PBL Netherlands Environmental
Assessment Agency

PERSPECTIVES ON THE FUTURE OF NATURE IN EUROPE: IMPACTS AND COMBINATIONS

Background Report

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Perspectives on the future of nature in Europe: impacts and combinations

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FINDINGS

Halting biodiversity loss and restoring ecosystems in the EU requires substantial action, in addition to measures currently implemented under the Birds and Habitats Directives. A closer connection between societal preferences and nature policy may enhance people's engagement in nature-related efforts. However, people all have their own view on nature. In PBL's Nature Outlook study, four 'perspectives' on nature in 2050 were explored to capture these differing views (Dammers et al., 2017; Van Zeijts et al., 2017). The perspectives cover a range of guiding values, expressing how people relate to nature and what interventions they would prefer to improve nature conservation. In this report, these interventions have been translated to a resulting state of the landscape regarding land use, land management and environmental conditions at the EU scale, in order to study their impact on biodiversity and ecosystem services in 2050. Moreover, potential synergies and conflicts between the various perspectives provide insight for policymakers into the possibilities for including various views on nature in policy-making, and may help set an agenda for nature policies beyond 2020.

The four perspectives explored are:
- *Strengthening Cultural Identity*, in which people feel connected with nature and the landscape, and consider this an integral part of their local and regional communities and as essential to a fulfilling life;
- *Allowing Nature to find its Way*, in which people feel strongly about the great intrinsic value of nature, where nature is defined by dynamic processes and should be left to its own devices;
- *Going with the Economic Flow*, in which nature suits people's lifestyles, and businesses and citizens take the initiative in nature development;
- *Working with Nature*, in which people try to use natural processes and strive for optimal, long-term delivery of ecosystem services, for the benefit of both society and the economy.

Additional action is needed to stop biodiversity loss…

Because of the projected developments in, for example, demography, economy and climate change, a number of pressures are expected to increase for many species. In this study, a trend scenario was used to assess the impacts of the projected developments across the European Union. These developments are negative for more than half of the species, as assessed by the BioScore 2.0 model. Climate change will have major and year-on-year increasing, negative impacts on most species. Urbanisation and forest regrowth lead to the loss of open natural vegetation. Species that benefit under this *Trend* scenario are particularly those associated with woodlands. Nutrient loading of water bodies and morphological changes in rivers and streams continue to present large pressures for aquatic biodiversity. Although expected depopulation reduces human impacts in certain areas, with a likely positive effect on a number of species, these areas become of increasing interest for the production of renewable energy, which would partly undo the benefits for those species.

…and to protect ecosystems for their delivery of services

The ecosystem services assessed in this study respond in different ways to the projected developments. Firstly, the supply of services is expected to decrease in densely populated areas and intensively used croplands and forests in the EU. This mainly affects local services, such as pollination control and recreation. Secondly, in areas of land abandonment and depopulation, regrowth of forest and natural vegetation leads to an increase in carbon sequestration and lowers the risk of soil erosion.

Each perspective leads to specific benefits for certain groups of species…

Each state of nature envisaged in the various perspectives has differing impacts on biodiversity. Interventions under *Allowing Nature to Find its Way* create positive conditions for endangered species. This is mainly due to the natural dynamics within the large nature areas that create conditions for all successive stages in ecosystems, including pioneer vegetation and natural grassland, as well as old growth forests. The interventions under *Working with Nature* include large areas with positive conditions for common species; in particular, for woodland species. As these interventions do not explicitly target endangered species, the benefits for these species are only small. Interventions under *Strengthening Cultural Identity* also create positive conditions for biodiversity. For endangered species, beneficial changes mainly relate to extensive agricultural practices in characteristic landscapes across the EU and more naturally managed forests. Liberalisation of agricultural policies under *Going with the Economic Flow* causes negative conditions for biodiversity in agricultural areas. Certain private initiatives may be positive for biodiversity, but would affect rather small areas only. In particular, common species in woodland areas could benefit in this perspective.

…and particular ecosystem services

Working with Nature has the most positive effect on regulating services, as these are closely linked to the guiding values of people with this perspective on nature. The envisaged changes in urban and peri-urban landscapes under *Strengthening Cultural Identity* may have positive effects on regulating services that have significance on a local level, and be beneficial for cities or agriculture, such as small water retention areas, natural pest control[1] and pollination. Large undisturbed nature areas under *Allowing Nature to Find its Way* can deliver ecosystem services on larger scales; for example, carbon sequestration and upland water retention. Corridors that connect those areas to form a network may serve as floodplains, and may provide natural pest control and habitats for pollinators. Under *Going with the Economic Flow,* private estates may provide services that are of importance on a local level; for example, when surrounded by orchards or cropland. However, the delivery of such services is uncertain because of the private character of such areas. *Strengthening Cultural Identity* has the most positive impact on cultural services.

Connecting societal preferences and nature policy: opportunities for combinations

Nature actions or interventions under each of the perspectives target the most relevant locations within the EU. Therefore, they are not made in equal measure across the EU, Moreover, different interventions may be targeted at the same locations. Broader support for these nature interventions can be expected when comparable land use, management and public accessibility is envisaged at a certain location. Such broad common interests are found in urban and mountainous regions, in particular. In urban and peri-urban regions, the provision of all types of ecosystem services, including recreation, is likely to lead to favourable combinations of services. In mountainous regions and large nature areas, regulating services, such as water retention and carbon sequestration, would be compatible with private parks for tourism. Development of blue corridors that increase the accessibility of rivers for large migrating fish could be combined with interventions that reduce the risk of flooding.

However, there are also interventions that, if combined, contain conflicting aims or management practices. An example would be the combination between large nature areas with natural dynamics, as envisaged under *Allowing Nature to Find its Way*, and the conservation of historically characteristic landscapes. Another example of conflicting aims is the restricted access to private parks under *Going with the Economic Flow,* in combination

[1] Natural pest control: natural mechanisms to supress pests and diseases

with other levels of access to nature under the other perspectives, especially under *Strengthening Cultural Identity,* where public access is key. For some, the level of conflict may be reduced when interventions are modified, whereas, in other cases, the best option is to choose one or the other, instead of attempting to combine them. Awareness of the potential synergies and conflicts may help policymakers to include various views on nature in policy-making and enhance the engagement in nature-related efforts.

1 Introduction

1.1 Context

Nature is everywhere throughout the European continent, and all people have their own perspective on nature and value nature in different ways. In the last 150 years, private and governments' initiatives have led to nowadays' nature policies, most notably the EU Biodiversity Strategy to 2020 (EC, 2011a), which includes the Birds and Habitats Directives. Although considerable progress has been made in creating the Natura 2000 network, and, thereby, in the conservation of targeted habitats and species, the mid-term evaluation of the Biodiversity Strategy indicates that additional efforts are needed to reach the 2020 targets. Furthermore, it is likely that the occurrence of many species will decrease due to trends up to 2050, of which climate change is one of the main pressures (Chapter 3).

The Nature Outlook (Van Zeijts et al., 2017) aims to widen the scope of nature policy strategies. The outlook starts with questions at the fundamental level: how do people value nature and what are guiding values to protect nature? The result has been captured in four stylised perspectives (normative scenarios) on nature: *Strengthening Cultural Identity*, *Allowing Nature to Find its Way*, *Going with the Economic Flow* and *Working with Nature.* The storylines of these perspectives are elaborated in detail in *Four perspectives on the future of nature in Europe: storylines and visualisations* (Dammers et al., 2017).

This report, as part of the Nature Outlook, assesses the consequences of these perspectives for species, ecosystems and their services. The concepts of the perspectives are elaborated into quantitative and spatial assumptions. How does nature look in each of the perspectives and where in the European Union (EU) would different types of nature occur? Which land-use change will take place? What is the consequence for agricultural and forestry practices? During the project, answering these questions served to create parts of the storylines (Dammers et al., 2017) in an iterative way.

In reality, perspectives exist simultaneously. Different states of nature with different aims appear in the same region. In addition to studying the potential benefits of the separate perspectives, this report analyses whether these varying forms and aims of nature of these perspectives can be combined, can exist next to each other or need rethinking. More fundamentally, the range of nature values could be addressed to engage more people in a region.

Current state of nature

The European continent contains diverse landscapes that are home to a rich fauna and flora, shaped by a long period of human activities such as farming and livestock herding. However, during the 20th century, landscapes were lost due to urbanisation and intensification of the use of agricultural areas. Currently, less than a quarter of all species protected under the Habitat Directive have a favourable conservation status. For habitat types, the numbers are even lower, with 16% (EEA, 2015c). For birds, the situation is slightly better, but still almost half of the protected bird species have an insecure state. The recent European Red list of Habitats concludes that the main pressures and threats vary considerably across the different groups, but overall, various kinds of agricultural activities are the most widespread and severe pressures to European terrestrial and freshwater habitats. These include intensification in more productive farming areas as well as abandonment of traditional land-use, that both especially affect grasslands. Other important changes are intensification of forestry, modification of hydrological process, eutrophication and – in particular for coastal habitats – urbanisation. At the same time, various species have benefited from the policy measures put in place (see for example Donald et al., 2007). However, until now, policy measures have not been sufficient to maintain or restore a favourable conservation status for all species and habitats in the European Union. Although some ecosystem services increased over the past decade, the state of services of most ecosystems is judged as 'degraded' (EEA, 2015d).

1.2 Four perspectives on nature

All around us, people are involved in various practices that influence their personal relationship with nature, such as when producing food or exploiting natural resources, or in outdoor leisure activities. These different opinions translate into different aspirations and different desired futures. The Nature Outlook captures these desired futures into four stylised perspectives.

