensitivity and suitability scores can be used to estimate impacts of environmental and habitat change on biodiversity. The algorithms used are described in more detail in Annex 4.

2.3.2 Species database

The BioScore database contains information on sensitivity and suitability of species for a series of environmental variables (Table 2). More than 1,000 species from different species groups are included.

Figure 4 shows a simplified structure of the BioScore database.

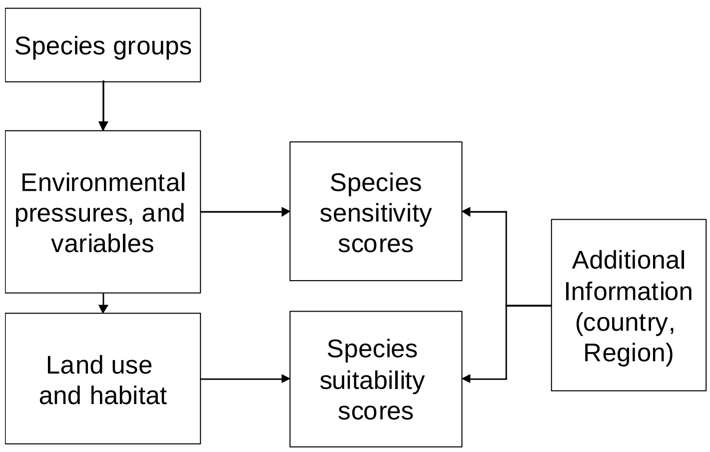


Figure 4: Simplified structure of the BioScore database.

The species datasets (species sensitivity scores and species suitability scores) form the core of the database. These datasets are related to the list of environmental variables and the lists of additional information. The additional information defines the species lists selected for different countries and BGRs, and helps to restrict the analyses to certain regions and countries in the aggregation protocol. The table in the BioScore database named 'Environmental pressures and variables' contains the link between species groups and available sensitivity scores. Table 7 summarizes this list.

Table 7: Available sensitivity and suitability scores in the BioScore database.

Environmental variable	Amphibians	Reptiles	Mammals	Benthic macroinver-tebrates	Birds	Freshwater fish	Vascular plants	Butterflies	Dragonflies
Land-use change	x	x	x		x	x	x	x	X
Pollution									
Nitrogen availability							x		
Soil acidity							x		
Salt tolerance							x		
Pollution					x				
Toxic pollutants					x				
Water									
Water quality sensitivity	x	x							
Water acidification				x		x			
Water eutrophication						x			
Water pollution	x	x	x	x		x			
Water siltation						x			
Water-related changes									
Soil moisture							x		
Permanent water surface						x			
Temporary water availability						x			
Water flow (reduced quantity of flow)						x			
Water transparency						x			
Bottom substrate changes						x			
Shoreline boundary zone changes						x			
Climate change									
Climate change in general	x	x	x						
Continentality							x		
Temperature increase							x		
Water temperature increase						x			
Fragmentation									
Fragmentation of landscape or water flows	x	x	x			x		x	
Disturbance									
Land disturbance (e.g. ploughing)					x				
Power lines					x				
Trampling					x				
Direct pressures									
Harvesting of crops or fish					x	x			
Hunting					x				
Poaching or trapping					x				
Species interactions									
Predation					x				

Environmental variable	Amphibians	Reptiles	Mammals	Benthic macroinver-tebrates	Birds	Freshwater fish	Vascular plants	Butterflies	Dragonflies
Introduction of non-native species or genotypes						x			
Disease organisms or parasites						x			
Forest management									
Amount of dead wood					x				
Even-aged forest					x				
Young felling age of forest					x				
Miscellaneous									
Light demand (related to open spaces)							x		
Flooding					x				

Using a series of queries and algorithms (Annex 4) the suitability and sensitivity scores can be extracted for various selections of environmental changes for selections of countries and regions, and basic information such as percentage of species expected to increase or decrease, can be generated.

2.3.3 Calculating impacts of environmental change

Sensitivity scores

Sensitivity of species is defined as the potential response of species to a change in the environment. Species are sensitive if they respond to a change, which can be either positive (the species increases in abundance or distribution as a result of a certain change), or negative (the species decreases in case of a change, or species are not expected to change). In general, species are not equally sensitive to every environmental change. A species can be very sensitive to one variable, e.g. eutrophication, and not to another, e.g. disturbance.

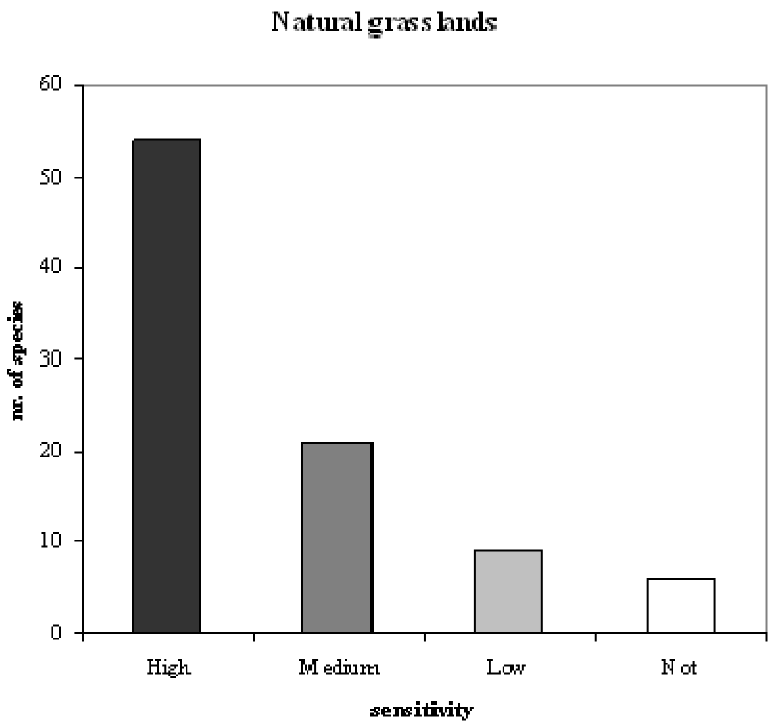


Figure 5: The number of species for each sensitivity class. An example for vascular plants of natural grassland and the sensitivity to increasing nitrogen deposition.

For each species, sensitivity scores are given for a selection of environmental variables (Table 7). These scores reflect the species sensitivity to a certain change of an environmental variable. Sensitivity scores are available in two classes: sensitive or not, or in four sensitivity classes: high, medium, low or not (Figure 5).

The information on sensitivity is linked to the magnitude and direction of change. Highly sensitive species will potentially respond even if the change in the environmental variable is small, while species with low sensitivity will only change if the environmental variable is changing considerably. This means that the magnitude of change can be calculated for three increasing and three decreasing degrees of magnitude (Figure 6). The direction of change of the environmental variable can be either increasing or decreasing.

magnitude and direction of change						
decrease		no change			increase	
---	--	-	0	+	++	+++
o----o----o----●----o----o----o						

Figure 6: Degrees of magnitude of a change in an environmental variable.

The response of a species depends on its sensitivity and on the actual environmental change. In BioScore this combination is modelled by linking the response to both the magnitude of change and the sensitivity of a species. Table 8 shows the general concept. For each environmental variable a similar scheme was constructed based upon expert opinions on the relevant ecological process.

Table 8: Linking response to change and sensitivity, an example.
0 means no change, - denotes a decrease of the species and + denotes an increase in either abundance or distribution (presence).

Magnitude of change*	High	Medium	Low	Not**
+++	-	-	-	0/+
++	-	-	+	0/+
+	-	0	0	0/+
0	0	0	0	0
-	0	0	+	-
--	+	+	-	-
---	+	-	-	-

* + is increase of the pressure, - is a decrease
** Species not sensitive is defined for an increase. Decreasing pressure will result in the opposite.

From Table 8 it is clear that highly sensitive species (sensitive to an increase in pressure) will decrease at any increase of a pressure. The same highly sensitive species will only respond to a large decrease of that pressure. Not sensitive species will not respond to an increase of the pressure, or will even increase as the available space for these species may increase, but will respond to a reduction of the pressure.

Figure 7 on the next page shows the resulting response of the species considered to the environmental change, as expressed in terms of percentage of the species that potentially will decrease or increase with varying degrees of magnitude of environmental change.

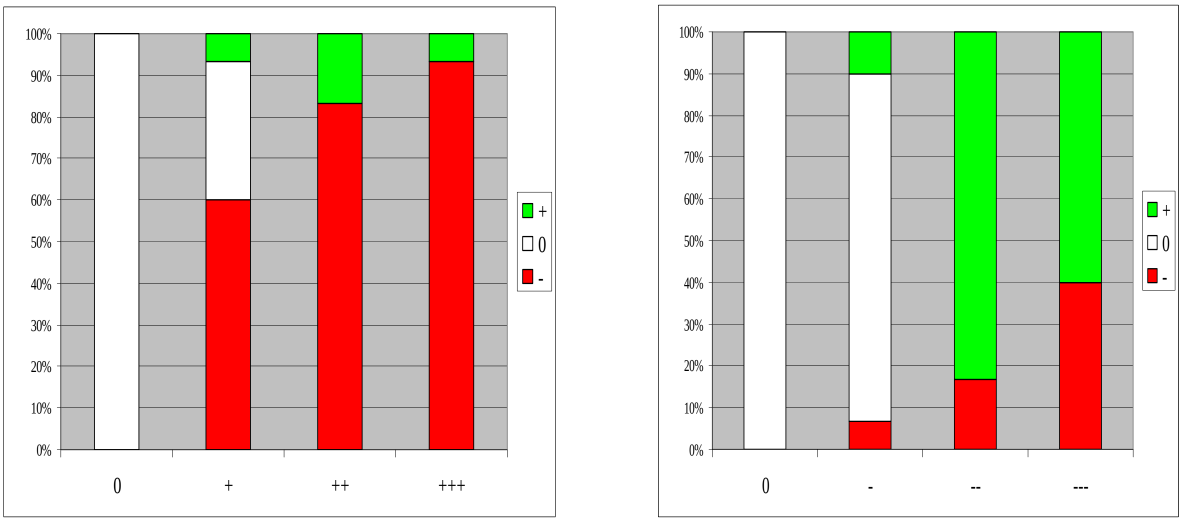


Figure 7: Percentage of species potentially increasing (green) and decreasing (red) at various magnitudes of change. + Denotes an increase of the pressure, - a decrease, as resulting from the example in Table 8 and Figure 5.

Suitability scores
Sensitivity scores for land-use changes are derived from the habitat suitability scores, available in the BioScore database. Suitability scores for each land cover type, according to the Corine Land Cover (CLC) database, are available in four classes: highly suitable, medium suitability, low suitability, not suitable.

Land-use changes result in changes from one or more land-use or land cover type(s) into one or more other land-use/land cover type(s). The net total area after change has to remain equal. By comparing the suitability scores from one land-use type to the other, the net change for each species can be determined. In this way a 'sensitivity score' for a species is derived for the specific land-use change(s) under view. To simplify calculations a species is considered present in a specific land-use type if it has a high or medium suitability score, in the other cases it is considered absent. To obtain the net effect of all land-use changes together for a species, an area-weighted calculation is performed considering the size of the land-use change, multiplied with the obtained 'sensitivity scores'. In Annex 4 the algorithms used to calculate increases and decreases are explained.

2.3.4 Combining environmental changes

BioScore allows the evaluation of simultaneous changes of different environmental pressures. As species are not equally sensitive for every change, the combined analyses use protocols to derive the net change of each species resulting from multiple environmental changes (Annex 4). To calculate the net change we first derive the potential increase or decrease for each species for each environmental variable. The net change is derived by summing up all the species responses. A decrease resulting from one pressure may be compensated by an increase due to another. The BioScore tool allows for weighing between environmental pressures and variables if the user considers a change of an environmental pressure more important than another (Chapter 3). The net change of a species resulting from all environmental changes determines whether a species increases or decreases in the specified geographical resolution. This can be a grid cell of a map when maps derived from other models are used as an input, or countries or BGRs if the BioScore tool is used.

Aggregation
The increasing and decreasing species are counted per species group and for each environmental variable. The same species may be expected to increase due to one variable and decrease due to another. Whether these species show a net change depends on the magnitude of change and the importance of the variable. To calculate the net effect of all changing variables combined, the effect per environmental variable is multiplied by its relative importance, so the relative importance weighs all selected variables relative to each other. The number of stable species in the aggregated results consists of the species that are not affected by any variable and those where increases are compensated by decreases.

The total aggregated value over species groups is a non-weighed mean of the percentages calculated for each species group.

3 How can the BioScore tool be applied for impact assessments?

3.1 Introduction

The BioScore database contains sensitivity and suitability scores of species in relation to environment variables so that a wide variety of environmental changes can be analysed. BioScore can be used in combination with socio-economic models, land-use change models and environmental models to evaluate scenarios and policy options. In Chapter 4 some examples are given in the form of case studies.

BioScore also provides a rapid assessment tool to support policy advisors in choosing options in the policy design stage. The aim is to provide a quick scan of possible biodiversity impacts for different alternative policy options. For a thorough analysis BioScore needs to be used in combination with other models.

3.2 Quick BioScore tool

The Quick BioScore Tool aims at answering directly policy questions or preliminary ideas on policy options in the 'what-if' form. The tool is independent and can be downloaded from the Internet. The tool works at the geographical level of Europe as a whole, for biogeographical regions (BGRs) and at the country level.

Five steps are needed to perform a quick analysis as part of what is called 'Define your own assessment'. Firstly, a policy option needs to be envisioned. Secondly, one needs to choose the geographical level: Europe as a whole, a specific country or a BGR. Thirdly, the environmental consequences of that policy measure need to be described. The BioScore tool provides a list of pressures and environmental variables to help in this process. In practice environmental pressures can be chosen and can be altered upward or downward in line with the consequences expected from the policy option. One needs to think of unwanted side effects of measures or synergy with other variables. These variables need to be altered as well in the tool. Then one needs to think whether the option has a land-use/cover effect in one way or another. The magnitude of expected change in variables can be selected as well. The last step is to execute the query on the basis of the choices made, and then the results are displayed. Results are provided in the form of a table, a graph or a map.

The four steps of 'Define your own assessment' are shown in Figures 8–13 on the following pages.

Step 1: Choose the relevant geographical level.
Choose the geographical scope of your interest: European Union (25 countries), a biogeographical region, or a country in the EU. In our example, the analyses will be performed for the whole of the EU.

Figure 8: Step 1 of 'Define your own assessment'**.**

Step 2: Select the changing environmental variables or pressures. In step 2 you choose those variables and indicate the expected magnitude and direction of change in the variable. You can use the sliders to simulate a change in environmental variables. You can change multiple variables and you can indicate how important the respective variable is.

In this example 'land cover change' is selected, eutrophication is expected to decrease, soil moisture is expected to be less of a pressure (which means higher soil moisture). The eutrophication is considered as the important change, whereas the soil moisture effect is only a side effect.

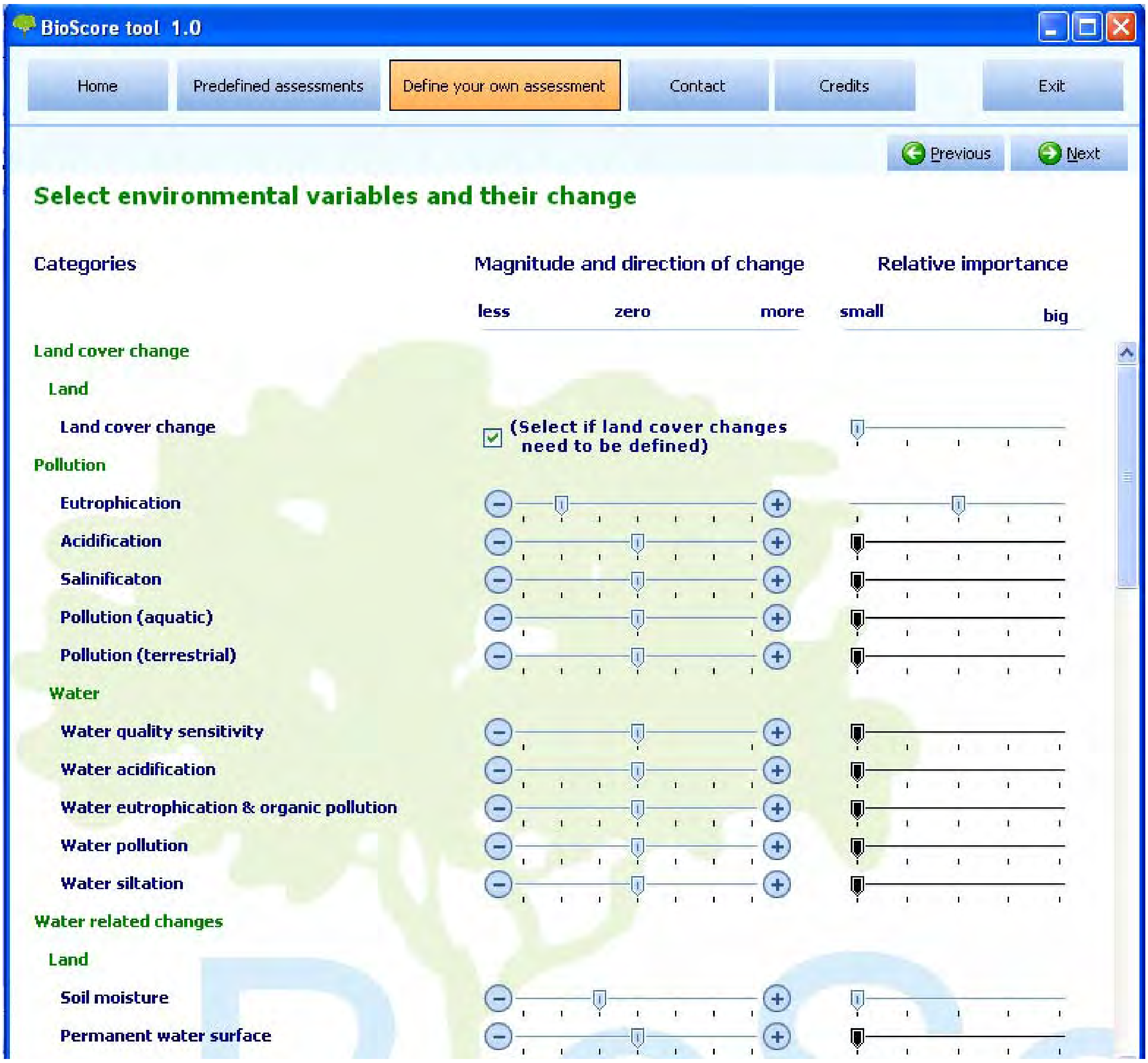


Figure 9: Step 2 of 'Define your own assessment'.

Step 3: Select the potential magnitude of land cover changes. This step only applies if in the previous step 'Land cover change' was selected.

Here, one can specify what land cover type is expected to increase/decrease in area. As the size of Europe does not change, a change in one category must be compensated with a change in one or more others, in order to stay within the indicated threshold. This threshold is scale dependent, i.e. it varies depending on the country or region selected.

In this example we set the decrease of arable land and pastures on approximately 5,000 km^2 each, and to compensate that we increased heterogeneous agricultural areas and natural grasslands by 7,000 and 3,000 km^2, respectively.

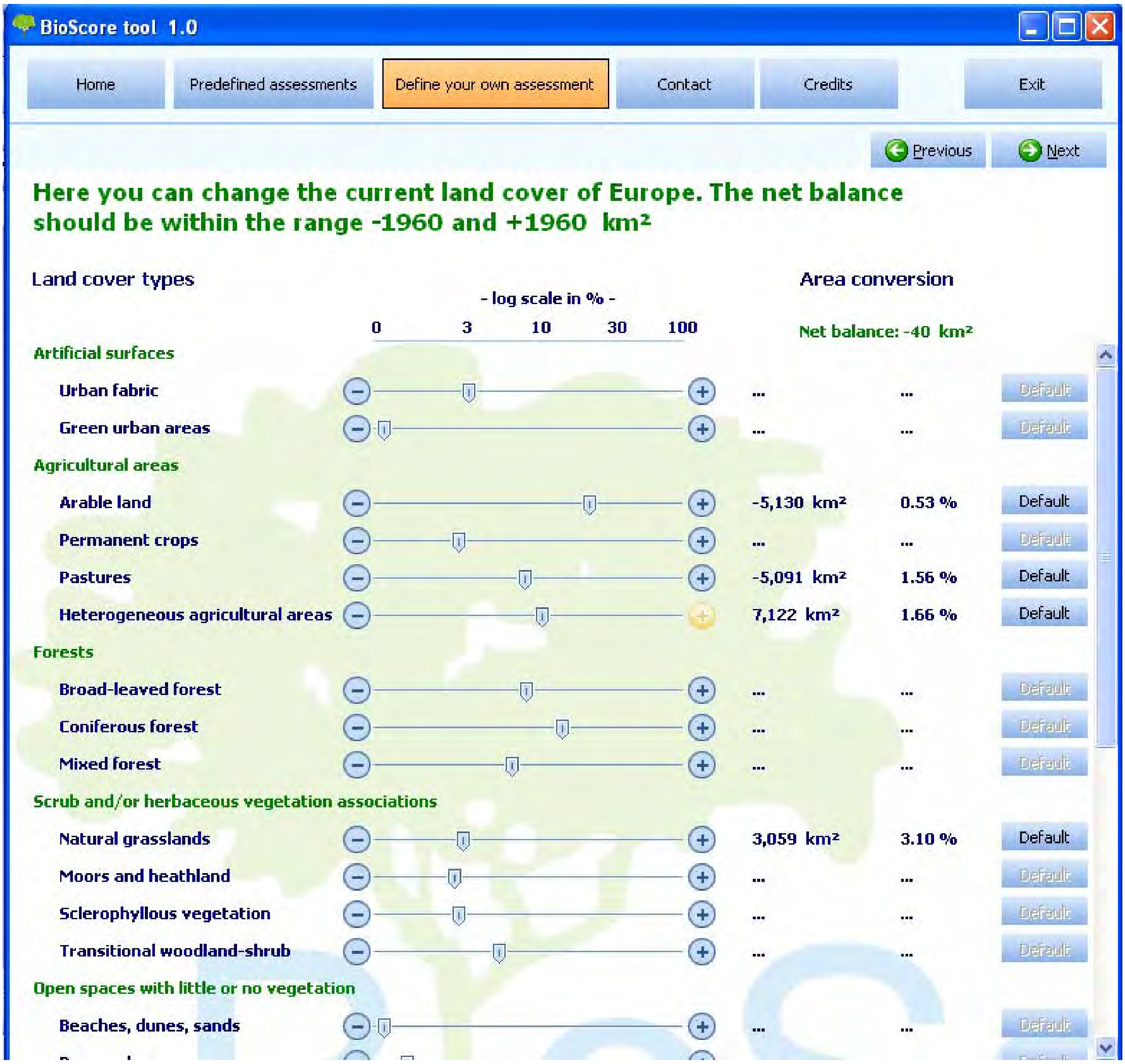
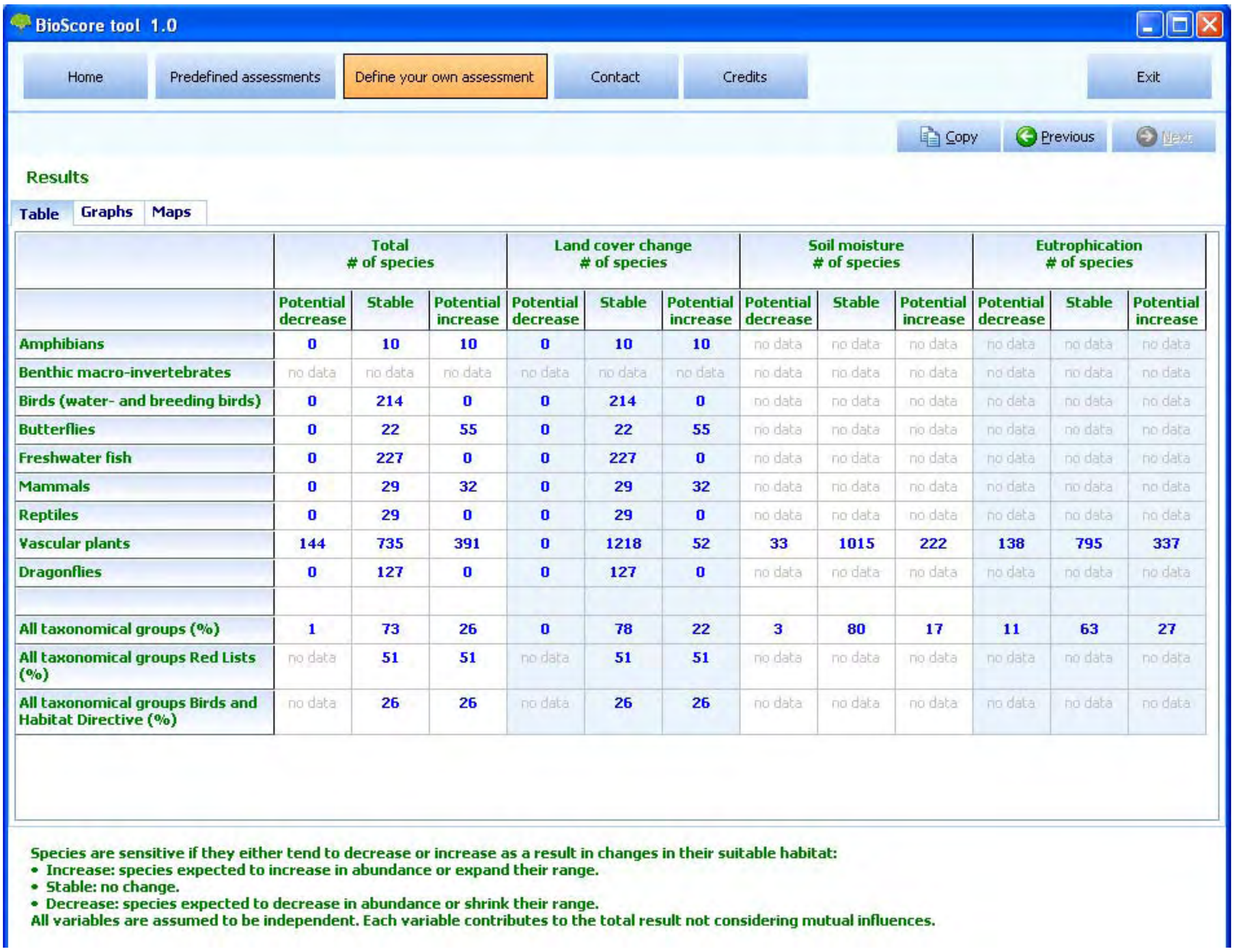


Figure 10: Step 3 of 'Define your own assessment'.