In *Strengthening Cultural Identity,* people identify with where they live. They feel connected with nature and landscape, and consider this an integral part of their local and regional communities and as essential to a meaningful life. From this perspective, nature is always nearby. Green in cities is well-designed and at people's doorstep. Landscape aesthetics is important and characteristic elements, such as hedgerows and brick walls, have therefore been renewed and expanded, and historical buildings have been restored. People prefer locally produced food; olives, beers and cheeses are considered as the best ambassadors for EU nature. The landscape can be experienced, for example, by cycling, sailing, angling and paragliding. Old cultural landscapes are cherished, including in remote areas – landowners receive support to preserve them. New landscapes are created, for example through redevelopment of abandoned industrial sites and airports, and by making (former) canals more attractive. Local communities, groups of citizens, farmers and entrepreneurs, take the initiative in *Strengthening Cultural Identity*. Regional authorities facilitate these groups and coordinate the initiatives, as landscape is considered a public good. One of the EU roles could be to financially support local initiatives.

In *Allowing Nature to Find its Way,* people feel strongly about the great intrinsic value of the processes and species of nature, and therefore nature should have its own space and time to develop. Nature knows best – plants grow where they fit the best, water flows freely and animals have room to migrate. Nature is defined by dynamic processes — it destroys and creates. To give room to dynamics, a large nature network has been developed that also includes wildlife corridors and rivers. Rivers within the network are free to meander, allowing fish to migrate. Ecotourism takes people to places where they can observe wolves, bears, deer, salmon and pike and where they can experience nature's tranquillity and greatness. From this perspective, nature elements within cities also have a 'wild' and dynamic character, with parks and rivers boasting a wide diversity of plants and animals. New wild nature is connected to socio-economic agendas, offering new income sources from tourism, and sustainable forestry, angling and hunting. In *Allowing Nature to Find its Way*, public authorities develop the local agenda together with local inhabitants, landowners, farmers, foresters and tourism entrepreneurs. Governments invest in dynamic nature systems. The coordination of initiatives is provided at supra-national level to ensure that all initiatives together lead to a coherent nature network.

In *Going with the Economic Flow,* the focus is on nature that suits people's individual lifestyle. Public authorities are responsible for ensuring a basic network of nature areas, while businesses and citizens take the initiative in nature management and development outside these areas; for example, for leisure or health, or as an attractive living environment. Beautiful private estates are developed with villas, shady tree lanes, meadows and lakes. Residents can enjoy the tranquillity of these areas – just as many birds will. Private parks are developed within cities, too, and memberships or entrance fees are common. Farming and forestry have sufficient room for efficient food and wood production, on the best soils. Nature managers have created ways to generate funds to co-finance nature conservation; for example, in the form of upmarket nature adventures or production of wind energy in nature areas. In *Going with the Economic Flow*, initiatives are primarily undertaken by private actors, such as businesses (including real estate, health and insurance), nature organisations, philanthropists or private landowners. Governments guarantee no net loss of biodiversity, for example by compensation for the degradation of nature reserves. Governments also stimulate private initiatives for nature protection).

In *Working with Nature*, functions of nature are considered the basis for human life. People try to work with natural processes and strive for an optimal, long-term delivery of services from these natural systems to society and the economy. For example, agriculture fully utilises biological processes with respect to soil, pollination and natural pest control. Integrated agricultural and forestry systems have become common in dry regions. Cities contain many trees, plants and water streams, providing water retention, and fresh and cool air for their inhabitants. Upstream forests, bogs and marshes and wide riverbeds decrease the risk of floods. An integrated approach to land-use planning is important to allocate functions in such a way that the benefits of various ecosystem services can be ensured. From the *Working with Nature* perspective, citizens behave as conscious consumers, with a healthy diet that contains less meat. Green frontrunners from business (including production chains), finance, health and nature organisations, citizens' organisations and research, all have been cooperating in the transition towards a green society. Possible roles of government are those of stimulating innovation and innovation networks, pricing external effects and paying for ecosystem services.

1.3 Research questions

This report addresses three research questions within the context of the Nature Outlook study:

1) What would be the impact on biodiversity and ecosystem services, assuming current policies and socio-economic trends towards 2050?
2) What would be the benefits and trade-offs of the four perspectives for biodiversity and ecosystem services?
3) Which combinations of interventions from different perspectives would be compatible, which interventions are likely to be conflicting?

Chapter 2 explains the methodology. Chapter 3 summarises future trends following current knowledge in literature, and their expected impacts on biodiversity and ecosystem services (question 1). Chapter 4 describes the quantitative and spatially explicit assumptions for the four perspectives as well as the benefits and trade-offs of the perspectives to biodiversity and ecosystem services (question 2). Chapter 5 indicates compatible and conflicting combinations between interventions under the perspectives (question 3). Points for further discussion and the role of uncertainties in the results can be found in Chapter 6.

This background report describes one part of the results of the Nature Outlook project, which is synthesised in Van Zeijts et al. (2017). Other related reports can be found at www.pbl.nl/natureoutlook.

2 Assessment framework

2.1 Introduction

The three research questions (Chapter 1) are answered following the framework shown in Figure 2.1. In order to answer the first question, socio-economic trends towards 2050 are investigated by a literature review. Besides a modelling framework was used that analyses the impacts of expected socio-economic trends on biodiversity and ecosystem services (Chapter 3)[2]. Answering the second question requires the quantitative and spatially explicit translation of the storylines of the four perspectives into maps of the study area, i.e. EU28 and Switzerland (Chapter 4). Assumptions on the desired state of nature, including land use or biophysical conditions, were identified, and targeted at specific locations (called an 'intervention' in this study). The impact on biodiversity and ecosystem services of the perspectives was estimated in a semi-quantitative way including expert judgement (Chapter 4). Finally, GIS analysis of the constructed maps and comparison of all interventions lead to the identification of interventions that might strengthen one another or that might lead to conflicts (the third research question; Chapter 5).

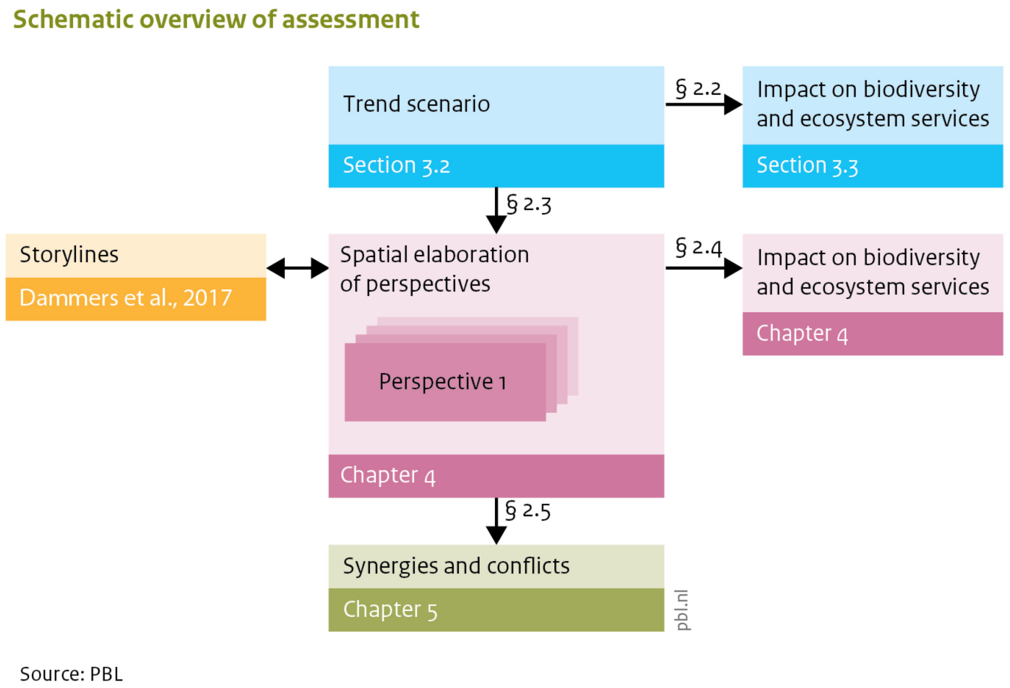


Figure 2.1 Schematic overview of steps taken in the assessment

[2] Since the research questions focus on the value of perspectives only one trend scenario has been analysed. It should be noticed that the impact of uncertainties under this scenario are, therefore, for the most part ignored.

2.2 Modelling framework

The assessment of the impact of socio-economic trends on biodiversity and ecosystem services is carried out using a model framework, which is embedded in a larger framework of drivers, pressures and impacts (Figure 2.2). Impact indicators relevant to our research question are *probability of occurrence* (Section 2.2.4) for terrestrial biodiversity, *mean species abundance* (MSA) (Section 2.2.3) for aquatic species, and a number of indicators that indicate the delivery of ecosystem services (Section 2.2.5).

In this modelling framework, developments in drivers, such as population and Gross Domestic Product (GDP), are used to project changes in consumption, production, trade and resource use. In the following step, the changes in production and resource use are used to define impacts on pressures, such as land management, water quality, air quality and climate change. Finally, these pressures were used to indicate the impact on biodiversity and ecosystem services.

The model framework of this study was linked to the VOLANTE framework (Pedroli et al., 2015) by using the output of the Dyna-CLUE model. In the VOLANTE framework, parts of the drivers indicated in the green boxes in Figure 2.2 have been modelled using a coupled set of macroeconomic and land-use-allocation models. Population growth, trade patterns, food and bioenergy demands and global land-use regulations were simulated using the combined models ReMIND/MAGPIE (Lotze-Campen et al., 2012; Luderer et al., 2013). With this output, the global equilibrium model LEITAP/MAGNET was used to simulate global changes in land use, agricultural production and consumption patterns, and regional sub-sector-specific changes in bilateral trade flows, while future trends in forest production were simulated with the global forestry model EFI-GTM. The output was subsequently fed into the agricultural economic model CAPRI (Britz et al., 2011) with which region- and product-specific yields and fertiliser use were simulated, and into the forest resource projection model EFISCEN (Schelhaas et al., 2007). Outcomes of these models are typically at the national or sub-national level. With the Dyna-CLUE model, implemented in the CLUE-scanner, the output was disaggregated into maps of land cover and land management, at 1 km^2 resolution (Verburg and Overmars, 2009; Temme and Verburg, 2011; Verburg et al., 2012).

Precipitation, temperature patterns and other climate variables were derived from the CliMond database, from which the output of the CCSM4 general circulation model was used (Kriticos et al., 2012; www.worldclim.org/bioclim). The air quality indicators originate from the GAINS model and are described in Amann et al. (2012).

2.2.1 EFISCEN

EFISCEN (European Forest Information SCENario model) is a forest resource projection model (Sallnäs, 1990; Nabuurs et al., 2006; Schelhaas et al., 2007). The current state of the forest, in terms of area per age and volume class, is derived from detailed national forest inventory data. The state of the forest is changing due to natural processes (growth and mortality) and forest management, implemented in the model as transitions of area between different classes (Table 2.1; Hengeveld et al., 2012; Petz et al., 2016). The model projects the state of the forest and timber production under assumptions of future wood demand at national level, forest area and applied management regime. The forest area is taken from the results of the Dyna-CLUE model. Outputs of EFISCEN serve as an input for several ecosystem service models as well as the BioScore 2.0 model. In this study, EFISCEN was

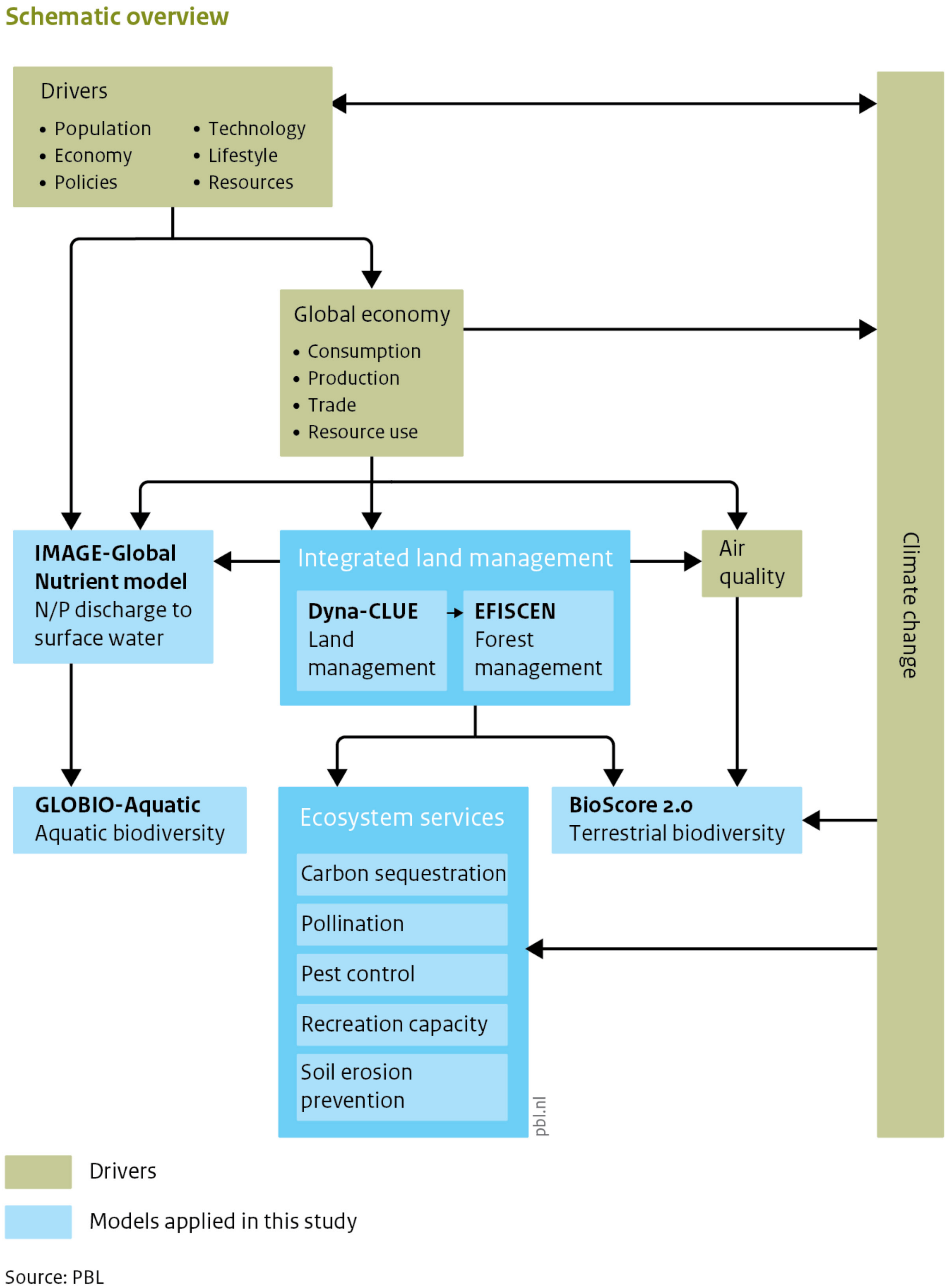


Figure 2.2 Modelling framework for the assessment of the *Trend* scenario

used to project changes in ecosystem services, such as the amount of timber production and CO_2 accumulation in the forest.

Table 2.1 Description of Forest Management Approaches

Forest Management Approach (FMA)	Description
1	Unmanaged nature reserves
2	Close-to-nature forestry
3	Mixed-objective forestry
4	Intensive even-aged
5	Short-rotation forestry

Source: Petz et al., 2016

2.2.2 IMAGE-Global Nutrient model

The nitrogen (N) and phosphorus (P) concentration levels of surface water was calculated by the IMAGE-Global Nutrient Model (IMAGE-GNM) (Morée et al., 2013; Beusen et al., 2015; Beusen et al., 2016). This grid-based model describes N and P delivery to surface water and in-stream transport and retention in rivers, reservoirs and lakes. It is implemented on a 0.5 x 0.5 degree resolution (about 50 x 30 km at European latitudes).

IMAGE-GNM uses the grid-based global hydrological model PCR-GLOBWB (Van Beek et al., 2011) to quantify water stores and fluxes, volume, surface area, depth of water bodies, and water travel time. IMAGE-GNM takes various spatially explicit input from the IMAGE terrestrial model (Stehfest et al., 2014) into account. Starting from the soil nutrient budgets, IMAGE-GNM simulates the outflow of nutrients from the soil in combination with emissions from point sources and direct atmospheric deposition to determine the nutrient load to surface water and its fate during transport via surface runoff (Bouwman et al., 2013; Beusen et al., 2015; Bouwman et al., 2017). It furthermore tracks nutrient transport in groundwater, riparian zones, lakes and reservoirs and in-stream biogeochemical retention processes. The so-called nutrient spiralling approach (Newbold et al., 1981; Beusen et al., 2015) was applied to describe in-stream retention of both total N and total P in one-year time steps. Projected trends in crop production, animal numbers and fertiliser use from 2006 to 2050 are based on the FAO outlook (Alexandratos and Bruinsma, 2012). No changes in precipitation and water discharge were assumed. In this study, the model was used to project water quality trends.

2.2.3 Aquatic biodiversity

Biodiversity in aquatic ecosystems – lakes, rivers and wetlands – was calculated by the GLOBIO-aquatic model (Janse et al., 2015). This model follows the same catchment approach as PCR-GLOBWB and IMAGE-GNM that is described above. The location of the water bodies in the grid has been derived from the Global Lakes and Wetlands Database map (GLWD; (Lehner and Doll, 2004). The main drivers included are land use within catchments, N and P loading from both diffuse, i.e. agricultural, and point sources (urban sources), and water flow deviations by river dams. It should be noted that the spatial resolution of the input data is much coarser than in the terrestrial biodiversity model BioScore (Section 2.2.4). For rivers, lakes and floodplain wetlands, the effects of the drivers on aquatic biodiversity are based on land use and nutrient accumulation in the part of the catchment upstream of the water body under concern. For isolated wetlands, only the land use and emissions in the specific pixel are taken into account. In rivers and floodplain wetlands the model also describes the effect on biodiversity of human interventions on the hydrology (e.g. through dam construction or climate change), based on the deviation of the current seasonal flow regime from the natural situation.

For each water type, the biodiversity is expressed as biodiversity intactness (MSA), which is the mean abundance of original species relative to that under the reference situation, such as in an undisturbed ecosystem (Alkemade et al., 2009). MSA is a composite indicator that includes all relevant biotic groups, such as fish, macro-invertebrates, macrophytes (aquatic plants), algae and amphibians. The MSA values of all water types within one pixel are aggregated into one value per pixel using the area-weighted average for the water types present. Pixels without surface water (according to the GLWD) are left out. This indicator is comparable to the Ecological Quality Ratio used in the European Water Framework Directive linked to an intact reference state (Van de Bunt and Solimini, 2007). The driver-impact-relationships are based on meta-analysis of empirical data from the literature. The model uses input from the PCR-GLOBWB and IMAGE-GNM model (Section 2.2.2). Data on river dams were derived from the GRaND database (Lehner et al., 2011) covering the existing big dams, and 2050 projections by Fekete et al. (2010) as implemented by Biemans et al. (2011).