Step 4: Produce the results.
By clicking ‘next’ after the previous step, the BioScore database will be queried on the basis of the selections made. Results of the query are presented in three ways: as a table, a graph and a European map.

Results presented in a **table** show for each taxonomic group the number of species as contained in the database that are potentially decreasing, remaining stable or increasing on the basis of the selected changes in environmental variables. An aggregated figure is presented for all changes together, and separate figures are presented for each individual environmental variable selected. Also, at the bottom of the table, relative figures (%) are given for all taxonomic groups together as well as for species featuring on European Red Lists or in annexes of the EC Habitats and Birds Directives. The values presented are relative to the number of species contained in the database, not necessarily all species on Red Lists or in annexes of the Directives.



	Total # of species			Land cover change # of species			Soil moisture # of species			Eutrophication # of species		
	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase	Potential decrease	Stable	Potential increase
Amphibians	0	10	10	0	10	10	no data	no data	no data	no data	no data	no data
Benthic macro-invertebrates	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
Birds (water- and breeding birds)	0	214	0	0	214	0	no data	no data	no data	no data	no data	no data
Butterflies	0	22	55	0	22	55	no data	no data	no data	no data	no data	no data
Freshwater fish	0	227	0	0	227	0	no data	no data	no data	no data	no data	no data
Mammals	0	29	32	0	29	32	no data	no data	no data	no data	no data	no data
Reptiles	0	29	0	0	29	0	no data	no data	no data	no data	no data	no data
Vascular plants	144	735	391	0	1218	52	33	1015	222	138	795	337
Dragonflies	0	127	0	0	127	0	no data	no data	no data	no data	no data	no data
All taxonomical groups (%)	1	73	26	0	78	22	3	80	17	11	63	27
All taxonomical groups Red Lists (%)	no data	51	51	no data	51	51	no data	no data	no data	no data	no data	no data
All taxonomical groups Birds and Habitat Directive (%)	no data	26	26	no data	26	26	no data	no data	no data	no data	no data	no data

Figure 11: Step 4: query results of ‘Define your own assessment’ presented as a table.

From the screen showing the results in table format the user can select another tab to see the same results presented in a graph. The graphs only present results aggregated over all species, not separately by taxonomic group.

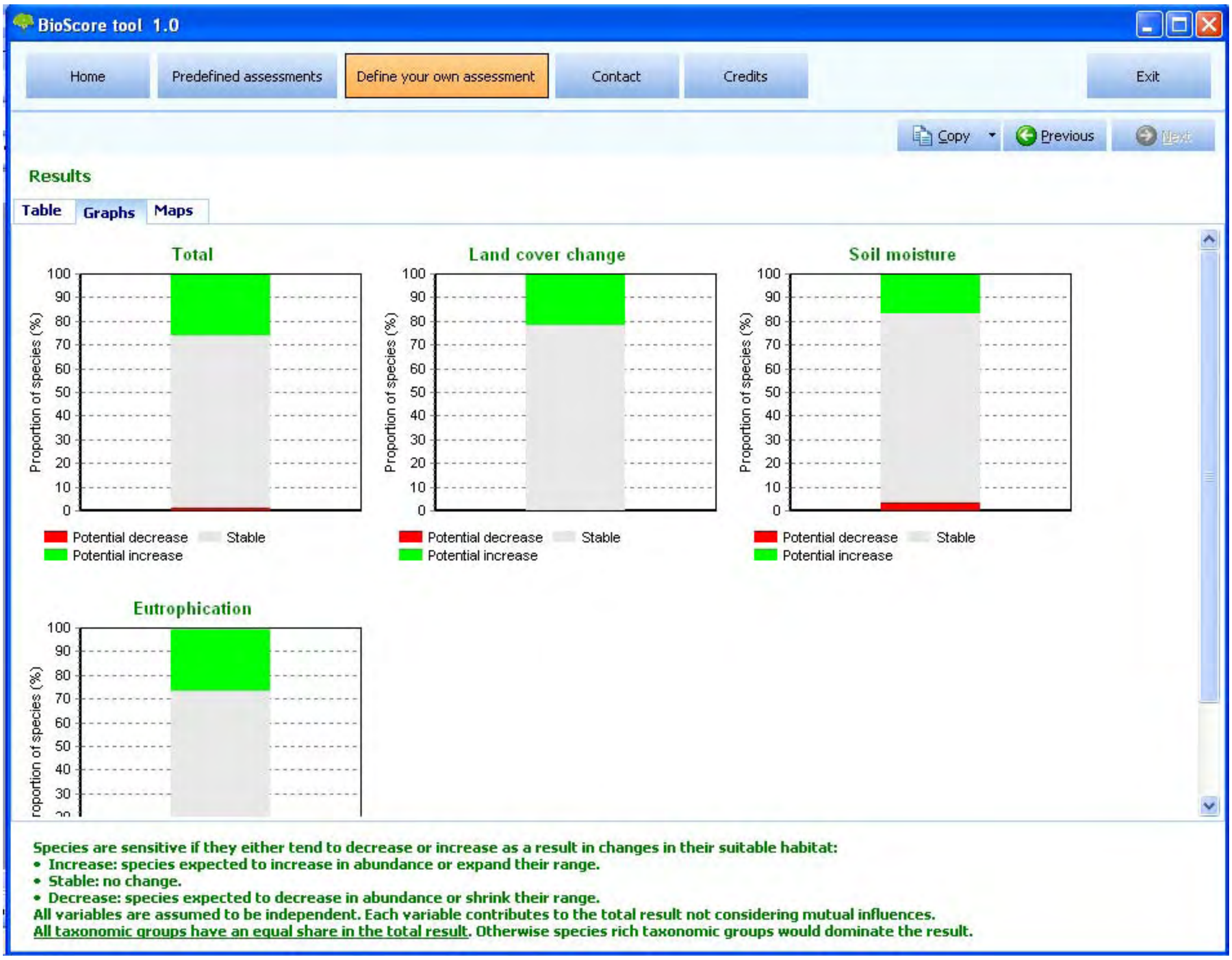


Figure 12: Step 4 query results of 'Define your own assessment' presented as graphs.

A third option is to look at the results on a European map. If 'Europe' was selected in step 1, then the analysis will have been run for the entire continent and one figure is presented as a colour, indicating the aggregated percentage value. Tabs at the bottom of the map allow the user to see separate maps for individual environmental variables.

If in step 1 a BGR or a country was selected, a European map showing only the selected region or country will be shown. The results will, however, have been calculated differently from the European analysis, in this case using data for the selected region or country only.

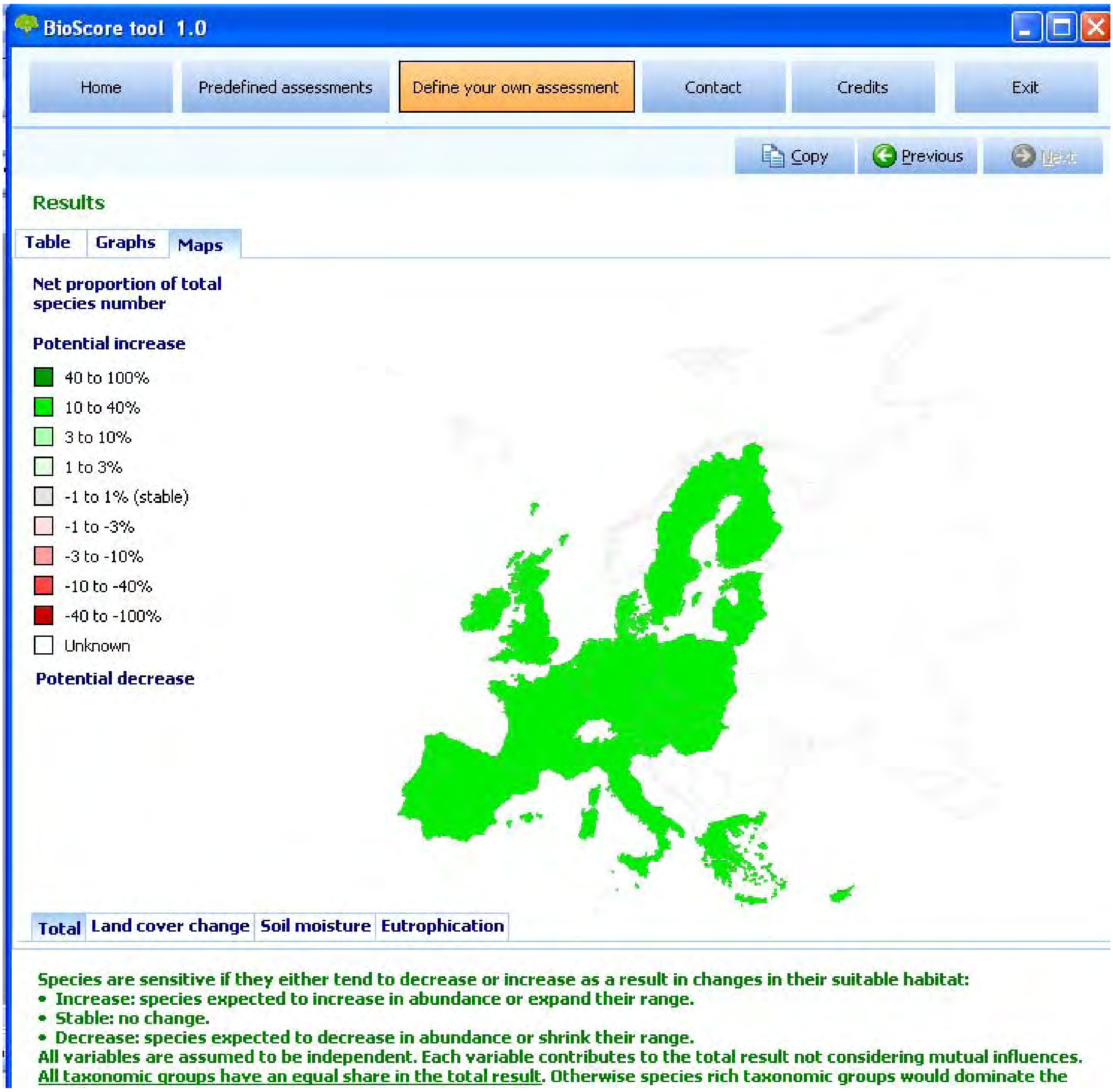


Figure 13: Step 4 query results of 'Define your own assessment' presented as a European map.

The analysis in the given example shows that this identified policy measure has potentially beneficial effects for many species groups. However, birds, fishes, reptiles and dragonflies are not affected and for some plant species the measure may have negative effects. Land-use effects seem to have effect mostly on animals and to a lesser extent on plants. The impacts of eutrophication and soil moisture are only available for plant species.

The methodology behind the calculation is described in Section 2.3. Although a map is shown, the assessment is not geographically explicit. The results presented cannot be regarded as an actual prediction or assessment. The map just indicates whether a policy option is potentially harmful for biodiversity, is promising or probably does not do so much. It is therefore currently only useful for rapid scoping exercises.

3.3 Conclusions

The BioScore tool can be used to select the most promising policy options from a wide variety of possibilities or to indicate what policy options that target other sectors may be harmful to biodiversity. Once a rapid assessment has been carried out a more elaborate analysis is needed to create a geographically explicit and balanced evaluation. This cannot be done via the Internet but can be carried out by experts, including from the team, by using the BioScore database in combination with other models. Case studies in Chapter 4 present the first examples of the use of this database for more refined purposes.

The database is applied in combination with other models (e.g. Eururalis) in Chapter 4. These applications aim at a geographically explicit calculation of effects as a result of socio/economic developments and policy measures. Models that can be combined with BioScore range from socio-economic models, environmental models (including climate), land-allocation models and so on. The BioScore tool aims at assessments in a broad context and is not a stand-alone tool, as it needs input from other models. It replaces general dose-response relationships as used in for example Eururalis and ‘Global Biodiversity Outlook’ calculations (CBD, 2006) or it adds information to single issue assessments (e.g. EEA, 2004) or single species groups assessments (e.g. Settele *et al.*, 2008).

4 Testing the BioScore database in case studies

4.1 Case study: How has afforestation impacted on biodiversity in Italy?

4.1.1 Introduction

Objectives and hypothesis
The aim of this retrospective study was to test the BioScore database against historical biodiversity data in order to demonstrate its usefulness and accuracy at predicting biodiversity changes as a result of policy. In this study the following hypothesis was tested to this end: European Union (EU) policies resulting in increased afforestation in the past four decades have led to a change in species composition and overall biodiversity loss in Italy.

History of afforestation in Italy
We defined afforestation as the establishment of forest on previously non-forested lands, i.e. not including post-harvest regeneration. EU policies have supported the afforestation of agricultural land since 1992. A time period of 10–15 years is, however, insufficient to show any significant effects. Therefore, a longer time frame was used for this case study. The scale at which afforestation has happened in Europe in the last decades is significant but still too small for a European assessment. Therefore, the biodiversity impact analyses focused on a country where large-scale afforestation has occurred in the recent past.

Italy provides such an example of significant forest area increase over the past decades due to natural afforestation and EU afforestation programmes. In addition, in the case of Italy historical land-use data and information on species distribution and population changes for several mammal species were available, allowing detailed analyses of afforestation impacts on biodiversity.

In Italy forest cover increased between 1963 and 2000 from 6.0 to 9.4 million hectares (FAO, 1963; MCPFE, 2007), corresponding to a net increase in forest of about 2,000 km^2 per year. The increase in forest area is the result of two main driving forces (Piussi & Pettenella, 2000):

1. afforestation programmes that took place in the last decades;
2. natural increase of forest vegetation on abandoned agricultural land, mainly in mountainous and hilly areas.

Significant afforestation programmes started in the 1970s with the Special Development Policy for Southern Italy and the EC policy for rural areas. In the context of Act 125/1975, 98,000 ha of forest were planted, often with a high degree of mechanization. EC Regulation 269/79, dealing with the financing of forestry investments in Mediterranean areas in Italy and France, was responsible for 43,000 ha of afforestation. In the 1980s an average of 8,300 ha were afforested per year. However, only half of the increase in forest area in the 1980s can be attributed to afforestation programmes. At the end of the 1980s, the financing of set-aside agricultural areas in the context of the Common Agricultural Policy reform encouraged the afforestation of fertile land in the Po valley and in other plain areas. High value (from an economic perspective) broad-leaved species such as hybrid poplars were mainly used. As a result of Regulation 2080/92, 54,000 ha were planted between 1994 and 1998, one quarter of the total increase in forest cover during those years.

Natural afforestation of abandoned agricultural land plays a much greater role in the overall increase in forest area compared to afforestation programmes. More than half of the Italian land area is mountainous (54%). Marginal areas of the mountain territories have been increasingly abandoned during the last decades. The abandonment of agricultural land ultimately leads to forest expansion (Piussi & Pettenella, 2000).

As it would be difficult to differentiate between afforestation through planting and natural succession on abandoned land, we needed to include both types of land-use changes in this case study.

4.1.2 Input data

4.1.2.1 BioScore database

As was shown in the previous chapters, the BioScore database contains information on the suitability of Corine Land Cover (CLC) types as habitat for a vast number of species. The suitability levels are given by biogeographical region (BGR) and differentiate between: not suitable, low, medium and high suitability. For vascular plants, the available habitat suitability data are limited to two suitability levels: 'suitable' and 'unsuitable'. Furthermore, the data on habitat suitability for vascular plants are not given by CLC type, but for 10 different habitat types (Coastal and halophytic habitats, Coastal sand dunes and inland dunes, Freshwater habitats, Temperate heath and scrub, Sclerophyllous scrub, Natural and semi-natural grassland formations, Raised bogs, mires and fens, Rocky habitats and caves, Forests, and Ruderal and Arable habitats), and they are not provided at regional level. Only terrestrial species groups were included in this analysis, in particular mammals, reptiles, amphibians, birds, vascular plants, butterflies and dragonflies.

4.1.2.2 Land-use/land cover data

Land-use data for Italy for the year 1960 and land cover data derived from Corine for the year 2000 were applied to relate species-specific habitat suitability levels from the BioScore database to a spatial level. Based on these datasets changes in forest cover between 1960 and 2000 could be derived at a resolution of 200 m. The historical land-use map for Italy includes eight land cover types (Annex 5 Table A1).

Geographical information system (GIS) analyses using the land cover maps indicate that the forest cover in Italy has increased from 19% of the land area in 1960 to 33% in 2000. Figure 14 presents a map showing areas subjected to afforestation and deforestation between 1960 and 2000 in Italy. New forest areas emerged mainly close to existing forest. Sardinia experienced a marked increase in forest cover. The main land-use types converted into forest were pasture/grassland (51%), agriculture (24%), heterogeneous agricultural areas (16%) and wooded plantations (6%).

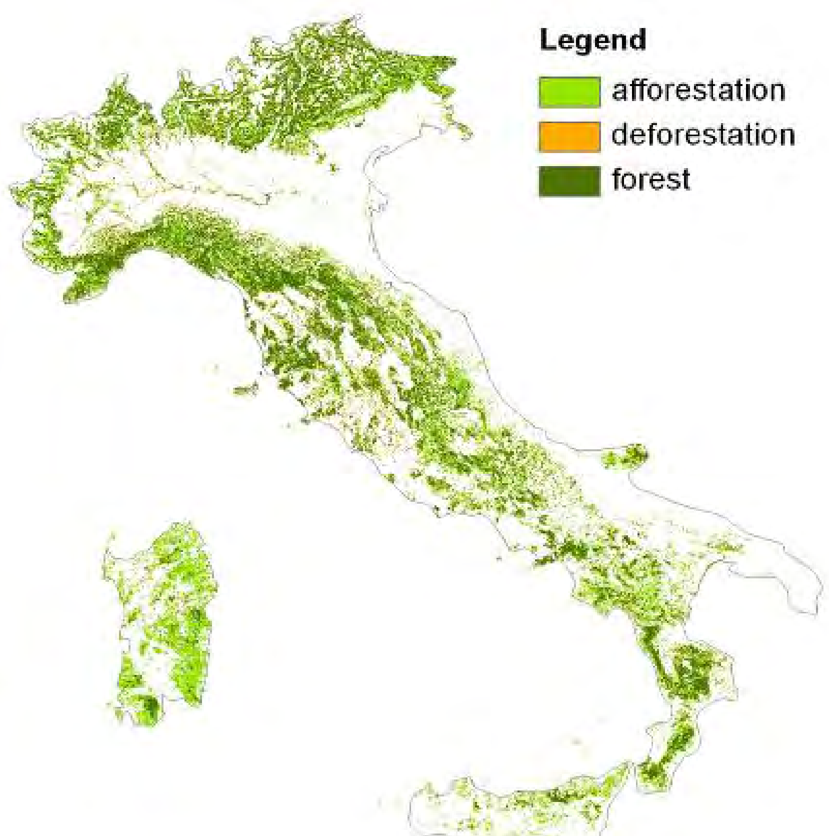


Figure 14: Forest area change in Italy between 1960 and 2000.

4.1.2.3 Distribution data/Population trends

Digital species distribution maps for the 1970s and the present (2002–2007) were available for the mammal species listed below. Information on population trends could be provided for a comparable time frame for most of these species.

- Golden jackal (*Canis aureus*)
- Grey wolf (*Canis lupus*)
- Alpine ibex (*Capra ibex*)
- Roe deer (*Capreolus capreolus*)
- Red deer (*Cervus elaphus*)
- Garden dormouse (*Eliomys quercinus*)
- Wildcat (*Felis silvestris*)
- Mountain hare (*Lepus timidus*)
- Alpine marmot (*Marmota marmota*)
- European badger (*Meles meles*)
- European polecat (*Mustela putorius*)
- Pyrenean chamois (*Rupicapra pyrenaica*)
- Chamois (*Rupicapra rupicapra*)
- Red squirrel (*Sciurus vulgaris*)

4.1.3 Methods

4.1.3.1 BioScore database queries for Italy

We retrieved the potential habitat suitability levels (0 – not suitable, 1 – low suitability, 2 – medium suitability, 3 – high suitability) for all relevant forest and open land cover types in Italy from the BioScore database for mammal, reptile, amphibian, bird, butterfly and dragonfly species, separately for the three BGRs occurring in Italy (Mediterranean, Alpine, Continental). All waterbird species occurring in Italy were excluded from the analyses. Annex 5 Table A1 gives a list of the forest and open land cover classes we considered. We included the CLC classes ‘Transitional woodland-shrub’ and ‘Sclerophyllous vegetation’ in the forest land. Transitional woodland-shrub can be seen as an intermediate stage between open land and mature forest in some locations, while in others it represents the final stage of succession. Sclerophyllous vegetation includes evergreen sclerophyllous bushes and scrubs which compose maquis, garrigue, mattoral and phrygana, and form recolonization and degradation stages of broad-leaved evergreen forests. When assessing the potential impact of afforestation, we differentiate between conversions of open land to all forest classes.

The open land cover types considered (agricultural land, heterogeneous agricultural land, pastures/grassland and wooded plantation) as given in the historical land-use map for Italy, form an aggregation of the CLC classes used in the BioScore database. Therefore, the maximum occurring habitat suitability was always chosen for each aggregated land cover type when querying the BioScore database. Annex 5 Table A1 shows which CLC classes are grouped together in each of the open land cover types. An overview of the complete CLC nomenclature can be found in Annex 5 Table A1. For assessing the potential impact of afforestation, the suitability for each of the CLC forest classes was compared to the suitability for the (aggregated) open land classes. An example for assigning the habitat suitability levels to the open land classes is given in Table 9a.

The information on habitat suitability in the BioScore database is classified into the four levels ‘no’, ‘low’, ‘medium’ and ‘high’ suitability. To relate our results to sensitivity to afforestation, changes in habitat suitability were grouped into seven classes: not sensitive, low/medium/high positive sensitivity, and low/medium/high negative sensitivity. For example, if the suitability level for a species decreased from highly suitable to not suitable, this species was assigned a high negative sensitivity to afforestation whereas an increase in suitability from unsuitable to highly suitable was considered as a high positive sensitivity. If suitability increased or decreased by two levels (e.g. change from low to high or high to low suitability) the respective sensitivity was defined as medium, if the suitability increased or decreased by one level only (e.g. change from medium to high suitability) the sensitivity was defined as low and if no change occurred the species was considered not sensitive towards afforestation. Table 9b demonstrates this approach by means of an example. For vascular plants, the sensitivity classes were limited to positive, negative and no sensitivity; and no detailed differentiation of the afforested land cover classes or of BGRs was possible.

The sensitivity was analysed separately for each species group and for each type of land cover conversion. In addition, and in order to give an indication of the total impact, all results were combined based on an aggregation formula which takes into account the area-based shares of the land cover classes afforested and of the forest classes at the afforestation sites. More details on the aggregation can be found in Section 2.3.4.

4.1.3.2 BioScore database queries in combination with GIS analyses

For 14 mammal species, distribution maps for the past (1970s) and present (around 2005) were available. Additionally, for nine of these species, information on population trends was also available. Using the land cover maps for 1960 and 2000 the land cover changes related to afforestation were analysed for this time frame for all species distribution regarding land cover type afforested and forest type at the afforestation site. Statistics were compiled for each species showing the percentage of the distribution range which had been converted from an open land cover to a certain forest type. Based on these results and the data on habitat suitability from the BioScore database, it was possible to derive information on the expected impact of afforestation on the 14 mammal species. An aggregation formula (Section 2.3.4) was applied to calculate the total impact. For those species with available distribution range/population trend data, we related the observed trends to the calculated expected impacts of afforestation.

Table 9: Suitability classes and sensitivity to afforestation for Red squirrel (*Sciurus vulgaris*).

Part A shows the suitability classes, with 0 – not suitable, 1 – low suitability, 2 – medium suitability, 3 – high suitability. Part B shows the sensitivity to afforestation that is derived from the change in suitability between the open land and the forest land cover classes. For the nomenclature of the CLC classes please refer to Annex 5 Table A2.

(a) Suitability															
CLC class	Agricult. land	Heterogeneous agricultural land			Grasslands/ pastures			Woody plantations			Shrubs		High forest		
CLC subclass code	211	241	242	243	231	321	322	221	222	223	323	324	311	312	313
Suitability	0	1	0	2	0	0	0	0	1	0	0	0	2	3	2
Aggregated suitability level (maximum)	0	2			0			1							

(b) Sensitivity					
	To:				
Sensitivity to Conversion from:	Sclerophyllous vegetation (323)	Transitional woodland/scrub (324)	Broad-leaved forest (311)	Coniferous forest (312)	Mixed forest (313)
Agricultural land	0	0	+2	+3	+2
Heterogeneous agricultural land	-2	-2	0	+1	0
Grassland/ pastures	0	0	+2	+3	+2
Woody plantations	-1	-1	+1	+2	+1

Sensitivity scores: -2 = medium negative sensitivity; -1 = low negative sensitivity; 0 = not sensitive
+1 = low positive sensitivity; +2 = medium positive sensitivity; +3 = high positive sensitivity

4.1.4 Results

4.1.4.1 Results of BioScore database queries for Italy

The results of this study show significant differences in the impacts of afforestation on biodiversity, depending on the land use before afforestation, the type of forest at the afforestation sites and the species group. Figure 15 shows the aggregated total impact of afforestation on six different species groups in Italy. These results indicate that afforestation is positive for the majority of mammal species whereas for all other species groups negative impacts dominate. Negative impacts are the largest for butterflies, reptiles and vascular plants. The impact of afforestation on dragonflies was not included in the aggregated results as the dragonfly species considered occur only in forests and moors/heathlands.

Figure 16 shows the impacts of the conversion of open land to coniferous forest on mammals, reptiles, amphibians and birds. In Annex 5 Figure A1 to Annex 5 Figure A4, a complete overview of the results for these species groups is given, differentiated by the forest types at the afforestation site. The impact on butterflies, dragonflies and vascular plants is presented in Figure 17. If the habitat suitability for a certain land cover differs for a species across the three BGRs or if not all the species occur in all the three regions, results are given only for the Mediterranean region. For dragonflies, where large differences between the BGRs occurred, all results are shown. The sensitivity of butterflies was analysed only with respect to afforestation of grasslands and pastures as there were no data available on habitat suitability for the land cover classes 'agricultural land' and 'wooded plantations' in the BioScore database. Similarly, for the dragonfly species the impact could not be differentiated between the different forest types as the species database holds only information on habitat suitability for 'forest' and 'moors/heathlands'. The dragonfly species listed in the database occur solely in forests or 'moors/heathlands'. The impacts of afforestation of land cover classes other than 'moors/heathlands' were grouped together and are shown in Annex 5 Figure A5. For vascular plants only the character of the sensitivity is presented (positive/negative/no sensitivity), without distinguishing between sensitivity levels due to limited sensitivity data availability.

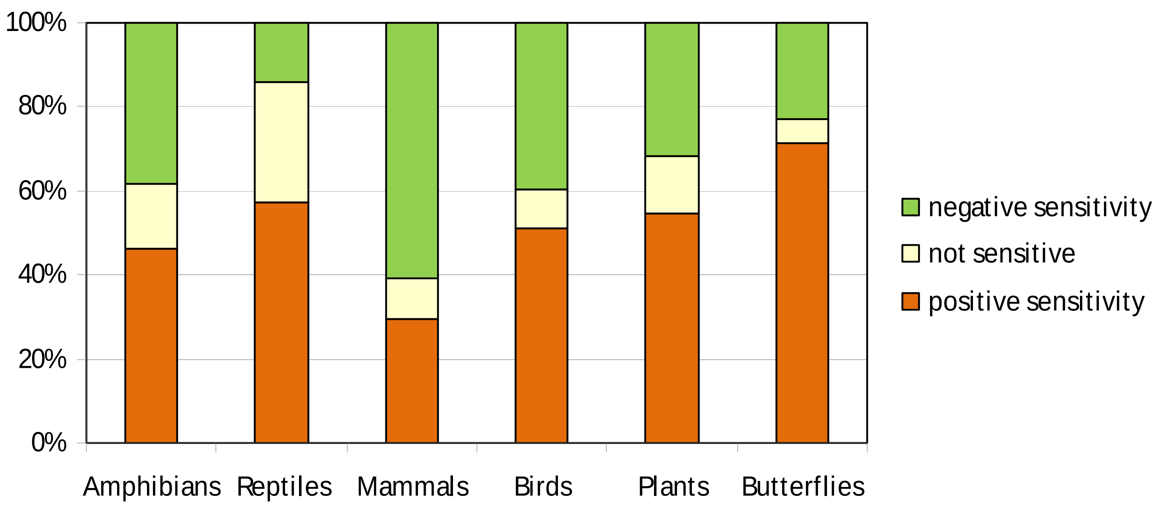


Figure 15: Aggregated results of the impact of afforestation on different species groups in Italy.

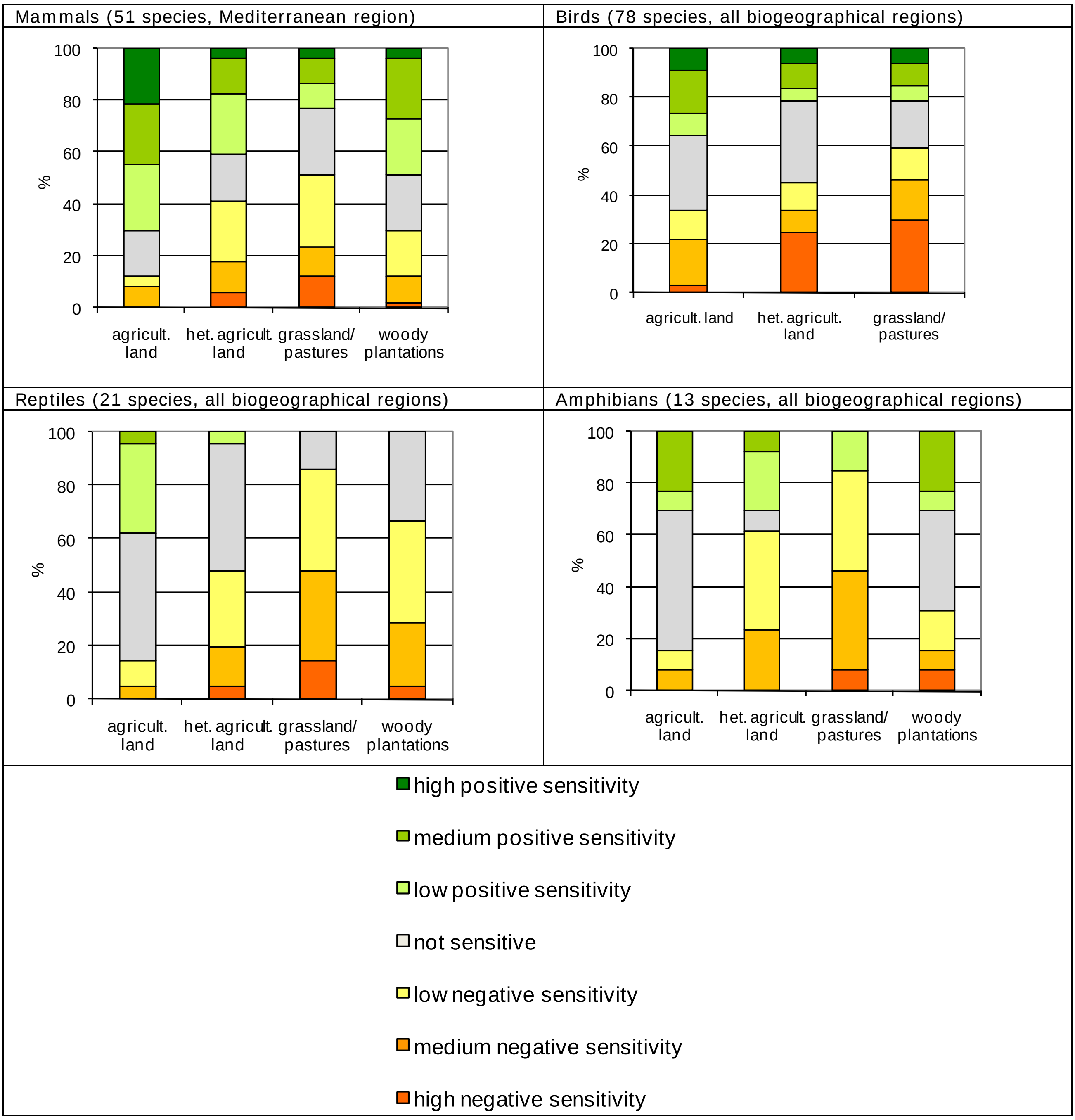
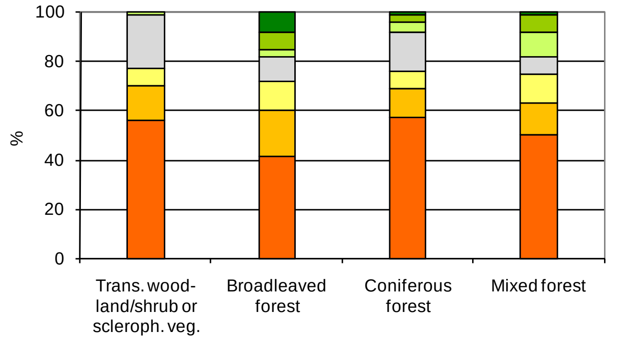
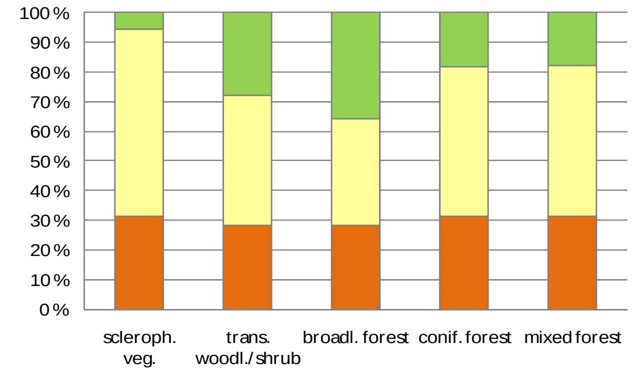


Figure 16: Sensitivity of mammals, birds, reptiles and amphibians to afforestation with coniferous forest in Italy. Waterbirds have been excluded from the analyses.

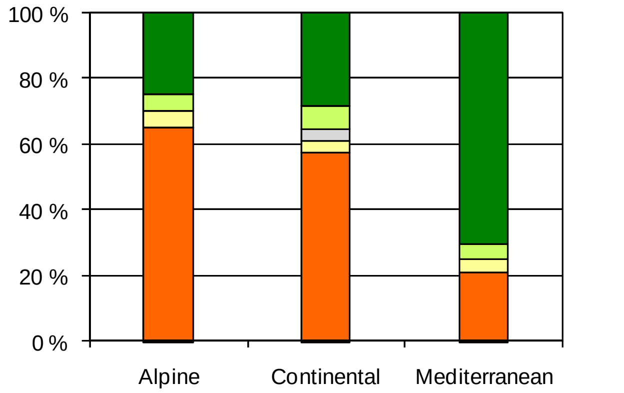
a. Butterflies (70 species, Mediterranean region): Afforestation of grasslands and pastures



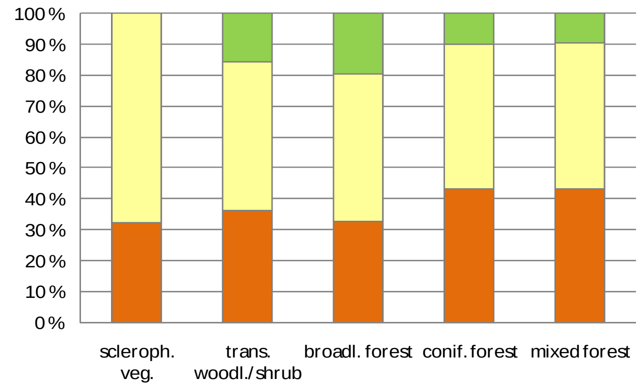
c. Vascular plants (630 species): Afforestation of arable lands



b. Dragonflies (20/28/24 species in the Alpine/Continental/Mediterranean region): Afforestation of moors and heathlands



d. Vascular plants (630 species): Afforestation of grasslands



- high positive sensitivity
- medium positive sensitivity
- low positive sensitivity
- not sensitive
- low negative sensitivity
- medium negative sensitivity
- high negative sensitivity

- positive sensitivity
- not sensitive
- negative sensitivity

Remark: for dragonflies no data were available for the differentiation of forest types. For vascular plants no data were available for the differentiation of BGRs, other afforested land cover classes and sensitivity level.

Figure 17: Impact of afforestation with different types of forest on butterflies, dragonflies and vascular plants for selected land uses.

4.1.4.2 Results of BioScore database queries in combination with GIS analyses

Table 10 shows the expected impact of afforestation on 14 mammal species for which distribution maps were available. The observed distribution ranges of the analysed mammals increased significantly between 1960 and 2000 for most of the species. Also the forest cover increased substantially in all distribution ranges, mainly at the expense of pastures and grasslands. The modelled impacts are expected to be mainly positive except for the Alpine ibex (*Capra ibex*), Mountain hare (*Lepus timidus*) and Alpine marmot (*Marmota marmota*). Annex 5 Figure A6 demonstrates an example of the underlying GIS analyses.

The expected potential impacts as derived from the database were compared to available (observed) population trends for nine mammal species (Table 10). In five cases the predicted impacts are in accordance with the actual population trends. A strong discrepancy between prediction and trend was only observed for Alpine ibex (*Capra ibex*) and Alpine marmot (*Marmota marmota*).

For both species many different local factors have influenced population trends, ranging from conservation actions and reintroduction programmes to the wide availability of currently unoccupied suitable habitats.

4.1.5 Discussion

The results of this case study indicate potential positive impacts on many mammal species, whereas the majority of species from other species groups did not benefit from afforestation. Falcucci *et al.* (2007) argue that large vertebrates such as bear and wolf, as well as temperate forest birds, benefit from land abandonment and afforestation by increasing their range and population sizes.

When analysing the impact of afforestation on biodiversity it is important to differentiate between the types of resulting forest and the original land cover types. The results obtained have to be interpreted with caution as they were based on land cover changes only and on the resulting changes in habitat suitability. However, apart from land cover, many other variables determine habitat suitability for species, such as human presence, management intensity, species–species interactions, or spatial patterns of land cover. For example, afforestation may contribute to habitat fragmentation of open land areas and thus reduce suitable habitat but may also add to landscape and species diversity in agriculturally dominated landscapes, and vice versa. Other potential pressures resulting from afforestation, such as lowering of the groundwater table and soil acidification from the plantation of conifers were not analysed in this study. The differences between the actual population trend data and the calculated expected impacts (Table 10) indicate that factors other than land-use changes related to afforestation are influencing the population dynamics of the species. We also have to keep in mind that species responses to a changing environment are very unpredictable, and many biotic interactions can potentially produce very different results.

Furthermore, our analyses are based on habitat suitability specified for the CLC classes, which is only a generalization of the actual habitat preferences of the species. Furthermore, habitat suitability levels for the open land classes were aggregated to conform to the classification scheme of the applied historical land cover map for Italy. For this reason the results of this study might overestimate habitat suitability for open land classes of the historical land cover map, since the maximum of the suitability levels for the corresponding Corine classes was used to describe the suitability of the open land classes (compare Annex 5 Table A1).

We demonstrated that the BioScore database, if used wisely, can be successfully applied in predicting the effects of European policies on biodiversity. However, we urge caution in using the database for species-specific applications: while conclusions on the general biodiversity patterns can be easily drawn if a sufficient number of species are considered, for single species local-scale contingent factors can potentially produce biased results. Our results indicate that additional data on variables such as disturbances, landscape fragmentation or species–species interactions need to be integrated in the analysis to allow a direct link between afforestation policies and biodiversity.

Table 10: Expected impact of afforestation on the populations of 14 mammal species in Italy as derived from the BioScore database and comparison with population trend data.

Species	Distribution range			Forest share in distribution range (%)		Main land cover types afforested	Main forest types on afforestation sites	Expected impact	Actual population trend
	Area [1000 km²]		Change [%]						
	1960	2000		1960	2000				
Canis aureus	-	12	-	-	40	P H	B M	0	+
Canis lupus	22	87	298	31	50	P A	B	+	+
Capra ibex	3	5	71	14	25	P	C T	-	+
Capreolus capreolus	56	96	73	40	50	P A H	B	+	+
Cervus elaphus	17	36	108	39	56	P H	B C	+	+
Eliomys quercinus	202	259	28	26	36	P A	B	+	*n/d*
Felis silvestris	83	106	27	22	43	P A	B S	+	*n/d*
Lepus timidus	41	40	-4	37	53	P H	B C	-	-
Marmota marmota	38	45	19	37	54	P H	B C	-	0
Meles meles	200	251	26	27	33	P A H	B	+	*n/d*
Mustela putorius	207	251	22	26	33	P A H	B	0	*n/d*
Rupicapra pyrenaica	0.3	0.9	243	52	54	P A	B T	+	+
Rupicapra rupicapra	35	41	16	37	55	P H	B C M	0	+
Sciurus vulgaris	178	198	12	30	40	P A H	B	+	*n/d*

Land cover types: A = Agricultural land; H = Heterogeneous agricultural land; P = Pasture/grassland
Forest types: B = Broad-leaved forest; C = Coniferous forest; M = Mixed forest; S = Sclerophyllous vegetation; T = Transitional woodland and shrub.

4.2 Case study: Are air and water quality policies benefiting Europe's biodiversity?

4.2.1 Introduction

Nitrogen is an important nutrient for life on Earth, but at the same time an excess of nitrogen is thought to be one of the major threats to global biodiversity. Biologically available nitrogen is often the most limiting nutrient in temperate terrestrial ecosystems (Bobbink *et al.*, 2008; Vitousek & Howarth, 1991). Most of the plant species from oligotrophic and mesotrophic habitats are adapted to nutrient-poor conditions, and are out-competed in high and dense vegetations when the availability of nitrogen increases (e.g. Tamm, 1991; Bobbink *et al.*, 1998; Aerts & Chapin, 2000). Increased atmospheric nitrogen levels also contribute to acid deposition and thus to the acidification of surface waters, which has a negative impact on freshwater species (Burton *et al.*, 1985; Harvey, 1980). During the last centuries, combustion of fossil fuels and modern agriculture have increased the atmospheric deposition on natural areas from 50–200 mol ha^{-1} yr^{-1}, to 500 mol ha^{-1} yr^{-1} over central and eastern USA, to about 1,200 mol ha^{-1} yr^{-1} over central Europe, and up to 3,000 in parts of the Netherlands (e.g. Galloway *et al.*, 2004, 2008).

To tackle the problem of increased air pollution in Europe, the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution was signed in 1979. The aim of the Convention is that parties shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. The Convention is supplemented by specific protocols that identify measures to be taken by parties to cut their emissions of air pollutants; among these the protocols on nitrogen oxides and on acidification, eutrophication and ground-level ozone are of particular interest for this case study. Besides this Convention several other EU directives and strategies aiming at an increase in air and water quality have taken effect during the last decades, including:

- Council Directive 78/659/EEC (1978) on the quality of fresh waters needing protection or improvement in order to support fish life;
- Council Directive 85/203/EEC (1985) on air quality standards for nitrogen dioxide, with the objective to fix a limit value and lay down guide values for nitrogen dioxide in the atmosphere specifically to improve the protection of human health and contribute to the long-term protection of the environment;
- Council Directive 1999/30/EC (1999) relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air;
- the EU Water Framework Directive (2000), which establishes a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater.

As a result of these policies, depositions of acidifying and eutrophicating nitrogen compounds have been reduced during the past two decades in most parts of Europe (EEA, 2008).