One specific group of aquatic species is that of anadromous fish. These fish migrate over large distances from the sea to spawning areas in fresh water and they are all threatened with extinction (Annex I). Hydromorphological changes in rivers, such as dams, are important pressures for these species (Parrish et al., 1998; De Groot, 2002; Schiemer et al., 2003; ICPR, 2009). Since the selection of rivers in the GraND database does not allow for an analysis on migration potential, an additional database was developed. This database includes the large rivers of Europe and their accessibility for anadromous large distance species (Van Puijenbroek and Kroes, 2015). Anadromous species that spawn in tributaries, such as Salmon and Sea trout, migrate from sea to shallow, small streams and are vulnerable to large dams in the main river and small dams in the smaller streams. In the past, all species — except the lampreys — were important fish species for fishing in all rivers.

2.2.4 BioScore 2.0: terrestrial biodiversity

The impact of pressures on terrestrial biodiversity was assessed by the BioScore 2.0 model. (Hendriks et al., 2016). BioScore 2.0 includes the impacts of future developments in climate, land use and environmental pressures on terrestrial biodiversity. The model assesses the impacts on more than 1300 species, including birds, mammals, plants, and butterflies, for each 5 by 5 km grid cell. Moreover, the results for plants are aggregated into several habitat types. The four taxonomic groups were chosen because they operate at various scales of the ecosystem (Carignan and Villard, 2002) and, together, they are a better representation of biodiversity than a single taxon would be (Wolters et al., 2006; Eglington et al., 2012).

For the assessments, the model executes four steps. Firstly, climate, elevation and soil maps are used to project species climate envelopes. Secondly, CORINE Land Cover is used to indicate potentially suitable habitat patches for each species within its climate envelope. In the third step, dose response curves between environmental pressures and species occurrence, are used to provide a quality index for each grid cell with a suitable habitat based on the environmental pressures. In the final step, the three steps are combined and the probability of species occurrence within each grid cell is calculated. The output per species is aggregated into various biodiversity indicators. The pressures considered are air pollution by nitrogen and sulphur deposition, intensity of agricultural land use, water stress, habitat fragmentation, forest and nature management, disturbance by roads and urbanisation. Changes in land use and land-use intensity towards 2050 were derived from the Dyna-CLUE model. Information on forest management was derived from the EFISCEN model.

The input maps for the pressure of fragmentation were provided by the LARCH-SCAN model (Groot Bruinderink et al., 2003; IEEP and Alterra, 2010; Hendriks et al., 2016). This model determines the connectivity of habitat patches in a landscape and shows the strong and weak parts of a habitat network. The contribution of each habitat patch or grid cell to the total connectivity is inversely proportional to its distance to surrounding habitat grid cells (Verboom et al., 1991; Hanski, 1994).

Two output-indicators of BioScore were used in this study, both based on the probability of occurrence. The first indicator is the average probability of occurrence of all species per grid cell. This average is an ecosystem-based indicator, such as Mean Species Abundance (Vačkář et al., 2012). The second indicator, the sum of the probability of occurrence, is a species-based indicator, which is the sum of the probability of occurrence over all grids cells within a region or the EU, per species. Trends between two time steps in these indicators were categorised into five classes: large decline (> 25%), decline of 5% to 25%, stable (5% decline to 5% increase), increase of 5% to 25%, and large increase (> 25%). Each grid cell, in case of the average probability of occurrence, or each species, in case of the sum of probability of occurrence per species, was assigned to one of these classes according to its trend. Trends in ecosystem types (forest, agriculture, urban area and open vegetation) were derived by assigning each species to one or more ecosystems. The results per ecosystem type were based on the aggregated results of the specific group of species.

2.2.5 Ecosystem services models

The ecosystem services included in this study have been selected based on their responsiveness to trends and on the availability of indicators and models. Three ecosystem services models (i.e. carbon sequestration, erosion prevention and pollination) were applied for policy support on a European scale (Tucker et al., 2013; Schulp et al., 2016). PBL developed a natural pest control model, building on earlier work (Petz et al., 2016). Recreation was assessed using expert judgement.

Carbon sequestration

The amount of carbon sequestered by or emitted from soil and biomass was calculated by the CLUE-SINKS model (Schulp et al., 2008). For each land-use type, specific emission factors are used. When land-use changes, the emission factor is changed to the emission factor of the new land-use type and intensity. Other factors included in the carbon emission/sequestration calculations are the amount of carbon already present in the soil (soil organic matter), the age of forest and forest biomass content. The output indicator reflects the emission/sequestration in tonnes C/km^2/y.

Erosion prevention

The erosion prevention model builds on the Universal Soil Loss Equation (USLE; (Wischmeyer and Smith, 1978) to calculate actual erosion risk, expressed as soil loss (t/ha). Firstly, the potential soil erosion risk from topography (slope factor), rainfall (rainfall erosivity factor) and soil erodibility was calculated at a 1 x 1 km resolution. Secondly, the protective vegetation cover factor was derived from the land-use map, taking into account three climatic zones within the EU. In addition, stone cover was included as an important factor explaining protection against erosion. Actual soil erosion was calculated by including the protective cover in the potential erosion risk map (Pérez-Soba et al., 2010; Petz et al., 2016).

Natural pest control

The predation rate (percentage of pests killed by natural enemies) in agricultural areas is determined as a function of the percentage of natural and semi-natural vegetation, based on empirical data from European studies (Tin-Yu Lai, 2015). Land-cover types are re-classified into natural habitat for pest predators or no habitat. Green linear elements (i.e. tree lines) were added as natural habitats for pest preditors, and the percentage of natural habitat was calculated within a 2-kilometre radius of each cell. Agricultural areas where the predation rate exceeds 26% were indentified as areas where such ecosystem services are provided.

Pollination
Pollination was modelled with an empirical relationship between the percentage natural habitat and the percentage cropland that is accessible for pollinators (Serna-Chavez et al., 2014). A map with suitable habitats for pollinators was derived from maps including green linear elements, such as hedgerows, and suitable land-cover types, as was done for the natural pest control model. For assessing the ecosystem service of pollination, the average suitable habitat was calculated within a 5-kilometre radius of each cell. Areas where the average exeeded the threshold value (Bianchi et al., 2013) — for instance, 20% suitable habitats within the 5-kilometre radius — were indentified as areas where the service is provided.

Recreation
The evaluation of recreation included both supply and demand of outdoor recreation services. The supply of the service was estimated by a group of European experts on recreation during a workshop (Annex II). They assessed the changes in attractiveness and accessibility for the main recreational activities: walking, biking, sunbathing, swimming and picnicking. Most recreational activities, such as walking, running or cycling, take place in a radius between 2 and 8 km around people's home (Sijtsma et al., 2012; Paracchini et al., 2014). Therefore, the population within 5 km radius of the impact area was used as a proxy for potential demand for green space.

2.3 Quantitative information of perspectives

Assumptions in the perspectives on land and water use, management and pressure levels were made explicit to strengthen the storylines and to assess the impact of the perspectives on biodiversity and ecosystem services. Land-use maps, including water, were designed based on spatially explicit and quantitative assumptions at a 1 x 1 km scale. These maps capture the desired future for nature under the four perspectives at the EU scale. For various landscapes (urban, agriculture, forest, nature, water) deviations from the *Trend* scenario (see Chapter 3) on land use, management, location, amount and height of environmental pressure were formulated and quantified. These assumptions were bundled in several interventions, each with a specific goal. Each intervention has a specific goal and the assumptions include the desired type of land use, the required land-use management and a targeted location. This quantification is described in Chapter 4. To assure that the quantitative part of the perspectives is considered credible and feasible, the changes within the designed maps were kept within a certain range regarding the land-use types urban area, cropland and pasture. This range was derived from literature on existing land-use scenario studies for the EU, such as the VOLANTE project (Lotze-Campen et al., 2014), Scenar 2020 (Nowicki et al., 2006; Nowicki et al., 2009) and the OECD & FAO Agricultural outlook (OECD and FAO, 2014); see for example ranges in Figure 3.4 and Figure 3.5).

2.4 Analysis of the impact of perspectives

The impact of the perspectives on biodiversity and ecosystem services has been analysed in a semi-quantitative way, by combining the quantitative information of the storylines, such as land-use change or affected population, with expert judgement about its impacts. For aquatic biodiversity, the impact of each intervention was assessed by expert judgement only.

For terrestrial biodiversity, impacts were estimated on endangered and common species associated with five land-use types: urban area, cropland, pasture, forest and open natural vegetation. Impacts were estimated for all kinds of land-use conversions (Annex IV).

Impacts could be estimated as positive, negative or neutral. Results show the impact on 10 groups of species compared to the situation under the *Trend* scenario, expressed as the area where positive changes are expected for the particular group of species.

To derive the impacts of the perspectives on regulating ecosystem services, areas with insufficient supply in the *Trend* scenario were defined. Next, impacts of land-use changes on ecosystem services were estimated as positive, neutral or negative. Results indicate the change of surface of the area with insufficient supply. To indicate impacts on recreation, the change caused by each intervention of the perspectives with respect to the *Trend* scenario was assessed on six indicators, that include aspects on accessibility and attractiveness. In this way assumptions that do not show up in a 1x1 km map of land use or land-use management, such as entrance fees or distribution of green areas across cities, could be taken into account. Finally, the results of the separate interventions were summed, using the proportion of the EU population in a radius of 5 km as a weighing factor[3].

Impacts of changing land use and land-use management under the perspectives on wood harvesting were assessed by the EFISCEN model. For crop production, impacts on yields have been estimated based on wheat yields (Table 2.2). Impacts on livestock production levels are based on maximum livestock density and the pasture area. Differences in yields and current crop and livestock management in each NUTS2 region in the EU28 and Switzerland are taken into account. Economic feedbacks were not taken into account for agricultural production neither for wood harvesting. Besides, changes in feed production were not considered when defining the impact on livestock production.