The objective of the retrospective case study was to test the usefulness of the BioScore database to analyse and validate the impact of these EU policies on Europe's biodiversity. In particular it was investigated if the measures introduced by the EU during the past 20–30 years to reduce atmospheric nitrogen deposition have helped to increase the amount of suitable habitat for terrestrial and aquatic biota in Europe. The analyses were split into two parts:

a) impact of reduced nitrogen deposition on vascular plant species, and
b) impact of reduced nitrogen deposition on freshwater fish and benthic macroinvertebrates.

While the first part relates to eutrophication of terrestrial ecosystems resulting from atmospheric nitrogen deposition, the second study concentrates on acidification of lakes and rivers caused by nitrogen inputs into the surface water.

Using species-specific sensitivity scores on eutrophication and acidification from nitrogen as stored in the BioScore database, as well as available population trend data for the species, potential impacts of reduced atmospheric nitrogen deposition on the biodiversity of Europe can be derived. Due to the limited availability of population trend data it was decided to focus on national scale only, specifically on the Netherlands (air quality) and Norway (water quality).

4.2.2 *Impact of improved air quality on vascular plant species in the Netherlands*

4.2.2.1 Background and hypothesis

Depending on the optimum for individual plant species and the trajectory in which the change is occurring, species react differently to a change in nitrogen availability. In the Netherlands most ecosystems suffer from a critical load exceedance. So, when a decrease in nitrogen availability occurs by lowered atmospheric deposition, theoretically first the species which prefer higher levels of nitrogen will show a negative reaction as they are highly sensitive to decreasing nitrogen levels. Conversely, species linked to nitrogen-poor habitats are not or only slightly sensitive towards a decrease in nitrogen levels and will react in a positive way only if the decrease in nitrogen is strong enough. However, the decline in atmospheric deposition in the Netherlands from approx. 3,100 to approx. 2,200 mol ha^{-1} yr^{-1} between 1981 and 2006 (Figure 19) is not expected to be sufficient for these slightly sensitive species to return. Furthermore, the area of suitable habitat for species depending on higher nitrogen levels is expected to show an overall decrease. Figure 18 gives an overview of this hypothesis.

	decrease of nitrogen			
	-	--	---	BioScore expectation:
no	0	0	+	>> overall increase (least)
low	0	+	+	>> overall increase (moderate)
medium	+	+	+	>> overall increase (greatest)
high	-	-	-	>> overall decrease

Figure 18: Expected impact of a decrease in nitrogen deposition on plant species with varying sensitivity to nitrogen availability.

The main nitrogen source in natural systems is from atmospheric nitrogen deposition. For systems that are under agricultural use the nitrogen input from manure and fertilizers leads to much higher nitrogen levels (Figure 20). So it is expected that recovery of plants in nature reserves will be seen more clearly than in agricultural ecosystems. Thus, the trends in atmospheric deposition in nature reserves can more directly be linked to EU policies on air quality compared to the deposition in agricultural areas.

Since our study concentrates on the impacts of reduced nitrogen depositions, only species sensitivity to decreasing nitrogen availability was considered in the analyses, while sensitivity to increased nitrogen levels and sensitivity to other pollutants such as phosphorus were neglected.

4.2.2.2 Input data

Data availability
For the following two main reasons we chose the Netherlands for the case study on air pollution: Firstly, nitrogen deposition in the Netherlands is relatively high and dropped considerably over the last decades; 70% of the natural areas experience an exceedance of the critical load, which increases the chance of finding effects of decreased deposition. Secondly, there were sufficient data on population trends for individual vascular plant species available.

BioScore database
The BioScore database holds information for 931 vascular plant species occurring in Europe. In particular, it shows for each species the preferred habitat type and the sensitivity to changes in nitrogen levels. The sensitivity scores (high, medium, low, and no sensitivity) are derived from the plant-specific Ellenberg values on nitrogen availability in the soil. Species that are highly sensitive to a decrease in nitrogen are the species that have high Ellenberg values (nitrogen-lovers), while species that have low or medium sensitivity to a decrease in nitrogen are those with low Ellenberg values, preferring low nitrogen levels. The database distinguishes between the nine Natura 2000 habitat types (Coastal and halophytic habitats,

Coastal sand dunes and inland dunes, Freshwater habitats, Temperate heath and scrub, Sclerophyllous scrub, Natural and semi-natural grassland formations, Raised bogs, mires and fens, Rocky habitats and caves, and Forests), plus the addition of Ruderal and Arable habitats.

Distribution data

Information on their distribution in Europe was available at Universal Transverse Mercator (UTM) grid cell level (50 km x 50 km) for 858 plant species from the BioScore database, i.e. for each plant species a list of UTM cells was provided depicting the areas where the species occurs. The country area of the Netherlands covers in total 29 UTM grid cells, including 334 plant species.

In addition, more detailed distribution data for individual plant species were derived from the FlorBase2M database from the Dutch National Herbarium Netherlands. This database contains plant species distribution on the scale of 1 km x 1 km. It contains at least 10,000,000 records from the period 1975–2005. It is the most complete source of distribution data of Dutch wild flora.

Population trend data

The frequency of occurrence of Dutch flora within 1 km x 1 km cells (FlorBase2M) has been assessed for vascular plant species for three assessment periods: 1902–1949 (Period 1), 1975–1987 (Period 2), 1988–1999 (Period 3). The assessment covers 36,800 grid cells in total and reports the number of occupied grid cells (frequency) for each plant species at national level (Tamis *et al.*, 2004). This information was made available for our study for 361 vascular plant species of which 230 could be linked to the BioScore database. The provided data had been classified into 10 frequency classes according to a logarithmic scale. To analyse the effectiveness of EU policies during the last decades, only the assessments for Period 2 and Period 3 were taken into account for this case study as their time frame overlaps with the introduced policy measures combating air pollution.

Furthermore, for selected Dutch plant species, trend data for both nature reserves and agricultural areas were available for the periods 1975–1989 and 1990–2005, also originating from the FlorBase2M database (MNP, 2007a). The data on plant species in natural areas are of high interest for this study because the trends in natural areas can be linked more directly to EU policies tackling air pollution (compare Section 4.2.2.1) as there is no direct input of nitrogen.

Since the population trend data were only available at national level and information on habitat preferences for the plants as given in the BioScore database was limited to 10 habitat types, a linkage with available spatial land cover data (Corine classification) was not applied in this study.

Deposition trend data

For the Netherlands information on nitrogen deposition (NHx, NOy) was available at national level for the period 1981–2006 (Figure 19). Over this time frame the yearly nitrogen input decreased from 44 kg/ha to 32 kg/ha (MNP 2007b). Nitrogen loads in agricultural areas are much higher than those for nature reserves due to the usage of manure and fertilizers (Figure 20). Average input of fertilizers from (artificial) manure in agriculture was almost 350 kg/ha/yr. On the other hand, nitrogen input in nature reserves relates mainly to atmospheric deposition and had an average of 35 kg/ha/yr, equivalent to 2200 mol/ha. In two-thirds of the area of Dutch nature reserves the critical load for nitrogen is exceeded. Critical loads differ between nature types, with bogs being most susceptible with a critical load of 400 mol/ha/yr and forest on clay soils being least susceptible with >2400 mol/ha.

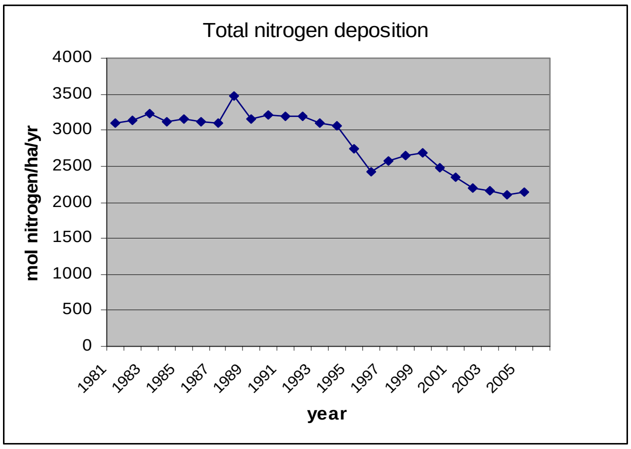


Figure 19: Nitrogen input on Dutch natural areas by atmospheric nitrogen deposition between 1981 and 2006 (MNC).

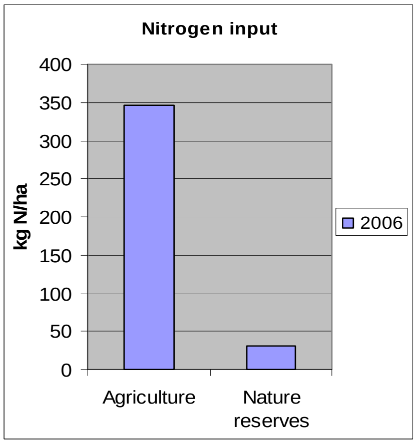


Figure 20: Average nitrogen input on nature reserves and agriculture in the Netherlands in 2006 (MNC).

4.2.2.3 Methods

The available data allowed us to test two approaches for which different datasets were used:

(A) Identifying the effect of decreased nitrogen inputs separately for nature reserves and for agricultural areas. For this analysis two separate sets of distribution and population trend data were used: one dataset for nature reserves and one for agricultural areas.

(B) Identifying the effect of decreased nitrogen inputs at national level with a differentiation of habitat types. For this analysis population trend data at national level were used.

(A) Analyses with differentiation of nature reserves and agricultural areas

To obtain trends for individual plant species from the FlorBase2M database, for nature reserves and agricultural areas respectively, a GIS analysis was performed. By making an overlay between a map of nature reserves and agricultural areas and the 1 km x 1 km grid cells of the FlorBase2M database, the percentage of nature reserve, agriculture and urban area in each 1 km x 1 km grid cell was calculated. For this study only those grid cells which consisted for 100% of natural area or for 100% of agricultural area were used in the analysis. To derive trends on the species level, a comparison of the number of grid cells in which individual plant species occur was made between two periods: 1975–1989 and 1990–2005. Only those 1 km x 1 km grid cells were selected that have been well sampled in both periods. The analysis was carried out for species which are characteristic for Dutch nature.

According to the same method used to determine the sensitivity (Ellenberg values for nitrogen) for individual plant species when compiling the BioScore database, sensitivity scores for all species with available trend data were derived, i.e. for more species than those included in the BioScore database. This was necessary because the number of species with actual measured trend data in combination with available sensitivity scores from the BioScore database was too small (60 species for nature reserves and 34 species for agricultural areas) and would lead to high levels of stochasticity. Including additional species with available trend data yielded a total of 244 vascular plant species for nature reserves and 130 for agricultural areas with sensitivity scores as well as trend information. The number of increasing/decreasing/stable species per sensitivity category (high/medium/low/no sensitivity) was calculated separately for agricultural areas and nature reserves. Most of the considered species show no or only a low sensitivity to decreasing nitrogen availability, i.e. they prefer low nitrogen levels (Table 11).

Table 11: Number of plant species applied in the analyses on nature reserves and agricultural areas, by sensitivity score.

Sensitivity to decreasing nitrogen availability	**Number of species**	
	Nature reserves	Agricultural areas
High	33	19
Medium	47	29
Low	67	36
Not	97	46

(B) Analyses at national level with differentiation of habitat types
Linking species population trends at national level with species-specific sensitivity scores from the BioScore database allows determination of how the plant species under consideration have changed overall in the Netherlands as a result of reduced air pollution.

Based on the given distribution data, all plant species of the BioScore database which occur in UTM cells covering the Netherlands were selected from the database. The number of selected plant species considered in the analyses was further reduced to those species with available population trend data. There are 931 plant species in the BioScore database; of these 334 occur in the Netherlands, and for 230 of these population trend data are available.

For each of these 230 plant species, information on sensitivity to decreased nitrogen availability was queried from the BioScore database. A large part of these species is highly sensitive to decreasing nitrogen levels (Table 12). Furthermore, for each species the frequency of occurrence was compared between the two assessment periods (Period 2 and Period 3), and an analysis was made of whether the species showed an increasing, decreasing or stable trend between the two periods. By linking the queried information, we could detect how many of the species with high/medium/low sensitivity show an increasing/decreasing/stable population trend. The analyses were performed separately for each habitat type, and in addition for all habitat types combined.

Table 12: Number of plant species applied in the analyses at national level, by sensitivity score.

Sensitivity to decreasing nitrogen availability	Number of species
High	75
Medium	52
Low	51
No	52

4.2.2.4 Results

(A) Analyses with differentiation of nature reserves and agricultural areas
The shares of vascular plant species with increasing, stable and decreasing population trends depending on their sensitivity to reduced nitrogen loads in nature reserves and agricultural areas are given in Figure 21. In nature reserves the overall percentage of species with a positive trend is higher than the number of species with a decreasing trend (Figure 21a). In comparison, more species are decreasing than increasing in the agricultural areas (Figure 21b). The share of species with increasing trend amounts to 63% in nature reserves and only 35% in agricultural areas, while the percentage of species with negative trend is 24% in nature reserves and 51% in agricultural areas.

According to the hypothesis, the percentage of species with a positive trend depends on their sensitivity score. For nature reserves the expected impacts are partly consistent with the observations (Figure 21a). Highly sensitive species, which prefer high nitrogen concentrations in the soil, have the highest percentage of decreasing species (33%) and the lowest percentage of increasing species (52%) relative to the other sensitivity classes. On the other hand, species which are not sensitive, i.e. species that prefer low nitrogen concentrations in the soil, are expected to show increasing population trends only when nitrogen levels drop significantly, which contradicts these results. Also in contradiction with what was observed, species with medium and low sensitivity are expected to show a stronger increasing trend than species that are not sensitive. There is no obvious pattern over the sensitivity groups for the agricultural areas (Figure 21b): the percentages of increasing species do not vary considerably over the different sensitivity groups: 37%, 34%, 33% and 35%, respectively for species with high, medium, low and no sensitivity.

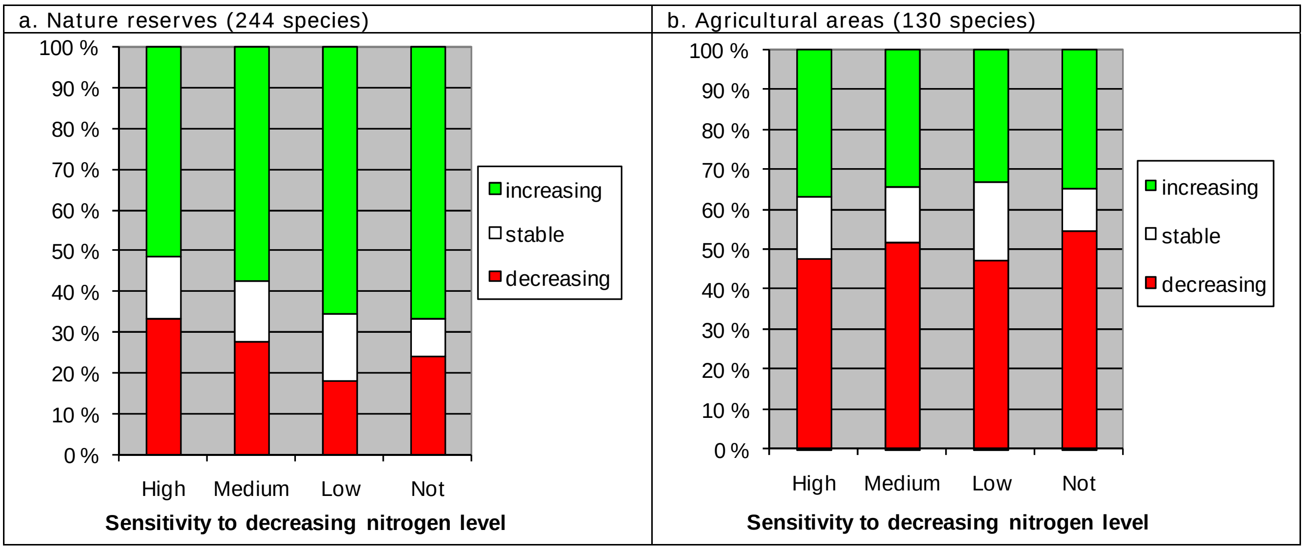
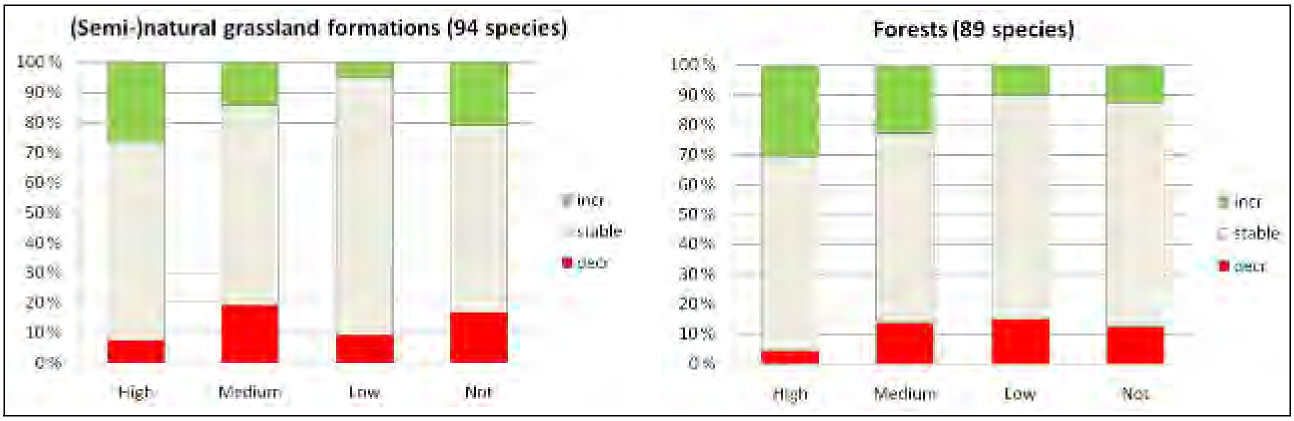


Figure 21: Percentage of species with increasing, stable and decreasing population trends for four different levels of sensitivity to decreasing nitrogen availability, for nature reserves (a) and agricultural areas (b), respectively.

(B) Analyses at national level with differentiation of habitat types

The shares of vascular plant species with increasing, stable and decreasing population trends depending on their sensitivity to reduced nitrogen loads are given in Figure 22 for the main habitat types and in Figure 23 as a summary of all habitats for the Netherlands in total. If nature reserves and agriculture are looked at together, it is not the plants with low or medium sensitivity that show the strongest population increase in the Netherlands, but the species with high sensitivity. Declining population trends are highest for species insensitive to decreasing nitrogen, as well as for species with low and medium sensitivity. Overall, the shares of species with positive population trends exceed the shares of declining species except for species with low sensitivity. When looking at the habitat types (Figure 22) plants favouring ruderal and arable habitats have the strongest population increase which is contrary to the results for agricultural areas shown above (Figure 21b). However, it has to be kept in mind that the data applied on population trends follow a logarithmic scale and thus mainly reflect the impacts on rare species with a low frequency of occurrence while the species with higher occurrence numbers are mostly stable in the applied classification scheme. Therefore, the share of stable species is highest in the given figures.



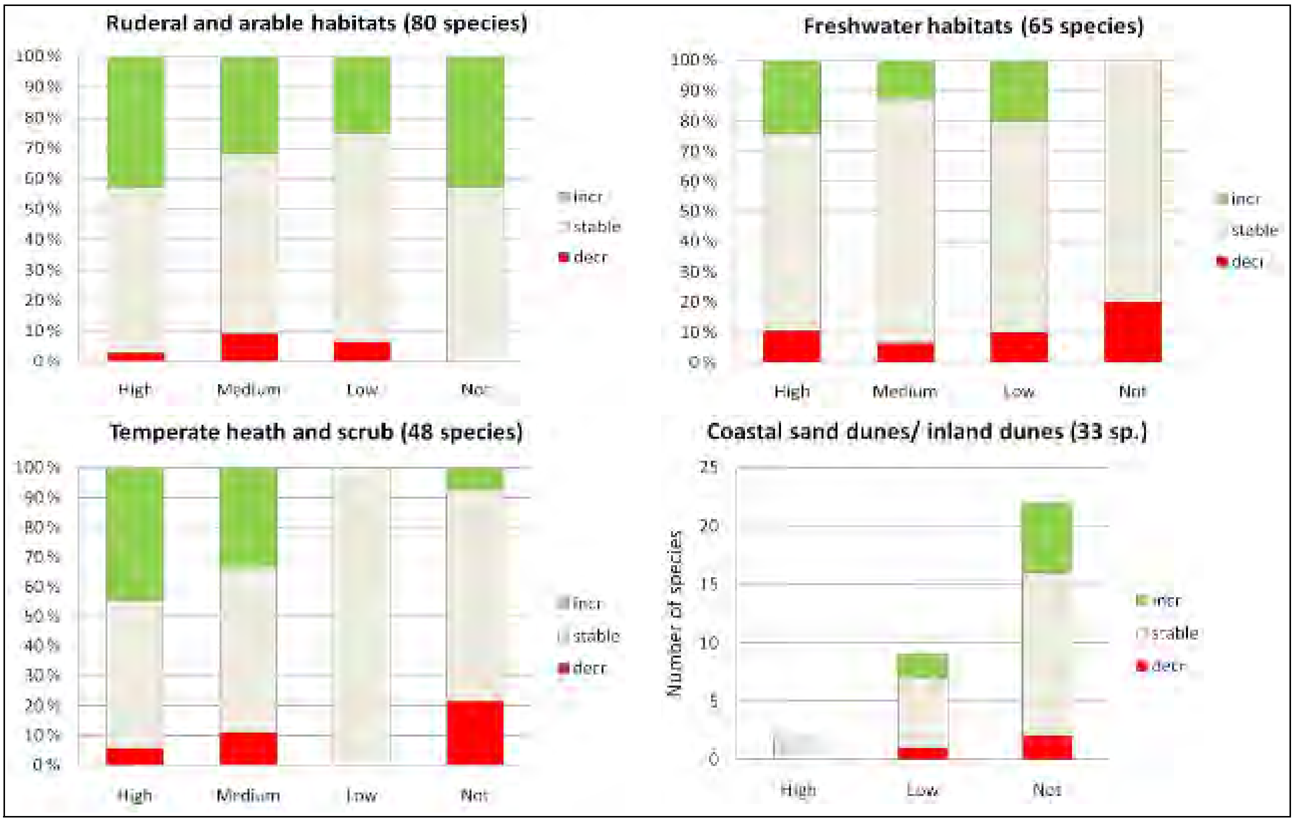


Figure 22: Share of species with increasing, stable and decreasing population trends for four levels of sensitivity (high/medium/low/no sensitivity) to decreasing nitrogen availability, by habitat type.

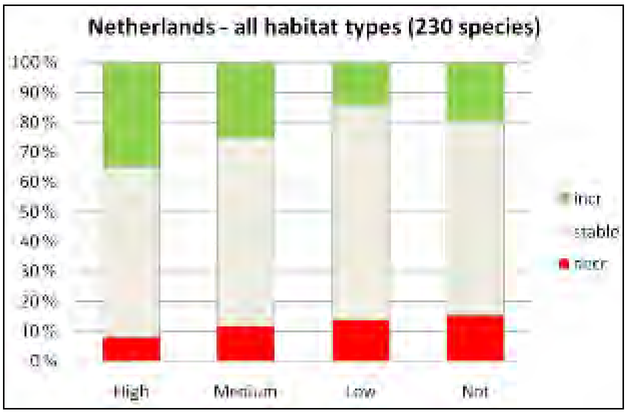


Figure 23: Share of species with increasing, stable and decreasing population trends for four levels of sensitivity (high/medium/low/no sensitivity) to decreasing nitrogen availability, for the Netherlands in total.

4.2.2.5 Discussion

In this case study we aimed to show the effectiveness of EU policies tackling air pollution for biodiversity in the Netherlands. We assessed the relation between decreased atmospheric nitrogen deposition and the biodiversity trend for vascular plant species using Dutch data on population and distribution trends as well as sensitivity scores for decreased nitrogen availability from the BioScore database.

A clear difference in the overall population trends between nature reserves and agricultural areas was found. Agricultural areas show an overall decrease of species, while nature reserves show an overall increase. The use of manure and fertilizers in agricultural areas could possibly explain why the overall proportion of species with decreasing trend is bigger for such areas compared to nature reserves.

Species which have low or no sensitivity to decreasing nitrogen levels are species with low Ellenberg values, thus preferring low nitrogen levels in the soil. Based on our hypothesis they were expected to show a population increase only if nitrogen levels drop significantly, but contrary to these expectations the observations show that they have the highest percentage of species with positive population trends. While on the basis of our hypothesis species with medium sensitivity are expected to have the highest percentage of increasing population trends, our results do not confirm such a pattern. On the other hand, according to the hypothesis the most sensitive species are expected to lose habitat, which is verified by our results in the case of nature reserves where the highest proportion of species with decreasing trends is indeed in the high sensitivity category.

Unlike the nature reserves, no obvious relation between species sensitivity scores and actual population trends was found for the agricultural areas. A possible explanation could lie in the fact that the high input of (artificial) fertilizer in the agricultural areas is overshadowing the pattern of recovery.

Also, in the analysis at national level it was not possible to relate the species trends to decreased levels of nitrogen deposition as no clear pattern supporting our hypothesis was found between species responses and species sensitivity. It is assumed that the results at national level are overshadowed by the population trend in the agricultural areas, because the area under agriculture in the Netherlands is far greater than the area of nature reserves. Also, the species trends analysed at habitat-type level do not reveal a direct link with decreased atmospheric nitrogen deposition. In fact, these results seem contradictory to our hypothesis, with the high sensitivity species showing the strongest positive development. However, it is important to note that these results reflect the classification scheme of the population trend data which were applied in this part of the analysis. The majority of the species appear stable in this approach, because the abundance classes are following a logarithmic scale. Thus, for species in the upper frequency classes, changes in species abundance need to be very large in order to be visible from the classified data. This is a drawback when analysing the species shares with increasing and decreasing population trends. For the trend data of the nature reserves and the agricultural areas this logarithmic classification was not used, resulting in much lower percentages of stable species. Moreover, different sets of species were used in the analysis, which also contributes to differences in the results.

Thus, it was not possible to make a direct link for all areas to the effectiveness of EU policies addressing the improvement of air quality. Moreover, the considered time frame in this analysis is relatively short because EU policies tackling air pollution have effectively been in place only for about 30 years. Considering only such a short time period it is unlikely that we can directly link results of these policies to biodiversity trends as species responses are complex. It can be concluded that the effect of improved air quality is best studied in nature reserves, which are impacted mainly by atmospheric nitrogen depositions rather than by direct inputs. Overall, we need to keep in mind that nitrogen is only one variable influencing the population trends of vascular plant species in the Netherlands, while land-use changes, climate change, disturbances and other pollutants have an impact too. For example, Ozinga & Schaminée (2007) showed that sensitivity of plants to climate change and habitat fragmentation can both explain part of the trends observed over the 20th century.

Furthermore, the study concentrated on eutrophication impacts caused by the deposition of nitrogen only, while we neglected other eutrophicating substances, such as phosphorus. However, it can be assumed that atmospheric phosphorus deposition is several times lower than nitrogen deposition (compare Anderson & Downing, 2006).

Also the availability of population trend data was a limiting factor in this approach. While the number of plant species listed in the database would be sufficient for such analyses, the available population trend data do not cover all of these plants. This made it necessary to include other plant species in the analyses which are not part of the database. For further analyses concerning the effectiveness of EU policies based on the BioScore database, it is therefore important to improve the availability of population trend data. In future analysis with the BioScore database it should also be taken into account that the effect of a changing pressure on species trends depends on the current state of the pressure.

In conclusion, the BioScore tool provides a useful aid for coarse analysis of policy impacts on biodiversity. However, the analysis shows that it is not possible to link observed species trends solely to a decrease in aerial nitrogen deposition in the Netherlands as several other variables are also influencing the population trends. Only for nature reserves were the results partly in line with the expected species responses as stated in our hypothesis.

4.2.3 *Impact of improved water quality on freshwater fish and benthic macroinvertebrates in Norway*

4.2.3.1 Background

Thanks to international regulations, emissions of acidifying substances in Europe have declined during the past decade. In the current 27 Member States of the European Union (EU27) emissions of nitrogen oxides have been reduced by more than 35% and sulphur dioxide emissions by almost 70% between 1990 and 2006 (EEA, 2008). In Norway the total deposits of nitrogen were reduced from 173,400 to 104,000 tonnes between 1980 and 2003, while total deposits of sulphur decreased from 191,000 to 62,000 tonnes within the same period, accounting for a reduction of about 40% and 68%, respectively.

Despite the significant emission reductions, acid rain is still a serious threat for freshwater ecosystems in Norway. Acidification of lakes and rivers has caused the depletion or complete loss of many fish stocks and has also affected other aquatic animals and plants. Norwegian freshwater ecosystems are very sensitive to acidification since, especially in the southern part of the country, critical loads are low because of thin soils and bedrock consisting of acidic rocks (Norwegian Pollution Control Authority, 2008).

Although this study is intended to focus on Norway only, at the same time it also reflects the development of air quality in other parts of Europe, since about 90% of the sulphur and nitrogen deposited in Norway originate from other countries, among which the UK, Germany and Poland contribute the largest part to acid pollution in Norway (Norwegian Pollution Control Authority, 2008).

4.2.3.2 Theoretical framework – Method and expected results

Our focus for this analysis was on Norway for the following two reasons: (1) Norwegian ecosystems are very sensitive to acidification as explained above, and (2) national monitoring programmes providing long-term information on trends in deposition, freshwater quality, fish populations and invertebrates exist in Norway since the 1970s.

However, due to an emerging lack in availability/accessibility of necessary population trend data for freshwater species in Norway (and throughout Europe), the study on the impacts of improved air quality on such species could not be pursued as planned. Bottlenecks related to the current status of data availability in Europe as encountered in this project are explained in Section 4.2.3.3. The current section describes the method which it was planned to apply within this study as well as the results we had expected from the analysis.

The BioScore database lists information on sensitivity to water acidification for 217 freshwater fish species and 182 benthic macroinvertebrate species occurring in Europe. The sensitivity of the listed invertebrates was assessed only for the Boreal, Atlantic and Alpine zones. The degree of their sensitivity as well as the number of species used to assess acidification levels vary between these zones. For the listed fish species, sensitivity scores are constant across all BGRs in Europe.

Querying the database allows us to estimate the percentage of fish and macroinvertebrate species in Europe with no, low, medium and high sensitivity to acidification. Figure 24 demonstrates the number of freshwater fish species for the different sensitivity scores as derived from the database. Most of the fish species have medium or high sensitivity to water acidification. The sensitivity of macroinvertebrates is given in Figure 25 for the different BGRs. Species sensitivity in the Alpine zone is about the same as in the Boreal zone. However, there are differences in species sensitivity scores between the Alpine/Boreal and the Atlantic zone. While nearly half of the macroinvertebrate species assessed for the Alpine/Boreal zone are not sensitive to water acidification, most of the species assessed for the Atlantic zone are highly sensitive to acidification.

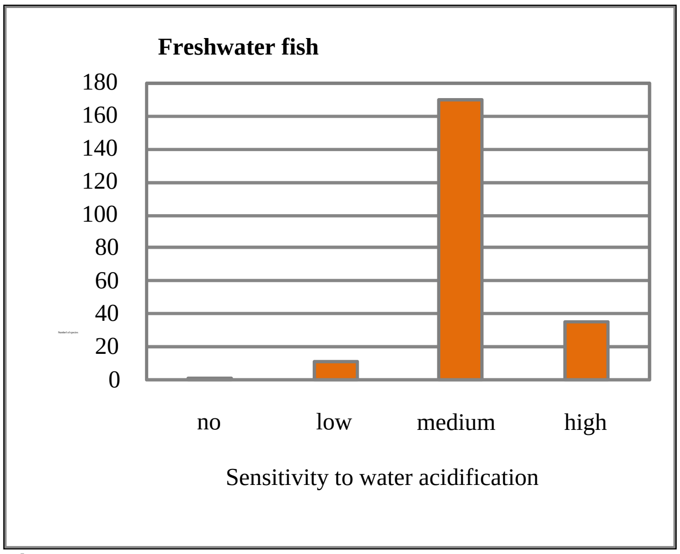


Figure 24: Number of freshwater fish species with no, low, medium and high sensitivity to water acidification in Europe, as derived from the BioScore database.
Total number of freshwater fish species listed in the database: 217.

a. Alpine and Boreal zones (108 species)
b. Benthic macroinvertebrates Atlantic zone (84 species)

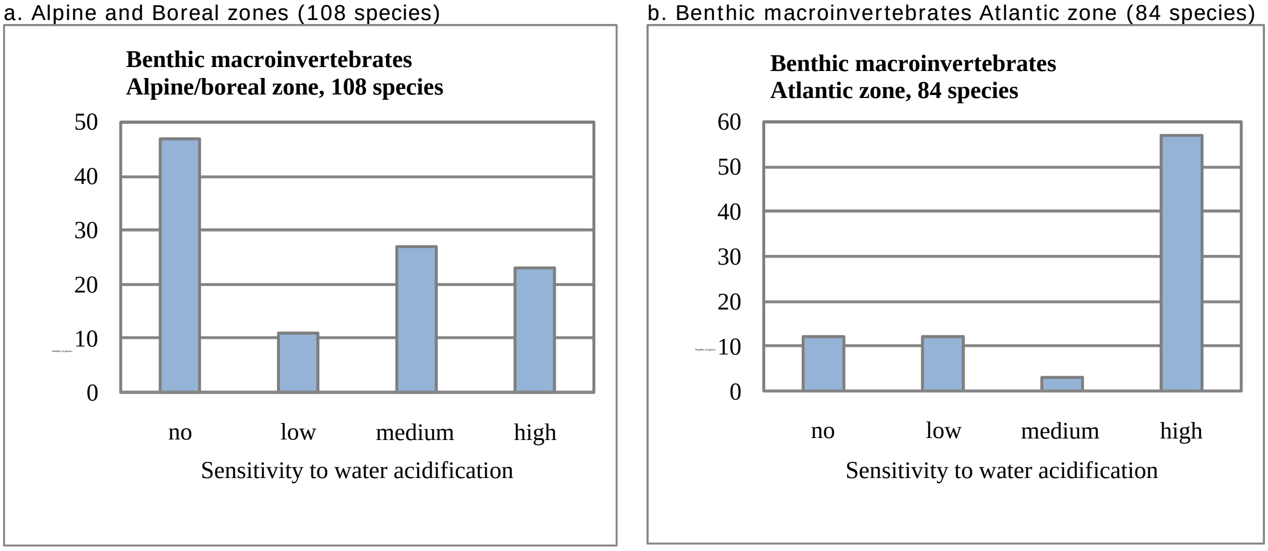


Figure 25: Number of benthic macroinvertebrate species with no, low, medium and high sensitivity to water acidification in the Alpine and Boreal zones (a), and in the Atlantic zone (b), as derived from the BioScore database. Total number of benthic macroinvertebrates listed in the database: 182.

With the focus on Norway, which covers parts of the Alpine, Atlantic and Boreal zones, the objective of this analysis was to relate the species sensitivity derived for the different zones (Figure 25) to population trends for the same species. Distinguishing between the different species-specific sensitivity scores, one can study which species show increasing, decreasing and stable population trends.

With regard to decreasing levels of water acidification, it is expected that first the species with low or medium sensitivity will show a positive reaction when the pressure (in this case water acidification) is declining, while highly sensitive species will react in a positive way only if this decrease is strong enough. Thus, most of interest lies in the reaction of the highly sensitive species. Based on regional trends in water acidification, the population trends of the highly sensitive species can be compared to the actual development in water quality. In this way, conclusions on a connection between population and water quality trends can be drawn which give us an indication of the effectiveness of introduced policy measures combating water acidification for freshwater species. However, as is the case in the air quality study we need to keep in mind that apart from nitrogen deposition other variables are also influencing population trends of the species.

With available data on water quality and population trends, this type of analysis can easily be applied to other countries or BGRs, or even at European scale. However, in the case of benthic macroinvertebrates, the BioScore database holds information on species sensitivity to acidification only for the Boreal, Atlantic and Alpine zones, where acidification is considered as one of the main ecological problems. We consider the BioScore database an effective tool to make the link between the sensitivity of freshwater species towards water acidification, and the actual population and water quality trends, in order to derive conclusions on the effectiveness of currently implemented EU policies combating water pollution with respect to biodiversity.

4.2.3.3 Drawbacks – Current status of data availability in Europe

The importance of a long-term ecological perspective is well documented, yet the availability of long-term data remains limited. A survey of recent literature on stream macroinvertebrates identified 46 papers published between 1987 and 2004 that included long-term (i.e. ≥5 years) population trend data. Most recently published long-term studies of stream macroinvertebrates began collecting data in the 1970s and 1980s and their duration (time between first and last year sampled) was relatively brief (median = 9 years, maximum = 96 years). Most studies did not expand their temporal perspective by incorporating older data collected by other researchers (Jackson & Füreder, 2006).

In 2000, the EU Member States, Norway and the European Commission jointly developed a common strategy for supporting the implementation of the Water Framework Directive 2000/60/EC establishing a framework for Community action in the field of water policy. In this context, Member States have made good progress in establishing monitoring programmes for aquatic ecosystems. All of the reporting countries track some, if not all, of the essential biological variables in their monitoring programmes. These variables include, among others, bottom-living invertebrate animals and fish (CEC, 2008). The national monitoring programmes will be able to provide Member States with a considerable amount of data, which could be useful for many other scientific purposes, beyond the scope for which the programmes have been designed. According to the Northern Geographical Intercalibration Group/working group's Acidification milestone report (JRC, 2007), all countries probably do not have a good distribution of monitoring sites across the ecological status range. A full evaluation of the distribution of sites is in progress. In general, data compilation and analysis is still in progress in order to come up with the finalization of the intercalibration of acidification with regard to macroinvertebrates.

Specifically, in our case study, the population trend and acidification status data from some of the Norwegian rivers is published yearly in relation to the national programmes on liming and acidification. However, an emerging lack of accessibility to necessary population trend data for freshwater species was the main bottleneck for the water case study's development.

4.2.3.4 Data needs and recommendations for future analyses

Although freshwater ecosystems have a long and very intense history of study in relation to their responses to an equally varied range of pressures, monitoring the effects of the impacts on biological communities is complex (CEC, 2003). The European Commission (DG Environment, Eurostat and Joint Research Centre) and the European Environment Agency (EEA) are committed to continue the development of a new, comprehensive and shared European data and information management system for water, including river basins, following a participatory approach towards the Member States, in order to have it operational as soon as possible and to implement it, including all the various elements set out in this document, by 2010 (WISE, 2007). Additional purposes of data and information reporting by Member States include, among others: (a) to assess state and trends for the environment and the associated pressures, impacts and socio-economic driving forces that either cause or result from changes, and (b) to use the information on implementation and trends to assess the effects and effectiveness (including cost-efficiency) of policy, both before and after measures have been introduced (CEC, 2003).

Information collection and reporting require finance, but much less compared to the costs arising from implementing poorly defined environmental policy based on insufficient knowledge. If we are to encourage long-term perspectives in science, we need to facilitate the transfer of individual studies, as well as knowledge and data, among scientists. This includes efforts to archive and annotate data more effectively, so that they can be more easily incorporated into future research. In conclusion, the key task for scientists in order to assess the impact of improved water quality on freshwater fish and benthic macroinvertebrates is to achieve better accessibility to long-term datasets.

4.3 Prospective case study: The impact of biofuel crop cultivation on biodiversity in Europe

4.3.1 Introduction

It is widely accepted that anthropogenic emissions of carbon dioxide (CO_2), among other greenhouse gases, are leading to global climate change (Solomon *et al.*, 2007). Renewable energies are seen as one of the key options to mitigate CO_2 emissions (EEA, 2006b; Faaij, 2006). Compatible with many conventional engines and blendable with current fossil fuels, biofuels have potential to contribute to emission reductions in the transport sector (Farrell *et al.*, 2006; Koh & Ghazoul, 2008; Tan *et al.*, 2008).

In recent years the production of biofuels and the problems related to it have received increasing attention in EU policy, a focus which is likely to remain in the coming years. The EU promotes the production of biofuels through the application of the Biofuels Directive (2003/30/EC Directive on the promotion of the use of biofuels and other renewable fuels for transport) which sets a target of 5.75% share of biofuels in the transport sector by 2010 for all the EU Member States. In 2008 the European Commission presented a proposal for a new directive aiming at establishing an overall binding target for biofuels in transport (10% minimum target) to be achieved by each Member State by 2020 (CEC, 2008b).

Sources for biofuels include dedicated biofuel crops, organic wastes, and wood residues from forestry. The focus of this study is on dedicated biofuel crops. Currently, there are two common strategies of producing biofuel crops. One is to produce ethanol from crops rich in sugar or starch (e.g. sugar beet, cereals and potatoes), the other is to produce oil or biodiesel from crops rich in vegetable oil (e.g. rape seed, sunflowers). These so-called first-generation biofuel crops are cultivated as normal arable crops in a rotational system. Second-generation biofuel crops, produced from non-food, ligno-cellulosic materials such as wood, energy grass or any other cellulosic biomass, are still under development, but are expected to play a vital role in the biofuel sector in the future. From a biodiversity perspective the production of second-generation biofuel crops such as short-rotation coppice and perennial biomass grasses has several advantages over the cultivation of first-generation arable crops.

The cultivation of biofuel crops has a significant impact on land use and cuts across several sectors: agriculture, forestry and energy. Out of the EU25's total arable land (97 million hectares), about 1.8 million hectares were used for producing raw materials for biofuels in 2005 (CEC, 2005). An increasing demand for biofuels could lead to the expansion of cultivated areas. Possible consequences are increasing environmental pressures, further habitat loss and biodiversity decline, especially if forest, grassland, peatland and wetlands are converted into monoculture plantations for the production of biofuels (CBD, 2008).

The aim of this case study is to show how the BioScore database can be applied to assess biodiversity impacts resulting from changing land use due to the production of biofuel crops in Europe, distinguishing between arable (first-generation) and woody (second-generation) crop types. (See for full paper Eggers *et al.*, 2009.)

4.3.2 Input data

4.3.2.1 Species-specific information

The BioScore database provides information on environmental requirements and sensitivity scores to various pressures for a vast number of species. In this case study, we considered only terrestrial species groups: mammals, birds, amphibians, reptiles, diurnal butterflies and vascular plants.

We used the information on the suitability of different land cover classes (following the Corine classification) as potential habitat for the species. This information is listed by BGR in the database. For mammals, reptiles and amphibians we also considered elevation ranges (minimum and maximum elevation) in which the species occur. The database distinguishes four different levels of habitat suitability ('suitability levels'): not suitable, low, medium and high suitability. For butterflies and vascular plants, we used information on occurrence per BGR as given in the BioScore database.

Maps on species distribution (presence/absence) in Europe at a resolution of 50 km were available for mammals, reptiles, amphibians and birds. These maps are based on a number of data sources (Hagemeijer & Blair, 1997; Mitchell-Jones *et al.*, 1999; Gasc *et al.*, 2004; Linnell *et al.*, 2007; Temple & Terry, 2007). For birds, we neglected cells with potential breeding in the distribution maps and used only probable and confirmed breeding areas. For a set of 60 mammals, 29 reptiles, 20 amphibians and 203 birds (312 species), both distribution data and habitat suitability level per CLC class were available. Therefore, we used this set of species to study the potential impacts of land-use changes resulting from increased or decreased biofuel crop cultivation in a spatially explicit way. In addition, we applied a general impact assessment for 77 diurnal butterflies and 931 vascular plants at the resolution of BGRs.

Data on elevation covering the entire study area were obtained from the GTOPO30 digital elevation model for Europe at 1 km resolution (USGS, 2006). To delineate the different European regions considered in the BioScore database we used boundary data of 11 BGRs as defined by the EEA (2005) at a scale of >=1:10,000,000.

4.3.2.2 Land-use scenario

The effects of the Biofuels Directive implementation were evaluated based on a land-use scenario for the 27 EU countries for the period 2000 to 2030 at 1 km resolution. This 'Global Economy' scenario is an output of the Eururalis 2.0 project (Rienks, 2008; Verburg *et al.*, 2008; WUR & MNP, 2008), and assumes a continuing globalization with open borders, open trade, rapid economic growth, strong economic development and low levels of government intervention resembling the scenario conditions of the IPCC *Special Report on Emissions Scenarios* (SRES) A1 scenario (Nakicenovic & Swart, 2000; Westhoek *et al.*, 2006). Within this scenario three policy options are explored related to the Biofuels Directive:

- Policy option (e1) of no or low ambition on biofuels: 0% blending obligation on share of biofuels in transport sector in 2010 and kept constant afterwards.

- Policy option (e2) of medium ambition on biofuels: 5.75% blending obligation on share of biofuels in transport sector in 2010 and kept constant afterwards.

- Policy option (e3) of high ambition on biofuels: 11.5% blending obligation on share of biofuels in transport sector in 2010 and kept constant afterwards.

In all three policy options, the biofuel ambitions are assumed to be met solely by first-generation biofuel crops. Furthermore, in its current implementation similar ambitions in other world regions are disregarded.

The policy option of medium ambition (e2) can be considered as a reference scenario, as it reflects the currently implemented target of the EU Biofuels Directive. Annex 6 Table A1 presents the land use in 2000 and in 2030 according to the three policy options. The e1 policy option indicates the abolishment of the biofuel target, while the e3 policy option reflects a doubling of the current target. The area devoted to the cultivation of biofuel crops increases from 0.5% of total land area in the year 2000 to 1.2%, 2.7% and 3.9% of total land area in the year 2030 for the policy options e1, e2 and e3, respectively. The land-use projections in all three policy options are attributed to different factors, such as demographic and economic development as well as agricultural and several other policies including biofuel targets (Westhoek *et al.*, 2006). However, the biofuel policy options differ from each other only in the biofuel target, whereas all other policies are kept constant. Thus, any difference between e1, e2 and e3 is solely linked to biofuel policy. Therefore, comparing the policy options allows us to quantify the relative impact of biofuel policy on land use, and thus to link the subsequent land-use changes to impacts on biodiversity. Besides the land-use projections for the three policy options, a base map for the year 2000 following the same land-use classification scheme was also used in this study.

4.3.3 Methods

4.3.3.1 Mammals, reptiles, amphibians and birds: Downscaling and scenario comparison

Downscaling of species distribution maps
The habitat suitability levels, the species-specific elevation ranges, and the information on BGRs were used to downscale and refine the available species distribution data (presence/absence) from the original resolution of 50 km to a resolution of 1 km for the three policy options (year 2030). For every species and each possible combination of land-use type, elevation and BGR, the related habitat suitability level was queried from the BioScore database. The species distribution data as well as the minimum and maximum elevation range specified for each species in the database were used to exclude areas where a species does not occur. The resulting downscaled distribution maps present habitat suitability levels within the area of species presence.