The presented results give insights in the kinds of benefits and trade offs for biodiversity and ecosystem services that can be expected when focusing on one particular perspective on nature. Although the modelling approaches would have allowed to calculate indicators for biodiversity and ecosystem services, several arguments – apart from the pretention of high accuracy – existed to refrain from quantification. Firstly, indicators that would be relevant for the full range of perspectives, such as perceived local identity or value of private initiatives, could not be modelled. Secondly, the uncertainty within the perspectives is high; the relevance of a targeted area may differ, from national, regional to EU perspective, for example with respect to the areas designated as characteristic landscapes.

Table 2.2 Impact of restricted management on wheat yields and livestock density

	Restricted management (kg N/ha)	Maximum wheat yield (tonne/ha)	Maximum livestock density (LSU/ha)
Cropland	100	3	
Cropland	150	4	
Pasture	30		3/5 other cattle
Pasture	50		other cattle

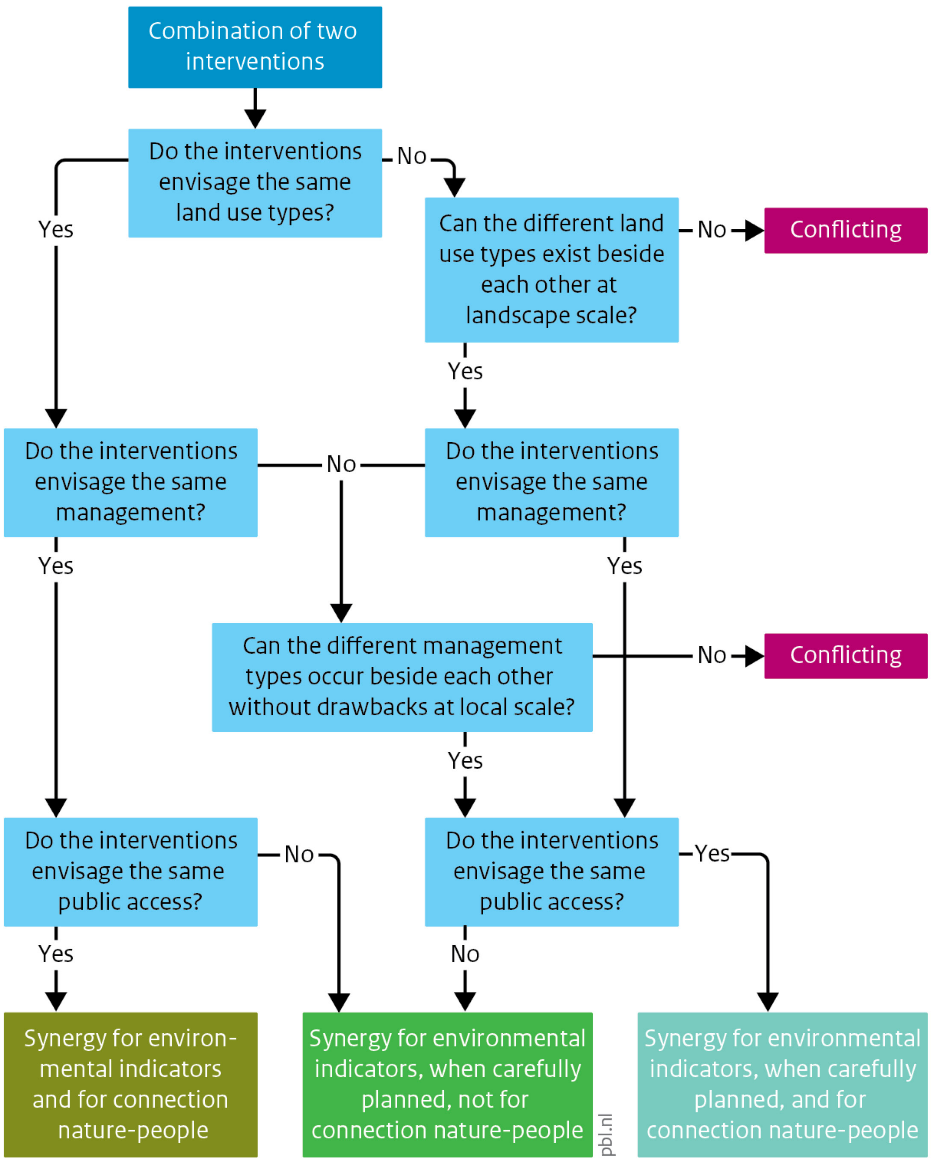
2.5 Synergies within and between perspectives

Finally, the perspectives were combined to indicate compatible and conflicting combinations of interventions or combinations that would potentially gain support for pro nature intervention from different perspectives, but that need some adaptation (see Dammers et al., 2017: Chapter 10). Combinations might lead to complementary landscapes. Firstly, all

[3] Using a 10 km radius instead of 5 km radius to calculate the proportion of the population affected did not change the ranking of the perspectives.

combinations of two interventions were assessed following the decision tree as shown in Figure 2.3. The envisaged land uses, management and public accessibility of the areas targeted in the intervention were compared, and then defined to be compatible, to be able to occur in the same landscape beside each other or to conflict with each other. Secondly, the different land-use maps of the perspectives were overlaid to obtain the overlapping area of each combination. The overlap between the areas was calculated using GIS, based on the 5 x 5 km maps of the targeted areas. Combining the areas overlap and the compatibility of interventions resulted in top 5 of combinations that are synergetic, a top of combination that are conflicting and 5 combinations that have the potential to be synergetic.

Decision tree



Source: PBL

Figure 2.3 Decision tree to assess the compatibility between interventions

3 The *Trend* scenario

The EU Biodiversity Strategy to 2020 has the vision '*By 2050, European Union biodiversity and the ecosystem services it provides – its natural capital – are protected, valued and appropriately restored for biodiversity's intrinsic value and for their essential contribution to human well-being and economic prosperity, and so that catastrophic changes caused by the loss of biodiversity are avoided'.* Main direct drivers of biodiversity loss and ecosystem service changes are changes in natural and semi-natural habitats, modification in water ways, pollution, over-exploitation, climate change and invasive species (Millennium Ecosystem Assessment, 2005; EEA, 2015b). These pressures are related to economic production and resource use, that, in their turn, relate to drivers as population growth and affluence.

To achieve the 2020 targets of the EU Biodiversity Strategy, additional efforts are needed (EC, 2015b). The efforts needed after 2020 to reach the vision for 2050 will be influenced by trends up to 2050 that develop more or less autonomously, such as population growth, economic developments across the EU and technology. This chapter describes the expected developments of these major drivers and pressures of biodiversity loss (Section 3.1), including uncertainties raising from different policy pathways. A business-as-usual scenario was developed, which builds upon these trends, in a situation without new policies (Section 3.2). This *Trend* scenario was used to assess the impacts on species and ecosystem services in 2050 (Section 3.3) and to show the challenges to meet the 2050 vision.

3.1 EU in 2050: drivers of change and the uncertainties

3.1.1 Demographic developments

Projections indicate that EU population numbers are almost stable up to 2050 with some slight variation, but the age distribution across the population will be different (Figure 3.1). The main reason for the variation is the uncertainty about inward migration (Mamolo et al., 2014), because without net immigration the population in the EU will decline. Within the EU, the picture will likely to be mixed. The population in most north-western countries is projected to increase, but in some eastern countries, such as the Baltic States, Romania and Bulgaria, it is projected to decrease. Throughout the EU, urban population is projected to grow at the expense of the rural population. The urban population is likely to increase from 72% in 2010 to 80% of the total population in 2050 (UN, 2014). Furthermore, the population is ageing with life expectancy steadily increasing and expected to be 83 years for men and 88 years for women in 2050 (EC, 2012).

3.1.2 Economic development

Long-term projections for GDP growth in the EU expect a continuation of moderate growth due to the declining proportion of the population in the working age. These projections vary between 1.3 and 2.3% per year (EC, 2012; EC, 2014; Lotze-Campen et al., 2014; OECD, 2014a). By 2050, the proportion of people aged over 65 is expected to rise to over a quarter of the population. This means that there are only 2 persons in the working-age population for each person over 65. Currently, this ratio is 4 to 1 persons over 65. Even the implemented pension reforms and increasing participation rates do not change this dependency ratio, according to *The 2015 Ageing report* (EC, 2014). Therefore, the expected change in population structure makes growth in labour productivity the sole source for GDP growth in the EU.

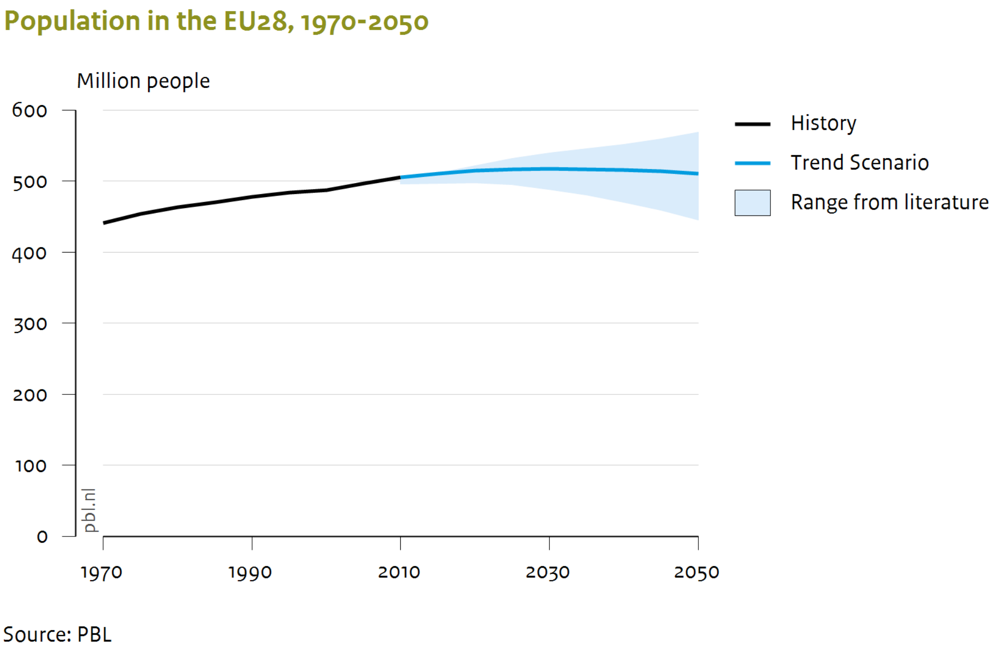


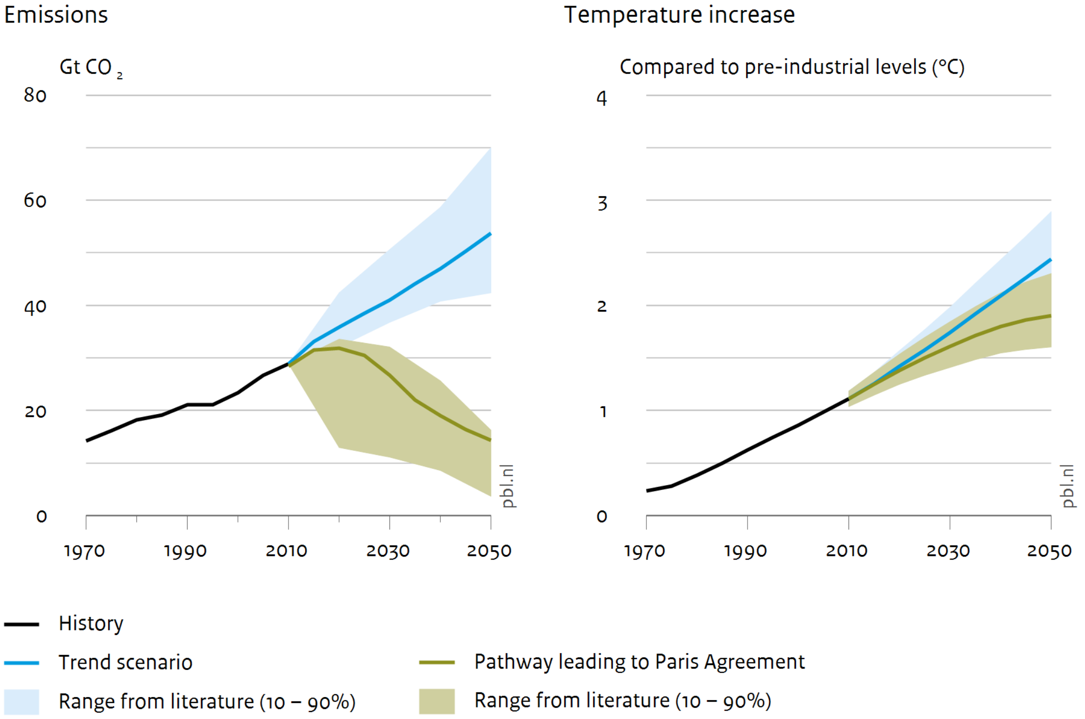
Figure 3.1 Population projection in the EU28

The blue areas indicate the 10–90th percentile of scenarios in literature (based on CIESIN, 2002; Lutz et al., 2008; UN, 2009; UN, 2013; Lotze-Campen et al., 2014; Wittgenstein Centre, 2015).

In contrast to modest GDP growth rates in the EU, the growth rates in emerging economies, for example in Africa and Asia, are expected to be much higher (OECD, 2014b). A main reason is the higher proportion of the population in the working age group (18-64). Although GDP growth in these regions is likely to gradually decelerate towards 2050, the differences in growth rate are expected to be large enough to lower the imbalance in prosperity between emerging economies and the OECD countries, including those in the EU. The increasing balance in economic power may also change political relationships between the EU and other countries (EEA, 2015a; ESPAS, 2015).

The structure of the EU economy is expected to remain quite stable, although current trends will slowly continue. More than half of the GDP will continue to come from the service sector, while the proportion created by the agricultural sector is expected to reduce slowly (OECD, 2015). However, growing disparities in social and economic developments within the EU can be expected (ESPON, 2014). Since trade with the rest of the world will become more important than intra-EU trade (ESPON, 2014; ESPAS, 2015), highly accessible and competitive regions, such as the regions located in the ellipse between London, the Ruhr area, Paris and Milan, are expected to profit. Responses are likely to differ between regions, depending on their economic specialisation and historical relationships. At the same time, regions with poor infrastructure and a large traditional industrial sector are likely to have difficulties to keep pace.

Global greenhouse gas emissions and temperature changes



Source: PBL, Roads from Rio+20

Figure 3.2 Global greenhouse gas emissions and temperature change under a trend scenario compared to those required to reach the 2 °C target

The coloured areas indicate the 10–90th percentile of scenarios in literature (Van Vuuren et al., 2008; Clarke et al., 2009).

3.1.3 Impacts of climate change

Impacts of climate change highly depend on the emission projections, which in turn result from global demography, welfare, technology and (climate mitigation) policies. Emission projections that only include mitigation policies implemented before the Paris agreement of 2015, lead to global mean temperature changes of around 2.5 °C by 2050 (3.2 to 5.4 °C by 2100) compared to pre-industrial levels (blue line in Figure 3.2, OECD, 2012; PBL, 2012; IPCC, 2014). Emission projections that would lead to a maximum rise of 2 degrees, as agreed upon in the Paris Agreement, should, therefore, include substantial emission reductions (green line in the left panel of Figure 3.2).

As part of the Paris Agreement, countries submitted their national contribution to emission reduction, the so-called Intended Nationally Determined Contributions. Rogelj et al. (2016) found that realisation of all national contributions to emission reduction — submitted before December 2015 — would likely limit the temperature increase to, only, between approximately 2.6 and 3.1 °C by 2100. Thus, assuming all countries will hold to the Paris Agreement, additional mitigation measures, such as the increase of renewable energy production, can be expected, in order to keep global temperature increase below 2 °C.

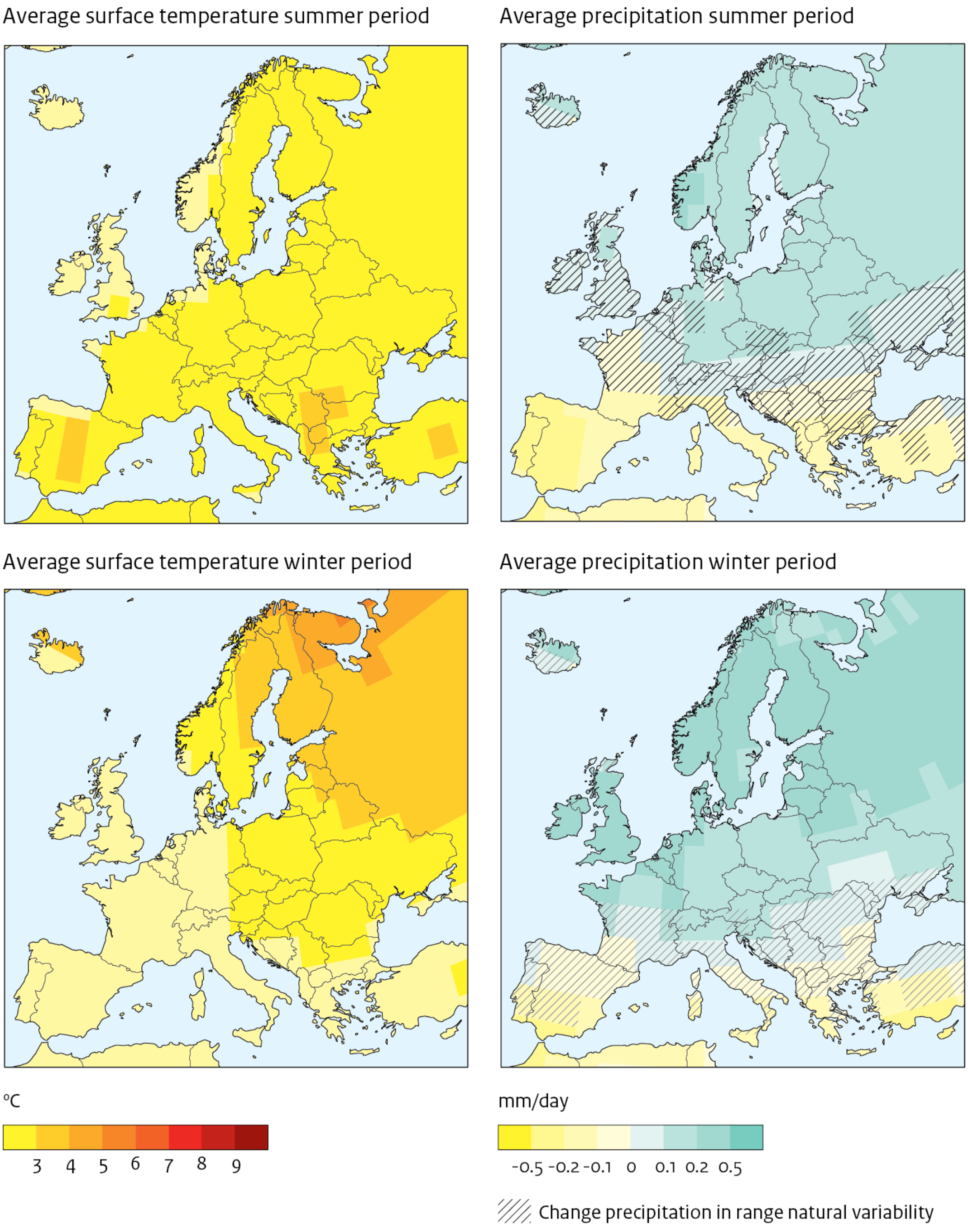
The impacts of climate change in the EU – even at the lower ends of temperature changes – are expected to include higher temperatures and higher precipitation levels in winter, particularly in the northern parts of Europe. In the summer, more frequent and longer dry spells can be expected in the south of Europe (Figure 3.3). These developments will have diverse effects on sectors such as agriculture (Section 3.1.4), forestry (Section 3.1.5) and impacts in urban areas. Impacts of climate change in urban areas are highly related to health and well-being of citizens. Buildings tend to retain heat and consequently increase temperatures. Heatwaves can compromise public health, reduce productivity and constrain the functionality of infrastructure. At the same time, extreme precipitation events can cause extensive damage, because of the high level of soil sealing and high density of economic activities and people in urban areas. Water scarcity will place cities in competition for water with other sectors, including agriculture, energy generation (cooling water and hydropower), and tourism (EEA, 2012c). Therefore, an increased use of adaptation measures than currently, can be expected in the coming decades that lower or minimise these impacts.