The land-use classes for the biofuel policy options were simulated based on a generalization of the CLC classes used in the BioScore database. A conversion had to be applied to link these two classification schemes and derive information on habitat suitability for the policy options. To establish such a conversion, in a first step the base map for the year 2000 was combined with the Corine 2000 map. In a second step, the dominant Corine class(es) was identified for each class of the base map in each BGR. If several Corine classes were co-dominant in one land-use class of the base map, multiple Corine classes were linked to that land-use class. In such cases, the maximum suitability level for these Corine classes from the BioScore database was assigned to the respective land-use class in the land-use maps of the biofuel policy options.

In the biofuel policy options, only first-generation biofuel crops are considered. In order to analyse the impact of cultivating different crop types on biodiversity, we assumed in a comparative analysis that woody crops would be cultivated instead of arable biofuel crops at the same sites. Thus, we considered two crop options when downscaling the distribution maps: (a) first-generation biofuel crops (arable crops such as maize, wheat or potatoes), cultivated at all sites marked as ‘biofuel crops’ in the three biofuel policy options; and (b) second-generation woody biofuel crops (short-rotation woody crops such as willow and poplar), cultivated at all sites marked as ‘biofuel crops’ in the biofuel policy options. In order to differentiate between the crop types, the land-use class ‘biofuel crops’ was linked with the habitat suitability level of the Corine class ‘arable land’ to analyse impacts of first-generation arable biofuel crops (hereafter referred to as option ‘arable’), and with habitat suitability of the Corine class ‘fruit trees and berry plantations’ used as a proxy for woody crop plantations to study impacts of second-generation woody biofuel crops (hereafter referred to as option ‘woody’). For birds, in addition to the suitability levels per CLC class as given in the BioScore database, explicit habitat suitability levels for woody crops were available. Therefore, we linked these levels to the woody crop option in our analysis for birds.

Comparison between the biofuel policy and crop options
A comparison of the biofuel policy options addresses two questions: (1) what might happen if we doubled the current biofuel target (e3 versus e2), and (2) what might happen if we abolished the current biofuel target (e1 versus e2)? These questions were assessed for the arable crop option. In order to compare the impacts of arable and woody crops, we also analysed the differences between the woody and the arable crop option for the e2 scenario.

Following the approach adopted by Maiorano *et al.* (2007), the habitat suitability levels of the downscaled distribution maps were grouped into two classes: potential species presence (medium and highly suitable habitat) and potential species absence (unsuitable and low suitability habitat or species not present). The resulting binary maps were used to calculate for each species group, and for all species combined, the total number of species potentially occurring in each 1 km x 1 km grid cell. Based on these totals, differences between the scenario policy options were calculated at European level.

At the level of BGRs and countries we analysed which species might gain or lose habitat if the biofuel target was doubled or abolished, and if woody crops were cultivated instead of arable crops, relative to the reference policy option e2. To concentrate on major changes in potential habitat size, we considered only those changes exceeding an increase or decrease of 1% of the potential habitat of the species in a BGR or country. In all other cases the potential habitat was considered as stable. The resulting figures were used to derive the percentage of species occurring in a BGR or country which might increase, decrease or keep their potential habitat size under the different assumptions.

Moreover, we analysed the relative species turnover between the different biofuel policy options and the two biofuel crop types. In literature, species turnover is defined as the rate or magnitude of change in species composition along predefined spatial, environmental or temporal gradients (Vellend, 2001). In our study species turnover indicates the amount of species which will potentially benefit or suffer from land-use changes caused by increased or decreased biofuel production or by changing the crop type. It was calculated as the ratio between the number of species potentially gaining or losing their entire habitat in each 1 km x 1 km cell when comparing the policy options, and the total species number (based on the e2 option) of that cell. When studying the species turnover for a change from arable to woody crops, the total species numbers in the e2 arable option were used as reference values. Our turnover calculation implies that even if the total number of species per grid cell increases, species loss can occur there. In fact, species turnover as we have defined it, does not necessarily correspond to a change in total species number per grid cell. We consider it to be a decrease in species number when one or more species potentially lose their entire habitat in a grid cell, while an increase in species number occurs when one or more species potentially gain habitat in a grid cell where they were not present before. Thus, the species turnover is a means to show changes in species composition. The higher the relative turnover (both potential species gains and losses), the higher the potential change in species composition. We aggregated the results of the species turnover calculation at the level of 50 km x 50 km cells. In particular, to each 50 km x 50 km cell we assigned the percentage of area potentially gained or lost within this cell by more than 50% of the species, taking the policy option e2 as reference. From this analysis, we excluded cells with fewer than six species (corresponding to a percentage of the study area of less than 1%), as they were considered as unrepresentative. The relative species turnover was calculated for all taxonomic groups combined.

In addition, we analysed the area with a potential change in total species number for each species group, based on the difference in the total number of species potentially occurring for each 1 km x 1 km grid cell between the policy options and between the two crop types.

All analyses were based on the EU27 area due to the spatial coverage of the land-use scenario.

4.3.3.2 Butterflies and vascular plants: General approach

No distribution data were available for butterflies. Therefore, information on species occurrence at BGR level was used to analyse regional impacts of biofuel policies. For every region the shares of the different land-use classes from the total area were calculated for all three biofuel scenarios, and the changes in land use between the different biofuel policy options and the two crop types were analysed. Changes were highest in the land-use classes arable land, biofuel crop plantations, permanent crops, pastures, (semi-)natural vegetation and forest. Suitability levels of these land-use classes were retrieved for the butterfly species by BGR from the BioScore database. As was done for mammals, reptiles, amphibians and birds, the habitat suitability for woody biofuel crops was derived from the Corine class ‘fruit trees and berry plantations’. Depending on the share of the different land-use classes in the total land-use change between the scenarios, an aggregation formula (Section 2.3.4) was used to calculate the expected impacts on habitat suitability by species and BGR. The result of the aggregation shows the average change in the suitability score for each species by BGR, and thus gives an indication of whether the potential impact on a species is positive or negative, or if no impact is to be expected. As the underlying land-use changes were derived from the Eururalis projections, the expected impacts are based on the EU27 area.

In the case of vascular plants we were lacking detailed information on habitat suitability. However, suitability information for 10 different habitat types was available: the nine Natura 2000 habitat types (Coastal and halophytic habitats, Coastal sand dunes and inland dunes, Freshwater habitats, Temperate heath and scrub, Sclerophyllous scrub, Natural and semi-natural grassland formations, Raised bogs, mires and fens, Rocky habitats and caves, and Forests), plus the addition of Ruderal and Arable habitats. As the habitat types do not follow the classification schemes of Corine or of the Eururalis projections, no detailed spatially explicit analysis could be accomplished, even though detailed distribution data were available. Therefore the same approach as for butterflies was applied to vascular plant species. To adapt to the classification scheme of the habitat types, the land-use classes ‘pastures’ and ‘(semi-)natural vegetation’ in the biofuel scenarios had to be combined into one class. Habitat suitability for the land-use class ‘permanent crops’ was derived from the habitat type ‘temperate heath and scrub’ as there was no better suitable habitat type available. Annex 6 Table A4 shows which habitat types were assigned to the land-use classes of the biofuel policy options. Similarly to the approach adopted for butterflies, the analyses were carried out at the level of BGRs. We focused on the impact of arable biofuel crops only, since analyses for the woody crop option were not feasible with the given data on habitat types. The expected impacts were calculated by species and BGR, applying the same aggregation method as described above for the butterflies. The results are limited to the EU27 region.

4.3.4 Results

4.3.4.1 Mammals, reptiles, amphibians and birds

Downscaled species distribution (mammals, reptiles, amphibians and birds)
Downscaled distribution maps were compiled for all species for the EU27 area for which data are available in the BioScore database. The maps show the habitat suitability of land use and elevation on a 1 km x 1 km grid per species, within the area of occurrence as given in the distribution data (Figure 26). The downscaled distribution maps served as input to all following analyses. We aggregated the suitability levels into two classes ‘species is present’ (medium and high suitability habitat) and ‘species is absent’ (unsuitable and low suitability habitat) (see also Section 4.3.3.1).

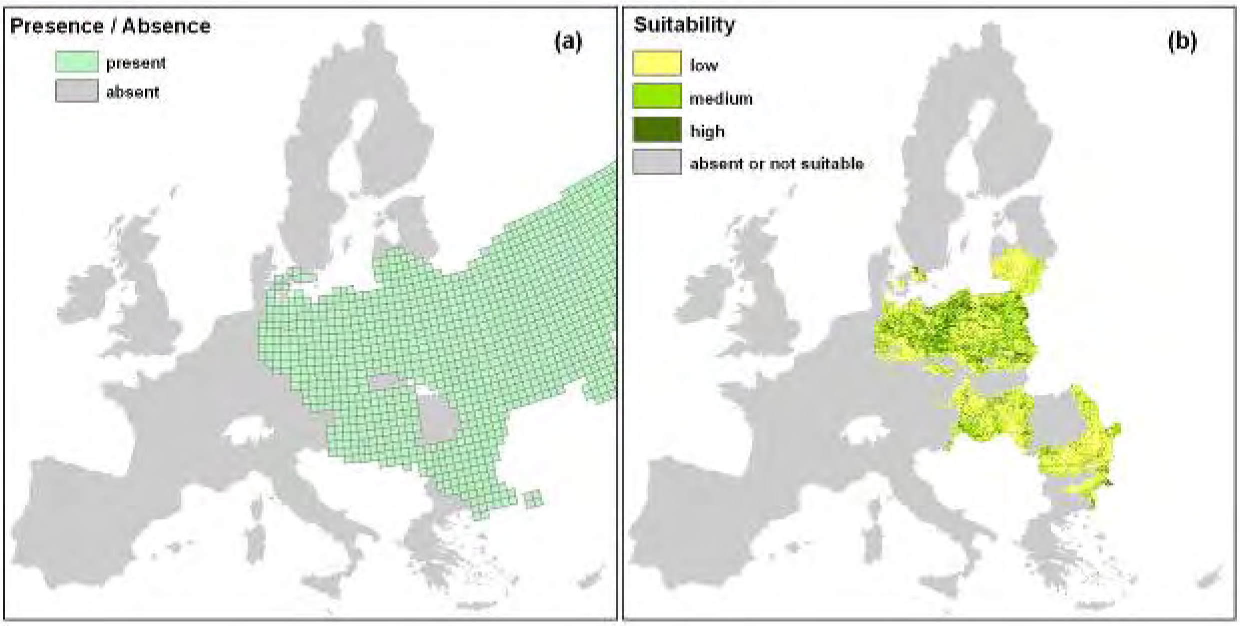


Figure 26: Example for distribution (presence/absence, 50 km x 50 km, a) and downscaled distribution data (b) for European Fire-bellied Toad (*Bombina bombina*).

Changes in the size of suitable habitat between the biofuel policy and crop options
Annex 6 Table A2 presents the share of species that might lose or gain potential habitat if the biofuel target is abolished or doubled under the arable crop option, per species group and BGR. Additionally, the table lists the share of species losing or gaining potential habitat if woody biofuel crops were be cultivated instead of arable crops (for the e2 policy option). Figure 27 presents the total number of species that potentially lose or gain habitat under the above-mentioned assumptions for all species groups combined by BGR. The total impacts at country level are given in Annex 6 Table A3.

The potential impact of biofuel plantations on species occurrence varies among BGR/country and species groups. For example, 28% of the mammal species occurring in the Boreal region might lose potential habitat if the biofuel target was abolished, while the effect on mammals is largely positive in the other BGRs. Besides the regional differences, these numbers also indicate that for most of the regions and species groups, the number of species that might lose habitat when doubling the current biofuel target far outweighs the number of species that might gain habitat. The potentially negative impacts of a doubled biofuel target are largest for mammals, especially in the Continental region. More species would win rather than lose potential habitat if the current biofuel target was abolished. Only in the Boreal zone is the situation different, as here potential habitat loss is higher than habitat gain for all species groups if abolishing the current target. The impact of cultivating woody instead of arable biofuel crops is positive for mammals and reptiles – more species might win rather than lose potential habitat. For birds, the effect would be slightly negative, while the crop option choice has only a small impact on amphibians.

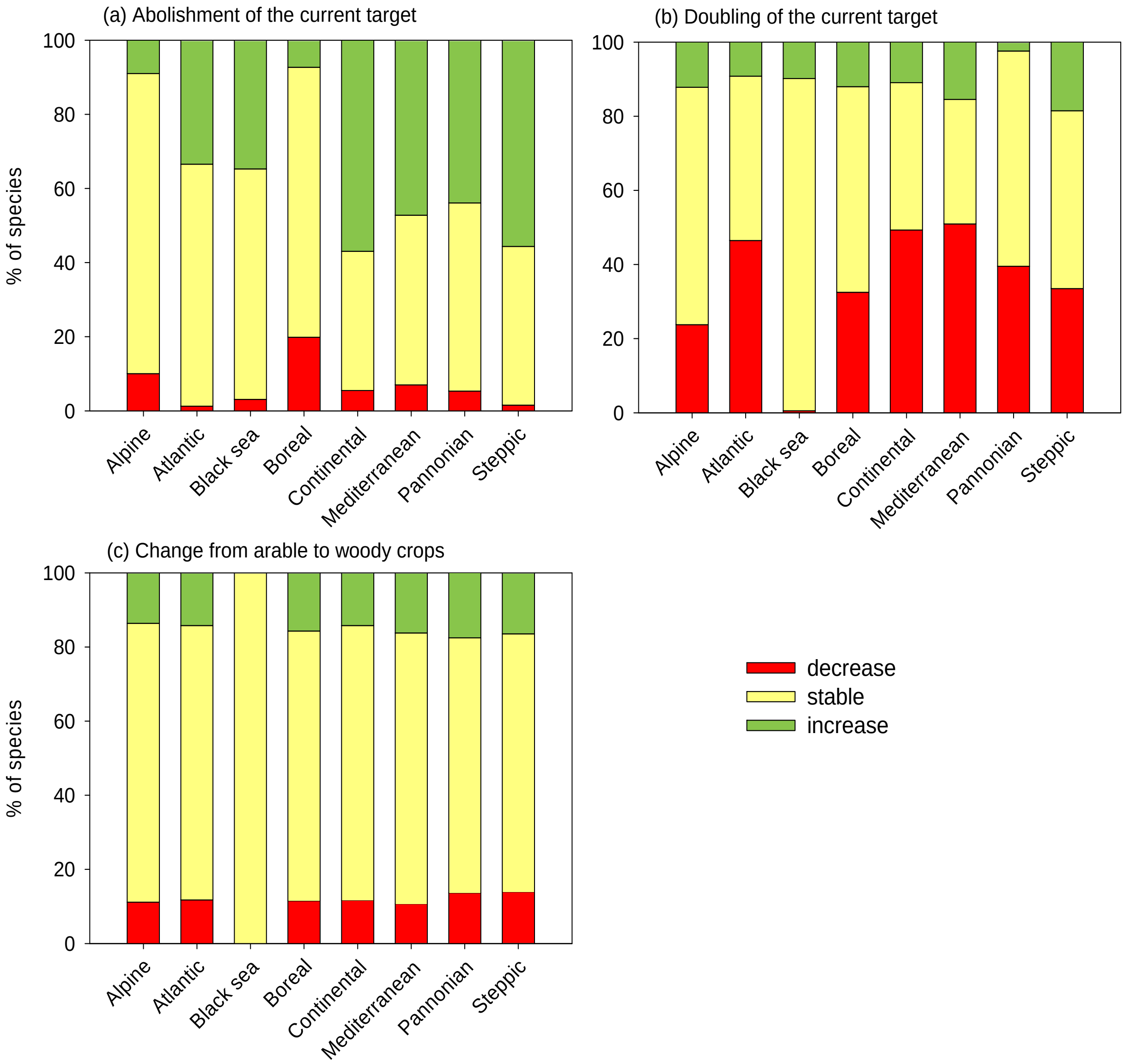


Figure 27: Total number of species possibly losing or gaining more than 1% of their potential habitat if the biofuel target is abolished (a) or doubled (b), or if the crop type is changed (c), per BGR. Figures are summarized for birds, mammals, reptiles and amphibians.

Relative turnover of species and changes in total species number

The area in EU27 where the species composition (potential species loss and gain relative to species number in e2) might change was aggregated per 50 km x 50 km grid cell for all considered species groups. For the comparative analyses on woody biofuel crops, the same locations of biofuel plantations were assumed for the crop production (compare Section 4.3.3.1). For comparison with the results of the species turnover, the figure in Annex 6 shows the percentage of area covered by first-generation biofuel crop plantations in the three biofuel policy options, aggregated at 50 km x 50 km level, the same resolution for which the species turnover is shown.

The species turnover potentially resulting from a change in the biofuel target is shown in Figure 28; note that this focuses only on the strongest effects (potential species gain or loss of >50%). The maps identify hot spots in Europe where more than 50% of the local species might lose their entire habitat (potential species loss of >50%) and hot spots where species gaining new habitat at sites where they were not present before amount to more than 50% of the local species (potential species gain of >50%), if the current biofuel target were to be changed. From the turnover maps we can see that the areas of potential species gain and loss do not necessarily overlap, indicating that the impact of biofuel crop production varies spatially. For example, if the biofuel target is abolished, the area of potentially high species gain exceeds the area of potentially high species loss in the Mediterranean region, while the opposite is true for the Baltic countries. Overall, if the target is abolished, the area with a possible species gain of more than 50% exceeds the area with potential species loss of more than 50%, while the effect is clearly the opposite if the target is doubled.

If woody instead of arable crops are cultivated, the potential species loss and gain is high in the affected areas (see figure in Annex 6 for an overview of the affected areas in the three policy options), because most species have a clear preference for either arable or woody crop habitats and do not occur in both habitats. Species composition in the affected areas would thus change almost completely if woody instead of arable crops were cultivated.

A higher demand for biofuels will increase the pressure on semi-natural land and forest throughout Europe (Annex 6 Table A1). The decrease of semi-natural land and forest areas is smaller under a lower biofuel target, thus resulting in an increase of such areas when comparing the e1 with the e2 policy option ('Abolishment of the target'). As the change in pressure is effective throughout Europe, it impacts also places where biofuel production is stable between the policy options. This phenomenon indicates that our results also reflect the indirect effects of the Biofuels Directive, i.e. impacts on species diversity do not only occur where biofuel production actually takes place, but throughout Europe.

Despite the considerable turnover in species when changing the biofuel policy, the total species number remains constant for most of the EU27 area (Table 13). That is, in most areas species loss and species gain are balancing each other out. The area in EU27 with a potential change in total species number resulting from a change in biofuel policy is rather small, showing an increase or decrease of mostly well below 2% of the area. For mammals, amphibians and birds, abolishing the biofuel target is beneficial, while doubling the target results in a net loss of species, indicating a negative impact of biofuel plantations for these species groups. For reptiles, the reference policy option e2 seems most favourable in terms of total species numbers, because both an abolishment and doubling of the target have stronger negative impacts than positive ones. Doubling the biofuel target would potentially result in larger areas with negative changes in potential species numbers than would be the case if the biofuel target were abolished. Mammals and birds seem more sensitive than amphibians and reptiles to a change in the biofuel crop choice. While mammals might only benefit from a change to woody crops in terms of species numbers, the net effect of a change in crop type would be negative for amphibians and birds.

Overall, changes in biofuel crop cultivation have only a small potential impact on total species numbers and available habitat in the EU27 area. Out of the four species groups considered, it is foreseen that mammals and birds would be the most affected.

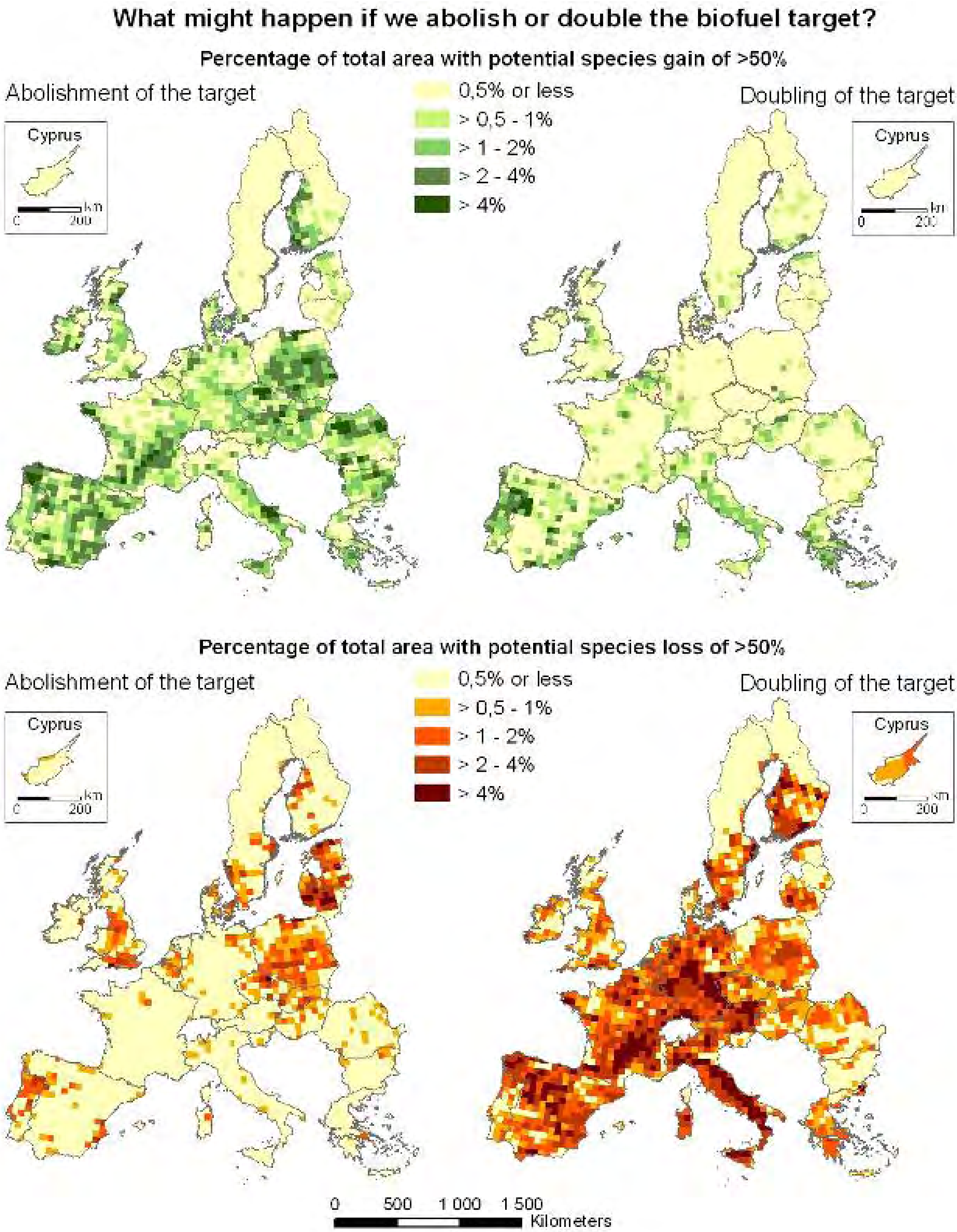


Figure 28: Percentage of area of 50 km x 50 km cells where more than 50% of the species would gain or lose their potential habitat if the current biofuel target were abolished or doubled. Only the cultivation of arable (first-generation) biofuel crops is considered.

Table 13: Percentage of the EU27 area showing a possible decrease, no change, or increase in potential species number (number of species with medium and high suitability habitat) if the current biofuel target is abolished or doubled or if the crop type is changed (woody-arable).

	What might change if we abolish the current biofuel target?	**What might change if we double the current biofuel target?**	**What might change if we cultivate woody instead of arable crops?**
	Comparison e1-e2	Comparison e3-e2	Comparison woody–arable in e2
Amphibians			
Decrease	0.3%	1.4%	0.7%
No change	98.8%	98.1%	99.0%
Increase	0.9%	0.5%	0.3%
Reptiles			
Decrease	0.8%	1.2%	0.3%
No change	99.0%	98.5%	99.5%
Increase	0.3%	0.4%	0.2%
Mammals			
Decrease	0.4%	1.8%	0.0%
No change	98.6%	97.8%	97.4%
Increase	1.1%	0.4%	2.6%
Birds			
Decrease	0.6%	1.6%	1.5%
No change	98.4%	97.5%	97.7%
Increase	1.0%	0.9%	0.7%
Total for all species groups			
Decrease	0.6%	1.8%	0.1%
No change	98.3%	97.5%	97.4%
Increase	1.1%	0.8%	2.5%

4.3.4.2 Butterflies and vascular plants

Impacts on butterfly species at the level of BGRs are shown in Figure 29. The results are presented as percentage of total species number by BGR. The total species number occurring in a region and for which data are available in the BioScore database varies between 65 species for the Boreal region and 77 species for the Continental region.

An abolishment of the current biofuel target would result in positive or indifferent effects only, in all but the Boreal zone. In the Boreal zone, 29% of the vascular plant species would suffer from abolishing the target, while 42% would benefit, therefore the net effect would be positive here, too. Butterfly species are sensitive to a doubling of the current biofuel target. Most of the species would react negatively, i.e. they would lose potential habitat. A positive effect would occur in the Pannonian region, where half of the butterfly species would gain habitat. A change from arable to woody crops would be beneficial for 11–13% of the species in all the regions, while the remainder of the species are indifferent to a change in crop type.

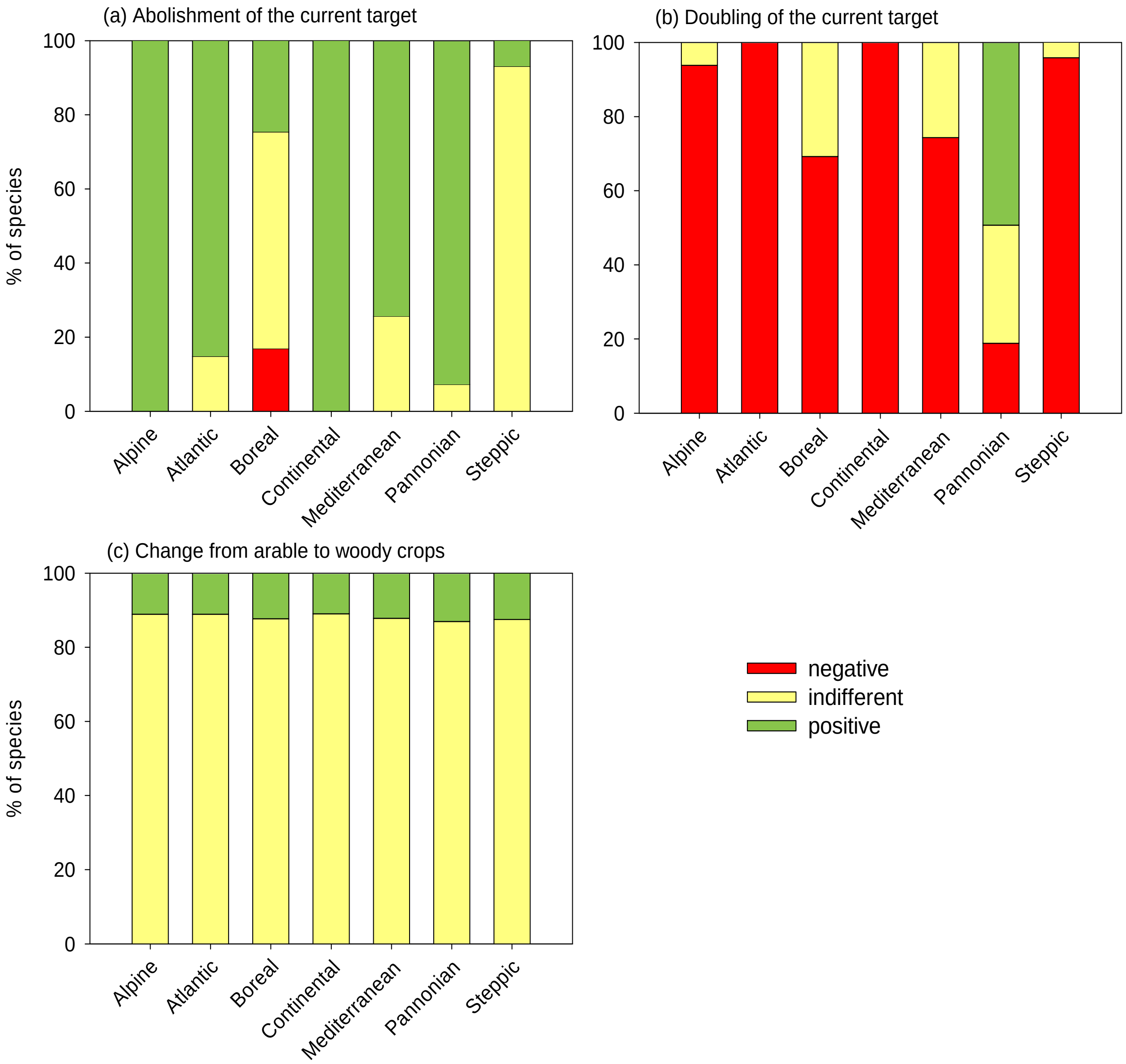


Figure 29: Impact on butterfly species if the biofuel target is abolished (a) or doubled (b), or if the crop type is changed (c), per BGR.

The impacts of changing biofuel policies on vascular plant species are given in Figure 30. The results are presented as percentage of total species number by BGR. The total species number occurring in a region and for which data are available in the BioScore database varies between 288 for the Boreal region and 523 for the Alpine region. The available data on habitat suitability for vascular plants did not allow comparative analyses between arable and woody crops.

In both policy comparisons the shares of species that benefit and suffer are very similar for most of the regions. Only the Alpine and Boreal regions form an exception. There the doubling of the current target would result in a much stronger negative effect than the abolishment of the target. The opposite effect occurs in the Steppic region, where a doubling of the current target would be beneficial for more than half of the species, while abolishing it would have a positive effect on only 35% of the species.

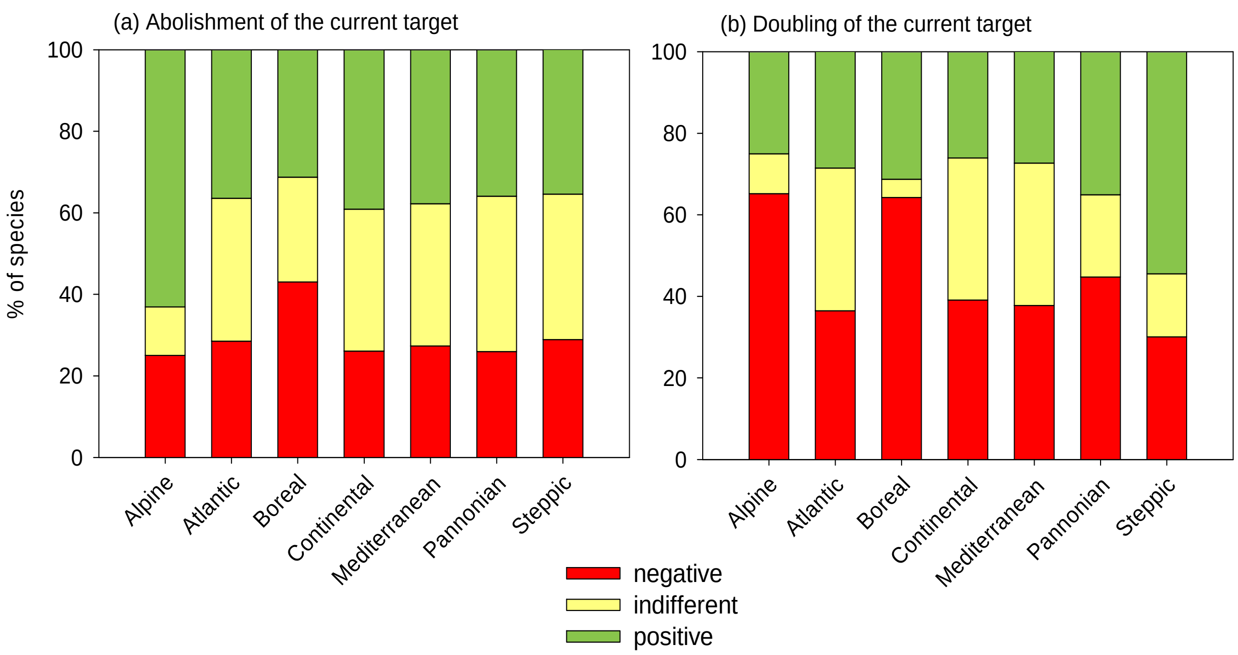


Figure 30: Impact on vascular species if the biofuel target is abolished (a) or doubled (b), per BGR.

4.3.5 Discussion

We found that the impact of increased biofuel demands on biodiversity varies spatially, and that there are substantial differences between the species groups. Our results indicate that more species would suffer rather than benefit from a doubling of the biofuel target. The potentially negative effect of increasing the biofuel target can be alleviated by careful crop selection – according to our analysis cultivating woody instead of arable crops would have an overall positive effect when looking at the combination of all species groups. The demonstrated potential impacts of changes in the EU biofuel policy seem small when looking at the area proportions which are affected. However, keeping in mind that these changes would happen in addition to the overall changes until 2030, a different biofuel policy might alter the status of biodiversity considerably by 2030.

Nevertheless, it should be noted that the distinction between first-generation arable and second-generation woody crops made in this study is broad, as for each crop option a range of different choices exists (cereals, maize, sugar beet, poplar, willow, to name just a few), all of which show different characteristics. With the focus on short-rotation woody crops, we neglect other second-generation ligno-cellulosic crops such as energy grasses.

In the absence of a specific woody biofuel crop scenario, in the biofuel scenarios we assumed that woody crops would be cultivated at the sites dedicated to arable biofuel crops. However, given their demands for suitable climate and water availability, the cultivation of woody biofuel crops will most likely be concentrated in the Boreal, Atlantic and Continental zones in the near future, while countries in the Mediterranean and Alpine zones are likely to focus on other biofuel crops (Tuck *et al.*, 2006). Preliminary simulations by Hellmann and Verburg (2008) indicate that, to some extent, hot spots of ligno-cellulosic crops clearly overlap with hot spots of arable biodiesel/bioethanol crops. Therefore, the assumptions used in this paper may give a good indication of the possible consequences of woody biofuel cultivation for biodiversity.

It is important to stress that our results reflect the impacts of biofuel policies solely on land-use changes, while the implications of such policies go beyond that. With our analyses we neglected other possible effects of biofuel crop production on biodiversity, such as the use of pesticides, groundwater depletion, introduction of alien and invasive species, or greenhouse gas emissions resulting from the production cycle (CBD, 2008). There are also likely effects on production intensity on all agricultural lands as a result of the Biofuels Directive.

Since a part of the biofuels consumed in the EU27 is imported, biofuel policy has an impact on biodiversity in other world regions, too. Although important, effects outside the EU27 area were beyond the scope of our study.

Uncertainties exist with regard to the input data and the approach adopted in this study. The allocation and area of biofuel crop plantations as used in our study are based on the variation of the EU biofuel policy within one scenario of development of economy, demography and policies. Thus, it should be noted that the results of this study are only valid against the background of the assumptions of the Eururalis Global Economy scenario, while a full ex-ante assessment of the Biofuels Directive should include multiple scenarios as a context.

Furthermore, the spatial distribution of the potential habitat for the species as derived from the land-use projections and the habitat suitability levels from the BioScore database can only serve as a coarse estimation of the actual habitat. We did not consider variables such as climate, management intensity, disturbances, interactions among species, small-scale habitat structure and species dispersal abilities, which also influence species occurrence. Moreover, species responses to a changing environment are very unpredictable.

All analyses are based on habitat suitability specified for the CLC classes by BGR. This is only a generalization of the actual habitat preferences of the species and does not reflect specific habitat requirements. Moreover, habitat suitability levels were aggregated to conform to the classification scheme of the Eururalis projections. For this reason the results of this study might overestimate habitat suitability for those land-use classes in the scenarios which overlapped with several Corine classes, since the maximum of the suitability levels for the overlapping Corine classes was used in such case (compare Section 4.3.3.1).

The restriction to the CLC classes places limits on the characterization of habitat suitability for woody and arable biofuel crops. There is no explicit Corine class for short-rotation woody plantations. Thus, following consultation with species experts, it was assumed that the Corine class ‘fruit trees and berry plantations’ is closest in its characteristics. The main argument for this choice is that both short-rotation woody plantations and fruit tree plantations are plantations without understorey in which human disturbances occur at regular intervals. However, by doing so, we neglect impacts of specific management practices related to the cultivation of short-rotation coppice, such as harvesting techniques or use of pesticides. Furthermore, fruit tree plantations offer food possibilities for micro-mammals and birds, a characteristic which is not present to such an extent for woody biofuel crop plantations. Therefore, associating woody crop plantations with the habitat suitability level of fruit trees and berry plantations probably gives an over-optimistic view of habitat suitability. When applying the habitat suitability levels of Corine class ‘arable land’ for the arable biofuel crop option, we assume that both management systems – crop cultivation for food production and crop cultivation for fuel production – are the same from the perspective of habitat suitability for the species. In this case we neglect possible differences between both systems, such as the probably lower use of pesticides and herbicides for biomass crops as well as different harvesting periods and techniques (EEA, 2007b), which can have an impact on habitat suitability.

Our results are limited to the set of focal species included in this study. We assume that the demonstrated impacts on these species also give an indication of the impacts on other species that have not been studied here. A test with a random set of mammal and bird species showed that the results do not vary much if another set of species is used (Annex 7). However, this cannot be generalized to the whole set of European species.

Even though there are uncertainties related to the input data and the approach followed, our results give a good indication for policymakers and decision makers of what might possibly happen under a changed biofuel policy in the EU. The method has the potential to be applied in future analyses as it is flexible in scale and can be extended to other species groups, provided that required input data are available.

5 The BioScore tool and monitoring

5.1 The BioScore approach and the need for links to monitoring

The basic idea of the BioScore approach is to explore the consequences of policies on biodiversity by linking species responses to the pressures resulting from the policies of interest (Chapter 1 Policy context and background, and Figure 1, Conceptual model of the BioScore tool). In order to specify the chain from policies to species responses, we need to answer two key questions:

- What kind of pressures will result from the various policy implementations?
- How will species respond to the various pressures that may follow from policy implementations?

The BioScore approach is tackling the first of these questions by drawing on policy analyses and scenarios from other projects and adapting the results on environmental consequences from these projects to the pressures specified by BioScore (see Section 1.3). This implies that the BioScore approach does not attempt to model or analyse the consequences of a given policy implementation for, say, land-use change or pollution deposition across Europe, but rather takes the manifestations of these consequences from the results of other projects. Alternatively, users may themselves define the environmental consequences of the relevant policy options. Once such consequences have been specified, the BioScore tool will be able to analyse their effects on selected species groups. The key link between various environmental pressures and the species responses is a database of species sensitivity scores for the various types of pressures considered to be relevant. For the species currently in the BioScore database, these sensitivity scores are based partly on explicit experimental, comparative or modelling studies of species responses to the pressures in question. For the majority of species, however, these sensitivity scores are based on expert judgement of the often quite variable knowledge about the various species and their responses to environmental changes.

In theory, the BioScore tool is self-contained and will not need input of data other than the results from other projects on environmental consequences of policies. However, these results and the knowledge underpinning the BioScore database on species sensitivity scores are far from perfect. In order to make BioScore a more precise and robust tool for the analysis of policy consequences for biodiversity, we will need better data on the state of and trends in environmental pressures and how they are linked to different policies across Europe. The species sensitivity scores of the BioScore database also need improvement, with respect to the dose-response relationships of species to pressures, as well as any variations in these relationships across Europe.

Further improvement of the BioScore tool would need input of results and/or data from specific studies of species responses to pressures or from monitoring that may provide long-term data on state and trends in relevant pressures and/or species under various policy implementations. Individual research projects will mainly have a limited scope and duration. For the purpose of improvements in BioScore, we would need to exploit results from such projects on an ad hoc basis, as relevant results become available. In general, long-term monitoring will have a permanent organizational and administrative framework to ensure continued delivery of data of a specified quality. Hence, as a way to improve the BioScore tool further, it may be possible to integrate BioScore with ongoing and planned monitoring in Europe, as Figure 31 schematically illustrates. This includes links to monitoring of various pressures, in particular the types of pressures identified as relevant in the BioScore model. Better information on how pressures vary across Europe in response to changes in policy will let us improve the precision of the policy-to-pressures relationships of the model and any scenarios built on these relationships. Species monitoring may provide valuable insights on how species vary in response to pressures in various parts of Europe and under different environmental conditions. This will allow us to improve the species sensitivity data in the BioScore database, perhaps even to the extent of developing more precise dose-response curves of how individual species respond to various levels of the environmental variables representing the pressure in question.

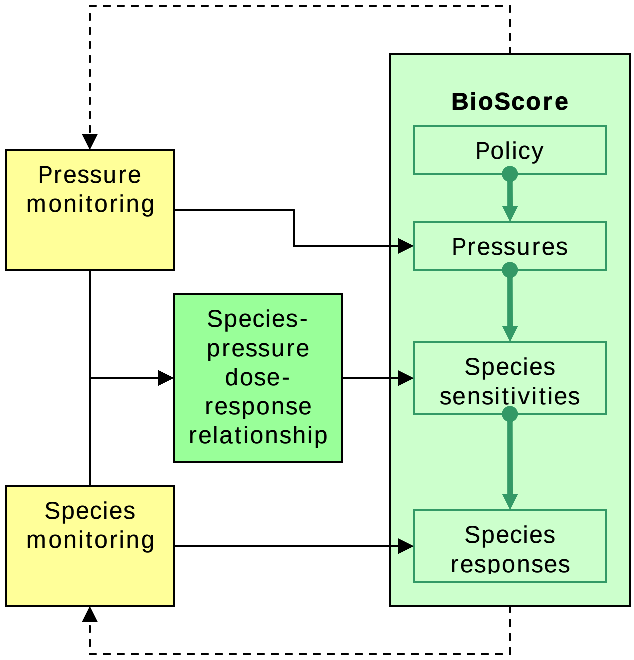


Figure 31: The BioScore model and its relationship to monitoring of pressures and species. Green arrows indicate links within the BioScore model, solid black arrows information from monitoring projects etc. to BioScore, and dashed black arrows indicate feedbacks from the BioScore model to monitoring.

An additional benefit of linking BioScore to monitoring is the opportunity to test whether the results from the BioScore model will fit the observed monitoring results. A significant discrepancy between these separate sets of results may represent an opportunity to review the underlying premises of the various links in the BioScore model and, indeed, of the wider assumptions about policy effects on biodiversity.

The BioScore tool also represents an opportunity to make the results of pressure and species monitoring more relevant to policy. BioScore provides an explicit link between policy, its environmental consequences and their effects on species. Monitoring that covers variables for environmental pressures and species that are also covered by BioScore will more easily allow interpretation of monitoring results in the light of policy changes, and thus the development of more plausible hypotheses about the causes of observed changes in the monitoring variables. In this sense, BioScore may represent an interpretive framework for monitoring results.

5.2 What kind of monitoring is relevant for BioScore and where can we find it?

Above we have made the claim that closer links between the BioScore model and information from the monitoring of pressures and species will be mutually beneficial. However, exactly what kind of monitoring is most relevant for BioScore – and where can such monitoring be found?

5.2.1 Pressure monitoring

The BioScore model has its main focus on environmental pressures related to land-use change, climate change, and pollution (see Section 1.3). These pressures are represented by specific environmental variables that may be measured and for which some kind of monitoring or other regular assessment of state and trends is likely to occur at least in some countries. The extent to which such information on pressures is available at the European level varies greatly, depending mainly on the need to report consistently across Europe in response to European or other international policy instruments.

There is currently no coordinated monitoring of changes in land use or land cover in Europe. The wide availability and gradually reduced costs of satellite imagery have made it possible to develop several initiatives for mapping Europe's land cover. The most well known of these is the Corine Land Cover (CLC), which was initiated by the European Commission for 1990 and has been updated for 2000 (EEA, 2004). CLC has been used as a basis for many studies of patterns and changes in land cover at the European level, including assessments of fragmentation of particular land cover types and indicators of pressures around Natura 2000 sites. However, there are some misgivings about the usefulness of CLC for more detailed and ecologically relevant analyses of land cover change, and CLC does not cover all of Europe. Most European countries have more detailed land cover maps that may be used to derive information about land cover patterns and change, but this information is not harmonized across Europe. Various statistical data may also be available for information on land use and land cover, especially for the economically most important land-use activities, such as those linked to the Common Agricultural Policy. Such information will to some extent be collated at the European level by Eurostat. Land cover information derived from maps of land cover will typically not be updated more often than every 5–10 years, whereas statistical information on land cover or land use may by updated on an annual basis.

The issue of global climate change requires harmonized data on climate variables such as temperature, precipitation and wind across Europe to be used in analyses and models. For a couple of decades, several institutions have worked on climate change issues, modelling past and future climate changes. Hence, such climate data are widely available, although mostly interpolated or modelled at rather coarse spatial scales for Europe as a whole. For use in BioScore this may still be quite adequate, when compared to the species distribution data available for BioScore and the general spatial resolution of the BioScore tool.

Pollution, in the form of shifts in major nutrients such as nitrogen and phosphorous, acidifying compounds and a wide range of toxic substances, has long been of major environmental concern in Europe. Several policy instruments, both at the European Union (EU) and wider international level, have been implemented to tackle these problems. For some of the long-established instruments, such as the Convention of long-range transboundary air pollution (http://www.unece.org/env/lrtap/) and the EU Nitrates Directive (Directive 91/676/EEC), programmes have been set up to provide data for the monitoring of the effects of these policies. Hence, fairly well-coordinated monitoring programmes exist for the measurements of emissions and/or depositions of acidifying and eutrophicating substances, at least for parts of Europe, and the results are reported regularly. For toxic substances, such as ground-level ozone, heavy metals and certain organic compounds, air quality monitoring is also fairly well established and harmonized across Europe. For toxic substances transmitted through other media (e.g. water, food chains), monitoring is more fragmented and results are not directly available at the European level.

Invasive species and the over-harvesting or exploitation of species are other environmental pressures on species. The problem of invasive species has been of policy concern for some time, and the SEBI2010 proposed headline indicators include *10 Invasive alien species in Europe* (EEA, 2007a). Nevertheless, little systematic monitoring of potential or actual invasive species exists, except for the monitoring of some problem species at national level. Except for a few marine fish stocks, over-harvested or exploited species are not monitored in any consistent manner at the European level. The issues of invasive species and over-harvesting are so far not included in the BioScore model. Hence, the lack of comprehensive monitoring data is not yet a problem for BioScore, but illustrates our limited ability to document the effects of such pressures on biodiversity.