3.1.4 Agriculture

Although the relative contribution of the agro-food sector to the economy is projected to become smaller, the sector's output will increase by roughly 10-20% (Lotze-Campen et al., 2014; Witzke et al., 2014). Crop production is rising faster than livestock production. The growing demand for food and feed in the rest of the world is putting increased pressure on the global market. Therefore, EU demand is likely to continue to rely on domestic production rather than being depended on imports. Recent studies on the future of agriculture indicate that production per hectare is likely to increase, while the area under agricultural production, including crops for bioenergy production, is remaining stable or decreasing slightly (Figure 3.4). The trend in the total area under agricultural production hides differences between regions. Abandonment of marginal areas, for example in mountainous areas, is expected, while the agricultural production in accessible areas with suitable conditions is likely to increase (Nowicki et al., 2009; Keenleyside and Tucker, 2010).

Several developments influence expectations on future farmers' management. Fertiliser use in intensively farmed areas, for example in the northwestern part of the EU, has been declining over the last 10 years. In contrast, in most eastern European countries, it decreased sharply around 1990 and is expected to increase again in the coming decades (Alexandratos and Bruinsma, 2012). Existing innovations, such as precision farming, are likely to be increasingly adopted, among other things, due to the use of smartphones that facilitate application in practice. This development could decrease or limit the use of fertilisers and chemicals.

Seasonal change in temperature and precipitation under a trend scenario, 2005-2050



Source: CMIP5 RCP85 data, processed by the KNMI climate explorer

Figure 3.3 Seasonal change in temperature and precipitation between 2005 (average over 1986–2015) and 2050 (average over 2036–2060) under a RCP85 scenario (source: CMIP5 RCP85 data, processed by the KNMI climate explorer (climexp.knmi.nl)).

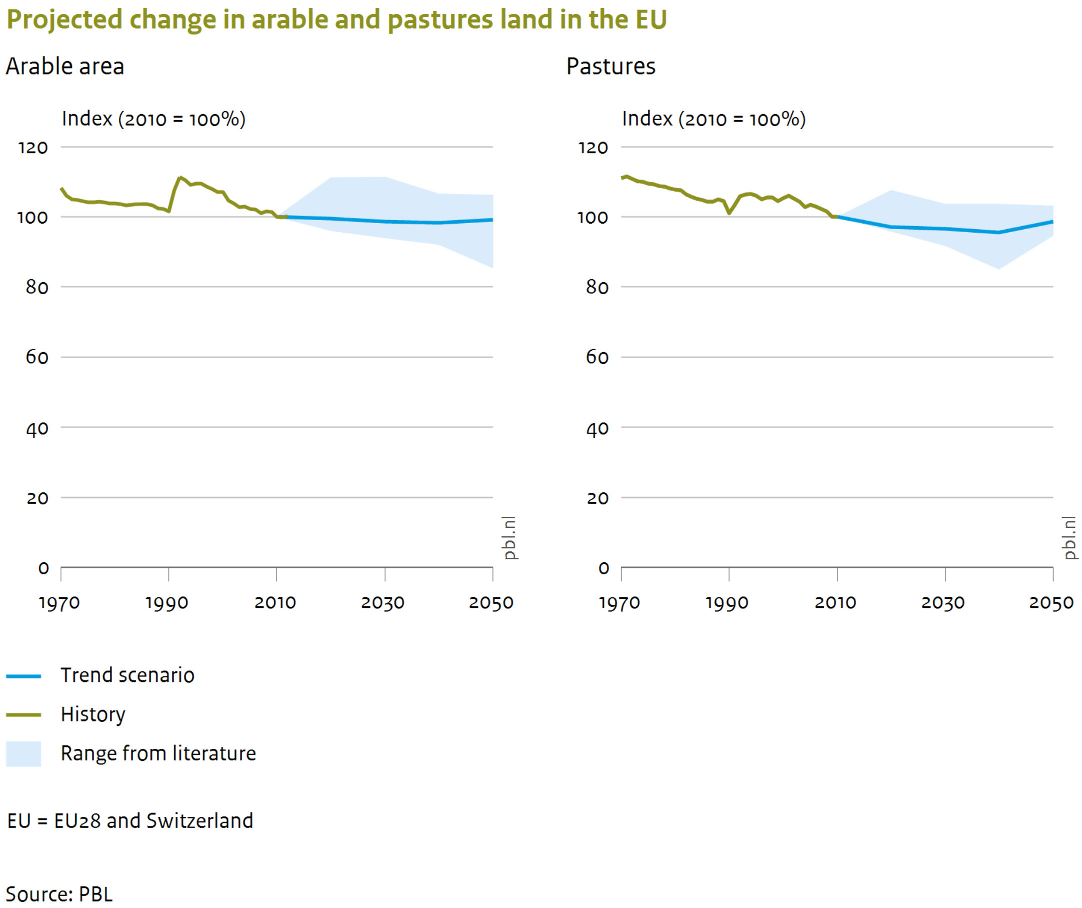


Figure 3.4 Trends in arable area and pastures in the EU

Shaded area indicates the range found in literature (Nowicki et al., 2006; Rienks et al., 2008; Nowicki et al., 2009; Westhoek et al., 2011; OECD, 2012; PBL, 2012; Lotze-Campen et al., 2014; OECD and FAO, 2014; Witzke et al., 2014; Maes et al., 2015). Data of before 1992 for Croatia, Czech Republic, Estonia, Latvia, Lithuania, Slovakia and Slovenia is missing from the FAOSTAT database.

The net impacts of climate change on agricultural production are uncertain. It is generally expected that productivity in northern Europe will increase due to the extension of the growing season (Olesen and Bindi, 2002). Impacts of droughts and changing precipitation patterns are difficult to estimate, as farmers can adapt their farming systems. Furthermore, the damage of extreme weather events to production largely depends on the moment of occurrence in the growing season. While the frequency of extreme events is projected to increase over the whole of Europe, increased temperatures and dry spells mainly affect farming in southern regions (EEA, 2012a). Water availability in these regions is expected to decrease, while water demand for irrigation probably increases. It may be difficult to maintain the production of cash crops, such as strawberries, in southern Europe, that currently have high irrigation demands. However, it may be possible to grow other crops or even advance the cropping season. Another uncertainty is the severity of desertification, which can be delayed with good management of soils or afforestation.

Policy changes, such as agricultural and biofuel policies, or alternative diets (see for example Nowicki et al. (2009), Westhoek et al. (2011) or Laborde and Valin (2012)) are likely to have moderate impacts on land-use trends in the EU: changes in cropland range between -15% and +10% in 2050 compared to 2010. A possible change in the EU Common Agricultural

Policy is a further reduction of trade barriers for agricultural products. This would result in a decrease in agricultural area within the EU compared to a business-as-usual scenario, and an increase of production and agricultural area in other parts of the world (Rienks et al., 2008; Nowicki et al., 2009; Prins et al., 2011). Renewable energy policies are another driver that could affect agricultural land use. Energy policies that promote biofuels tend to slightly increase the area under agricultural production compared to a business-as-usual development, which could also mean less decrease in area under agriculture in absolute terms (Prins et al., 2011; Laborde and Valin, 2012; Prins et al., 2014). More extreme scenarios explore the impacts of a decreased consumption of animal products in the EU (not included in the uncertainty range of Figure 3.4). Such a development could have considerable impacts on the agro-food sector. Its impact on agricultural land use in the EU will be influenced by the existence and the system of agricultural subsidies. Pastures will not disappear: when agricultural subsidies are continued to be granted per hectare, it is likely that farmers continue to use their pastures, but at a lower intensity (Westhoek et al., 2011).