5.2.2 Species monitoring

BioScore has limited its species coverage to several taxonomic groups, for which taxonomic status, distribution and ecology are fairly well known (see Section 2.1.3). These include vertebrates, butterflies, dragonflies, freshwater macroinvertebrates and plants in terrestrial and freshwater ecosystems. In the future, the BioScore database on species sensitivities may be expanded to other taxonomic groups, such as other groups of invertebrates and plants.

In the BioScore database of species sensitivities, the ecological information for the species includes detailed assessments of the species' sensitivities to various pressures, as specified by a range of environmental variables. In terms of species responses, as consequences of their sensitivity scores, the species' abundance and geographical distribution are the properties of interest. Changes in abundance or distribution should tell us whether species actually respond to changes in pressures, as we would expect from their sensitivity scores. Hence, to test or assess the relevance of the BioScore model, we will need monitoring to provide data on species abundance and distribution trends, for the relevant species groups and preferably for a representative cross-section of Europe.

Box 1

EuMon – EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest

EuMon aims to review and evaluate methods and approaches to monitor trends in species and habitats. EuMon will integrate the most promising methods, approaches and techniques into a comprehensive framework for assessing the approach to the 2010 target of hating biodiversity loss.

As part of its work, EuMon has assembled a database with information on current monitoring of species and habitats in Europe. This database contains only meta-data on the various monitoring schemes, no actual monitoring data.

The species part of this database contains information about:
- administrative information: contacts, duration, protection status of sites, funding, resource needs, etc.;
- policy relevance;
- geographical coverage;
- main habitats covered;
- taxonomic groups covered;
- statistical design and type of information covered.

Although the EuMon database aims to cover information on all kinds of species and habitat monitoring schemes, there is still considerable bias in its geographical and taxonomic coverage.

As of December 2008, the EuMon database contained information on 443 species monitoring schemes for the following species groups, with number of schemes:
- mammals: 76
- birds: 120
- reptiles and amphibians: 44
- fish: 10
- butterflies: 22
- other invertebrates: 19
- plants: 26

More information about EuMon can be found on http://eumon.ckff.si

European-wide coordinated or harmonized monitoring of any species group or individual species does not yet exist. However, for some groups, especially birds, monitoring efforts are conducted in a comparable manner in several European countries, allowing collation of data on population trends for various species and subgroups. The best example of such pooled assessments of joint monitoring efforts is the Pan-European Common Bird Monitoring Scheme (Gregory *et al.*, 2005), one of the headline indicators for biodiversity (EEA, 2007a). Another similar effort, although with a less systematic coverage across Europe, is the common butterfly index (van Swaay *et al.*, 2008a; van Swaay & van Strien, 2008). Extensive and to some extent harmonized monitoring of wetland birds and certain birds of prey (during migration in particular) also allows comprehensive assessments of abundance trends across Europe (e.g. Gilissen *et al.*, 2002, for results from the International Waterbird Census). These abundance assessments draw on a wide range of monitoring activities in many countries, and are the results of many years of efforts to build networks among national representatives and data providers. For the other species groups of interest to BioScore, networks of national scientists and interest groups may also exist, but national monitoring efforts still lack the breadth of coverage and sufficiently harmonized approaches to allow similar collation of abundance trends as for birds and butterflies.

Box 2

ALTER-Net – A Long-Term Biodiversity, Ecosystem and Awareness Research Network

ALTER-Net's main objective is to achieve lasting integration among its 24 partner and collaborating institutes involved in biodiversity research, monitoring and/or communication.

ALTER-Net has six specific integration objectives and six main research activities. The most relevant in the context of BioScore are linked to (a) the development of a network of multi-functional long-term ecosystem research platforms (LTER) and (b) the development of a framework for a distributed data, information and knowledge management system. As part of these activities, ALTER-Net has initiated the formation of LTER-Europe, a cooperative network among national LTER networks in Europe and part of the similar international network ILTER.

A major activity within LTER-Europe (based on previous work in ALTER-Net), is the development of a catalogue of meta-data for long-term, site-based ecosystem research and monitoring activities in Europe. This information is assembled in a database which covers:

- administrative information: contacts, location, site management, research infrastructure, etc.;
- main research issues;
- variables covered;
- characteristic habitats;
- species information, for community structure and/or selected species;
- statistical design.

The main focus of LTER-Europe and its database is on long-term studies of ecosystem processes located to specific sites. This implies that information about species abundances is likely to be quite variable and information on geographical distributions marginal, if at all relevant.

More information on ALTER-Net can be found on www.alter-net.info, and more information on LTER-Europe can be found on www.lter-europe.net.

Some of the monitoring programmes associated with international policy instruments directed against reduced pollution effects, such as the Convention of long-range transboundary air pollution, also cover biological monitoring (e.g. ICP Waters and ICP Forests). This mainly includes quality measures of selected biotic components or communities, rarely population monitoring at species level. The exception is the monitoring of populations of freshwater fish at selected sites. The monitoring of community structure of freshwater macroinvertebrates may also provide insights into species abundance trends. With the implementation of the Water Framework Directive,[2] countries must report on the ecological state of their water bodies, based on a number of biological and other quality elements. Ideally, such reporting should be based on some form of harmonized monitoring of the relevant quality elements, allowing comparisons of state of and trends in the individual variables, as well as in the overall ecological state (as currently covered in the reporting). The challenge for BioScore is that such monitoring linked to international policy instruments is not well harmonized across Europe, making any common assessments of abundance trends difficult.

For several of the BioScore species groups there are active scientific groups working to develop and update information on species distributions, with the aim of providing atlases of species distributions. For most of them, e.g. birds and mammals, such atlases already exist (Hagemeijer & Blair, 1997; Mitchell-Jones *et al.*, 1999). Although the distribution information of these atlases is rather coarse and infrequently updated (Delbaere & Nieto Serradilla, 2005), it provides the most comprehensive information on the recent distribution for the species covered.

In order to collate information on species abundance trends across Europe for most species groups, individual, national or local monitoring projects or programmes must be consulted. At present, there is no comprehensive overview of such monitoring activities. However, a handful of European research projects

[2] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF

are in the process of assembling information on biodiversity-related monitoring across Europe. Typically, these projects build databases of meta-information about the monitoring projects covered. They do not provide direct access to the monitoring data or results. To inspect or analyse such data, individual monitoring projects must be consulted, either to see what data or results they may have published or to contact the responsible project managers, who may grant access to such data or results. Boxes 1 and 2 give brief descriptions of the databases of monitoring projects and programmes that have been generated in two recent projects with a special focus on biodiversity monitoring: EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest (EuMon) and ALTER-Net.

5.2.3 Gaps in coverage

Overall, we may conclude that with respect to the needs of BioScore, monitoring results or comprehensive assessments of the trends in selected environmental variables are available for some of the key pressures linked to pollution and climate change. For land cover change, only quite coarse data are available from land cover maps such as CLC. Statistics on land-use change may be more detailed thematically, but will have limited thematic coverage and be linked to administrative reporting units that may not reflect the ecological or biogeographical breakdown most suitable for the ecological assessments employed in BioScore. For pressures linked to invasive species or over-exploitation of species, few, if any, data or results on trends are available at the European level.

With the exception of the established networks for monitoring and assessment of abundance trends for birds and butterflies, no harmonized monitoring of species groups of interest to BioScore exists across Europe. In order to collate data and results to make reasonable assessments on abundance trends, the many diverse monitoring activities at national and regional level must be consulted. For such a purpose, the databases of meta-information for various monitoring activities assembled by the EuMon project and LTER-Europe will be of key interest (Boxes 1 and 2). However, it is important to be aware that these databases are not complete or unbiased in their thematic or geographical coverage.

5.3 Integration of BioScore with monitoring

As we have seen above, there is not yet any comprehensive framework for delivery of biodiversity monitoring data or results at the European level. Although such a framework may be available in the future, for the time being, we need to consider other ways to provide some form of integration of the BioScore model with the data and results from existing monitoring of environmental pressures and species abundances and/or distributions.

The BioScore tool will need information from monitoring mainly for three reasons:

- To improve the understanding of the kind of environmental consequences that may follow from the implementation of specific policies.
- To improve the assessments of species sensitivities relative to the various environmental pressures, as represented in the BioScore species sensitivities database.
- To test or verify predictions from the BioScore model when the tool is used to analyse the consequences of various policy options and constraints.

This implies that the BioScore model will need monitoring results during a phase of further development (the two first bullet points above) or under active use in the analyses of policy options (the third bullet point). In neither of these cases will BioScore need continuous data flows from monitoring activities. It will be enough to have access to relevant monitoring data that can be mobilized or consulted on an ad hoc basis whenever specific development activities or analyses need such data. Then the key question is where the development team or users of BioScore can find the relevant monitoring data and make them accessible for use with the BioScore tool.

There are essentially two types of monitoring information available for use with BioScore:

- Meta-data information on a range of existing monitoring projects and long-term ecological research sites available from the databases collated by the EuMon project and from LTER-Europe, respectively.

- Monitoring data available through existing European-wide networks, for some pressures, as well as for common birds and butterflies.

The EuMon database on species and habitat monitoring schemes (Box 1) and the LTER-Europe database on monitoring and long-term studies in LTER sites (Box 2) are available for search by external users on their respective websites. For both of these databases, information will be available on the focus of the long-term studies or monitoring, i.e. what kind of studies or monitoring are being conducted, allowing the user to sort through and select the monitoring and LTER projects that may have relevant data for the specific issues of interest to the BioScore user. These databases also have relevant contact information for project or site managers, and there may be information on whether the data from the respective projects are publicly available and, if so, how data can be accessed. For most long-term studies and monitoring projects, however, the data will not be freely available, and the relevant contact person must be approached in order to secure possible access to the data.

The easiest way to let BioScore users have access to the information of the EuMon and LTER-Europe databases is to provide a direct link to these databases from within a future version of the BioScore tool. Users will have to consider how best to navigate these databases in view of their issues of interest and the specific information they need. Further access to and use of data from the identified relevant monitoring or LTER projects will have to be on an ad hoc basis. The specifics of the searches and of possible contents and formats for available data are likely to be too variable to allow any direct integration into the BioScore tool.

As stated in Section 5.2.2, monitoring activities for common birds and for butterflies are sufficiently widespread and harmonized to allow assessments of abundance trends at the European level. The actual monitoring results at national or European level are generally not available to external users, although the abundance assessments are published regularly (e.g. www.ebcc.info/pecbm.html for birds; Botham *et al.*, 2008; and van Swaay *et al.*, 2008b, for butterflies). If BioScore users need access to the actual monitoring data, they must negotiate with the respective data owners – European Bird Census Council and Butterfly Conservation Europe. However, for some types of use, e.g. overall continental or regional patterns of abundance changes, the overall European assessments should be adequate.

Data to represent various types of pressures at the European level are likely to be available for some aspects of pollution and most relevant aspects of climate change. Through CLC, data on land cover patterns and changes since 1990 are available, at the thematic and spatial resolution offered by CLC.

In case of existing monitoring data or results on pressures or species, integration with the BioScore tool will be similar to the mechanism indicated above for access via databases on meta-data. The BioScore tool can provide direct links to contact the relevant data managers who may provide access to the data. However, further use of the data or results is likely to be so specific that it is unrealistic to provide an analytical module for such data as an integral part of the BioScore tool.

5.4 What about the future?

There is considerable interest in making monitoring of biodiversity more comprehensive and harmonized across Europe (ETC/NPB, 2003; EEA, 2007a). There is also a great emphasis on making data and results from existing monitoring widely – maybe even freely – available. Experience so far indicates that such efforts at European integration of biodiversity monitoring are tedious, and the specific needs of EU directives seem to be the most effective incentive for driving such a process forward.

Nevertheless, the potential mutual benefit of the BioScore tool and species monitoring may also focus on the need for improvements in European biodiversity monitoring on several points:

- improved data flow and accessibility of data from existing monitoring activities;
- the need to fill gaps in geographical and thematic coverage, i.e. in countries and species groups covered;
- better linkages between pressure monitoring and biodiversity (species) monitoring to generate a more solid basis for hypotheses on causes for observed changes.

If such improvements in harmonized monitoring and accessibility of monitoring data and results are achieved, we can imagine fruitful linkages with the BioScore model, as indicated in Box 3. To inspire such improvements in biodiversity monitoring, BioScore can help illustrate the benefits to monitoring. By linking policy, environmental pressures and effects on species, the BioScore model can improve the framework for formulating hypotheses about causal relationships. The BioScore model can also show that monitoring data are relevant for the exploration of effects of policy implementation. However, more case studies linking monitoring data to the BioScore model are needed to illustrate these points.

Box 3

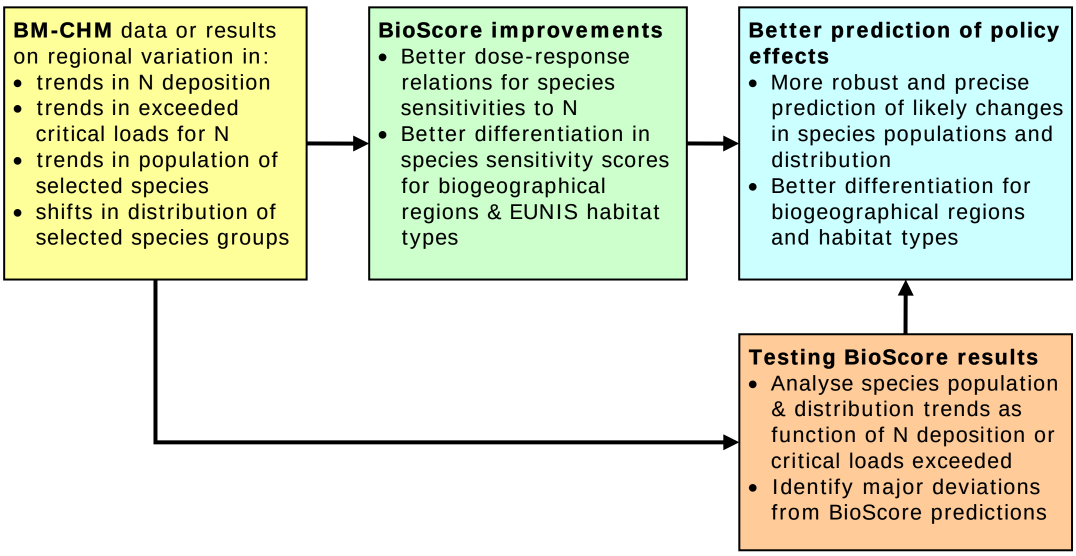
Future scenario: Linking information from a Biodiversity Monitoring Clearing-House Mechanism to the BioScore model

In Chapter 5 we indicated the kinds of benefits that may result from close linkages between pressures and species monitoring on the one hand and the BioScore model on the other – if such adequately harmonized monitoring results were easily available.

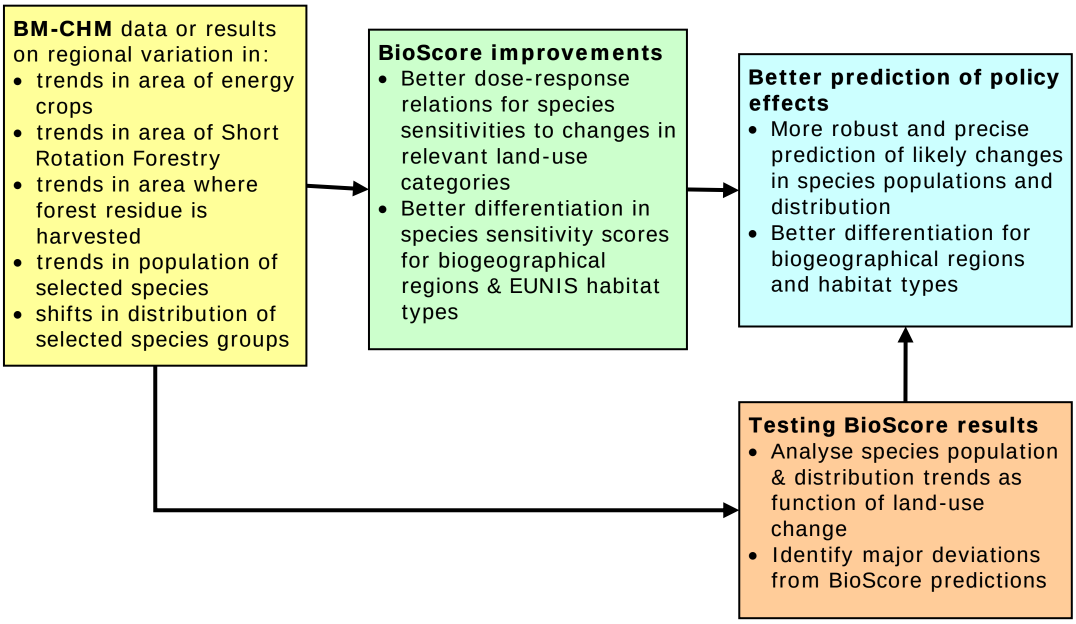
Let us assume that a form of Biodiversity Monitoring Clearing-House Mechanism (BM-CHM) will exist in the future, to provide easy access to harmonized data and results from biodiversity and environmental pressures monitoring across Europe. Such a Clearing-House Mechanism may even provide access to analyses of regional patterns in the trends of biodiversity properties and pressures, thus giving us a basis for analysing differences and similarities in regional trends across Europe and formulating hypotheses about causal relationships.

How could such a future access point for monitoring data and results link up with the BioScore model to improve the analyses of policy effects on biodiversity? This may be illustrated with a couple of key examples. Here we assume that such an access point will provide data and results on the pressures and biodiversity properties (i.e. species) of interest. These data may then be used as input to the BioScore model, either to improve the functioning of the model or to test the model output against observed relationships between pressures and species responses.

Example 1: Effects of reduced nitrogen emissions



Example 2: Effects of increased bioenergy production



Better access to relevant monitoring data should allow us to improve the basic species sensitivities module of the BioScore model relative to the environmental variables for the pressures of interest, as well as a more realistic regional differentiation of these sensitivities across Europe. Monitoring data on species population trends or distribution shifts that may be correlated with the environmental pressures of interest may be compared to the predictions of the BioScore model under similar variations of the environmental pressures. Although such comparisons do not constitute a formal test of the BioScore predictions, they will give an indication of whether the predictions are reasonable or not.

6 Conclusions

Based on three years of work in developing a European biodiversity impact assessment tool – BioScore – the project team concludes the following:

1. The BioScore tool has provided a unique methodology and basis for assessing the impacts of selected policy-related pressures on biodiversity in Europe.
2. BioScore identified the main environmental pressures related to the Community policies.
3. At present, the BioScore database contains information on habitat suitability and sensitivity to environmental pressures for more than 1,000 species. These represent mammals, birds, freshwater fish, benthic macrofauna, reptiles, amphibians, butterflies, dragonflies and vascular plants, covering a large part of Europe's species diversity, thus providing for a good representation of biodiversity.
4. By relating environmental pressures to European Community policies, the BioScore tool can create rapid scoping assessments (indicative at a coarse scale). It can do so for the pan-European territory, for individual biogeographical regions or for individual countries.
5. The case studies have shown that the database can be applied to more detailed assessments at finer resolutions on different spatial levels.
6. In its current form, BioScore provides the possibility for assessing single-variable and multivariable impacts.
7. The results of the BioScore assessments give an indication of potential impact on biodiversity based on modelled habitat suitability and species sensitivity, rather than predicting the actual impact.

The BioScore team has identified the following elements for improvement and is committed to further develop the BioScore tool:

- Interactions and indirect effects are not taken into consideration, which makes it hard to assess relative importance of policy measures in relation to predicted impacts.
- The BioScore tool has proven to be able to assess biodiversity impacts of pressures. However, the tool can be much improved if more recent and fine scale species distribution data become available.
- Improved biodiversity monitoring will provide much higher value to the tool and will allow policymakers to make more reliable assessments.

List of abbreviations and acronyms

BGR	Biogeographical region
CBD	Convention on Biological Diversity
CEC	Commission of the European Communities
CLC	Corine Land Cover
Corine	Coordinate Information on the Environment
DPSIR	Driver, pressure, state, impact, response
EEA	European Environment Agency
ESDP	European Spatial Development Perspective
EU	European Union
EU27	the current 27 Member States of the EU
EuMon	EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest
GIS	Geographical Information System
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
MCPFE	Ministerial Conference on the Protection of Forests in Europe
MNC	Milieu- en Natuurcompendium
MNP	Milieu- en Natuurplanbureau (Netherlands Environmental Assessment Agency)
SRES	*Special Report on Emissions Scenarios* (IPCC)
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WISE	Water Information System for Europe
WUR	Wageningen University and Research Centre

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The Centre for Ecosystem Studies performs basic and applied research in ecology, teaches students at BSc, MSc and PhD level and advises governmental and non-governmental organizations on the conservation and restoration of biodiversity and the sustainable use of natural resources. Central themes are: biodiversity and ecosystem services, population dynamics of threatened plant and animal species, effects of climate change and the efficacy of nature policy in Europe. The Centre for Ecosystem Studies is a cooperative alliance of six research groups of Alterra and four groups of Wageningen University.
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The association aims to prevent the extinction of any species of butterfly and moth, especially in Europe, and promote all activities and initiatives to conserve butterflies, moths and their habitats in Europe. A major focus will be to help implement the Convention on Biological Diversity with respect to butterflies, moths and their habitats, and contribute to the EU target of halting biodiversity loss by 2010. We regard butterflies as a vital part of this.
www.bc-europe.org

The European Forest Institute, EFI
The European Forest Institute is an international organization established by European States. By the end of 2007, a total of 17 European States had ratified the Convention on EFI, namely Austria, Bulgaria, Croatia, Czech Republic, Denmark, Finland, Germany, Latvia, the Netherlands, Norway, Portugal, Romania, Slovenia, Spain, Sweden, Turkey and United Kingdom. With its nearly 130 Associate and Affiliate Members and seven Project Centres, it offers the best forest research contacts and acknowledged collaboration at the European level.
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Department of Animal and Human Biology
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The Department of Animal and Human Biology (Sapienza Università di Roma) is one of the leading research centres in Italy dealing with systematic zoology, animal ecology, anthropology and particularly conservation biology. A particular emphasis has been placed on systematic conservation planning and large carnivore conservation. In recent years, the Department has had a prominent role in a number of national and international research projects dealing with the distribution of terrestrial vertebrates on a global scale (Global Mammal Assessment, in collaboration with Conservation International and IUCN), on a regional scale (the South-East Asian Mammal Databank and the African Mammal Databank) and on a national scale (National Ecological Network for Italy). Moreover, the Department is actively involved in the Large Carnivore Initiative for Europe and in a number of research projects on the efficacy of existing protected areas and of the Natura 2000 network, at both the national and EU level.
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Wetlands International is a global non-profit organization dedicated solely to the work of wetland conservation and sustainable management. It was founded in 1954 as the International Wildfowl Inquiry and the organization was focused on the protection of waterbirds. Later, the name became International Waterfowl & Wetlands Research Bureau (IWRB). The scope became wider; besides waterbirds, the organization was also working on the protection of wetland areas. Later, organizations with similar objectives emerged in Asia and the Americas: the Asian Wetland Bureau (AWB, initiated as INTERWADER in 1983) and Wetlands for the Americas (WA, initiated in 1989). In 1991, the three organizations started to work closely together. In 1995, the working relation developed into the global organization Wetlands International. Wetlands International has recently endorsed the Forests Now Declaration, which calls for new market-based mechanisms to protect tropical forests.
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