3.1.5 Forestry

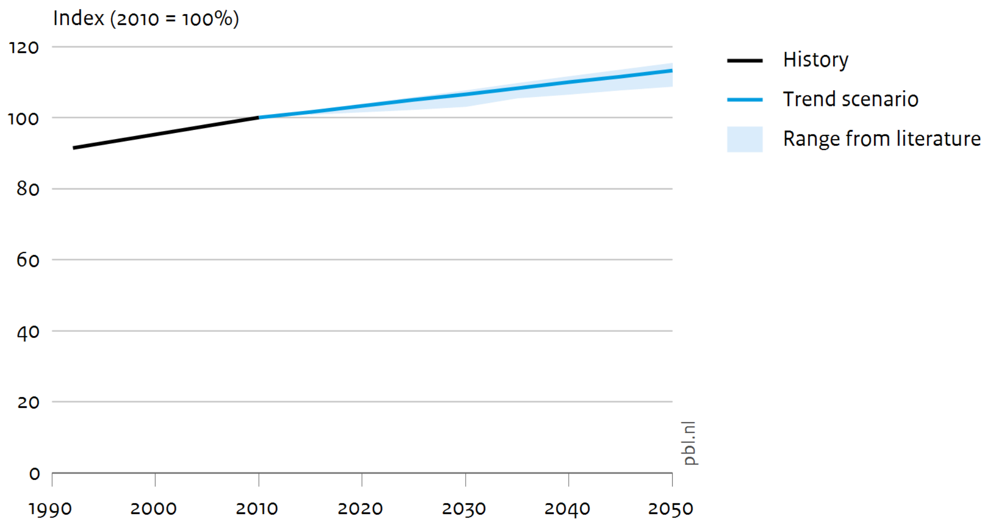
Due to expected increase in GDP and population, wood and paper consumption are projected to increase in the coming decades, globally and within the EU (UNECE and FAO, 2011; FAO, 2014; Lotze-Campen et al., 2014). While globally the increase is even higher after 2030, the use of traditional wood products is expected to stabilise in the EU in that period. Whether the use of wood for energy production will increase after 2030 is highly uncertain and depends on developments in the energy system and future energy policies. The consumption of woody biomass for energy production is projected to increase from 435 in 2010 to 859 million m^3 in 2030 (UNECE and FAO, 2011).

Increased future demand for wood may not be met from domestic resources, despite the positive forest resource situation in the EU. Mobilisation of resources is hindered by highly fragmented ownership, an overall high cost level, owners not actively managing their forests, and inadequate maintenance of soil fertility caused by extraction of harvest residues. Furthermore, on a considerable proportion of the forest area, wood production is combined with other functions, such as nature conservation, avalanche protection and recreation, limiting the potential for intensification. Thus, it can be expected that increased consumption will be met from higher imports rather than higher domestic production. Main regions in this respect are North America (wood pellets), South America (pulp and paper) and Russia.

Climate change is expected to lead to increased forest productivity, especially in central and northern Europe, while productivity in southern Europe might decrease due to increased drought stress (Reyer et al., 2014). Furthermore, an increase in natural disturbances, such as fires, storms or insect pests, might lead to considerably greater damage, reducing production (Seidl et al., 2014).

Recent scenario studies that include little policy intervention, often assume a further increase in forest area in the EU (Figure 3.5), either based on extrapolation of past trends (UNECE and FAO, 2011), or derived from land-use projections (Lotze-Campen et al., 2012). The increase is mainly a result of land abandonment and not of active reforestation to meet, for example, increasing demand for wood. However, the rate of ecological succession from abandoned land to forest is uncertain. Consequently, the increase of forest area is uncertain. Besides, changes in demand for forest products as a driver of land-use change, is often not included in projections.

Projections of forest area in the EU



Source: PBL

Figure 3.5 Projections of forest area in the EU

Shaded area refers to range found in literature (UNECE and FAO, 2011; Buongiorno et al., 2012; Lotze-Campen et al., 2014; d'Annunzio et al., 2015; Keenan et al., 2015).

3.1.6 Energy sector

Considerable changes are expected in the energy sector, which may have large impacts on the landscapes across the EU as they are today. These changes are driven by the vision of achieving a low-carbon economy by 2050 (EC, 2011b) as well as a European energy union (EC, 2015a). Although energy consumption in the EU is expected to remain at current levels, production will undergo considerable transition (Capros et al., 2014). Driven by factors such as renewable energy targets and developments in smart grids, renewable energy sources are expected to increase their contribution to electricity production by up to 50%. Whereas wind will play a key role in electricity generation, biomass and waste are the main renewable sources for steam and heat supply. Solar capacity is expected to increase almost seven-fold and hydropower with 10%, from 2010 to 2050 (Capros et al., 2014).

3.2 Impacts of trends on the environment

3.2.1 The *Trend* scenario

The *Trend* scenario follows a business-as-usual path, and includes all drivers and pressures described in the previous section. The *Trend* scenario does not take into account the introduction of new policies or unexpected events. This scenario was based on the results of the A2 marker scenario of the VOLANTE project for the year 2040 (Lotze-Campen et al., 2012; Lotze-Campen et al., 2014; Pedroli et al., 2015), which is a conservative scenario with respect to policy changes. This scenario was extended towards 2050 using the Dyna-CLUE model, following trends from Maes et al. (2015). Table 3.1 shows the assumptions for main drivers in the *Trend* scenario. Pressures that were not included in the VOLANTE project, such as air and water quality, have been derived from other sources that are in line with a business-as-usual approach.

Table 3.1 Assumptions of developments of drivers in the *Trend* scenario

Driver	Development in the *Trend* scenario
Population	-1% (2005-2050); -0.02% (per year)
Economy	1.4% growth (per year)
Trade policies	No change in trade policies
Climate mitigation policies	No stringent climate policies (+ 2 °C by 2050)
Agricultural policies	No change in CAP, stable budget
Energy policies	Biofuel targets phased out
Spatial policies	No restriction on urban expansion
Environmental policies	Air: implementation of current legislation[4] Water: Implementation of Water Framework Directive
Nature policies	No change, current legislation

Under the *Trend* scenario, population in the EU28 will peak in the coming decades and then decreases towards 490 million in 2050 (Figure 3.1). Annual GDP growth is expected to be 1.5% over the coming decades and to decline to 1.3% after 2030. Expected consumption changes are taken into account and linked to population growth and increasing welfare. Assumptions on policies are conservative. No further liberalisation of trade policy has been assumed. At EU level, it is assumed that biofuel targets are phased out and the CAP budget remains stable. Milk quota are abolished and CAP payments are decoupled from production before 2020 and this will be continued. Weak spatial planning policies are assumed, resulting in high pressure of urban developments in densely populated areas (Lotze-Campen et al., 2014). Natura 2000 sites remain protected, which means that no land-use changes occur in these areas.

Similarly, climate policy is conservative, and based on the policy context before 2015. Such a projection lead to high emission levels and a 4 °C warming in 2100 compared to pre-industrial levels, which implies approximately 2 °C rise in 2050 (OECD, 2012; IPCC, 2014; Lotze-Campen et al., 2014). However, the policy context has been changed in 2015 as the Conference of the Parties agreed on the Paris Agreement, which aims to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels (www.unfcc.int). Although, implementation of the current nationally determined contributions – national mitigation policies — would lead to between approximately 2.6 and 3.1 °C by 2100 (Rogelj et al., 2016), we analysed the impacts of a more extreme, alternative climate scenario on our results in the year 2050. The alternative climate scenario analysed, results in a 2 °C rise by 2100 .

According to Lotze-Campen et al. (2014), the assumptions in the *Trend* scenario result in an increase of value in agricultural output of almost 20% in 2050 compared to 2010, in particular due to an increasing crop production. Timber production is growing by 10% in the period 2010-2050. These developments together with the assumed policies lead to different trends in land use and water quality across the EU.

3.2.2 Impacts on land use

The land-use changes resulting from the assumptions under the *Trend* scenario show three marked developments. Firstly, urbanisation is expected to continue, due to increases in regional population and welfare. The surface under urban fabric increases by 19% from 2010 to 2050 (Figure 3.6). The regions that are highly urbanised today become even more

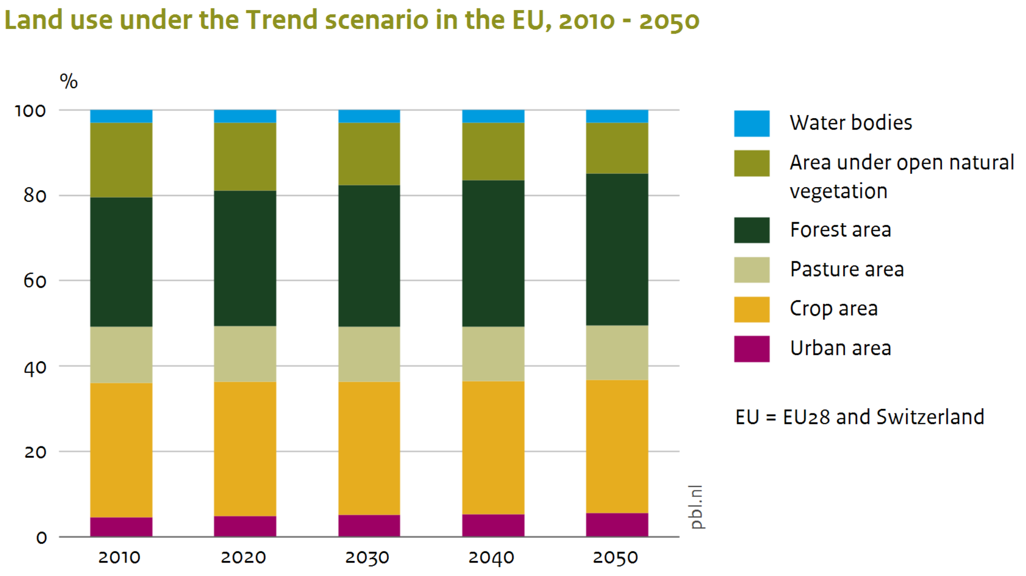
[4] according to Amann et al. (2012), p. 23

urbanised for housing and commercial purposes (Figure 3.7). These regions can mostly be found in north-western Europe and stretch from north-western England to northern Italy. Secondly, the total surface under agriculture is projected to remain almost stable, with some variations between regions. For example, abandonment mostly takes place in mountainous regions, while in other regions agricultural expansion may occur. Thirdly, regrowth of forests in abandoned areas is expected to occur at a large scale, resulting in a proportional growth of forested areas of 17% between 2010 and 2050 and a proportional decrease in the area under natural open vegetation by more than 30%.

Impacts of climate change and mitigation policies, except mandatory biofuel blending, are not included in the direct drivers for land use. Therefore, mitigation and adaptation measures can be expected in the coming decades, that change land use across the EU. This could be land used for energy production (wind or solar) or for flood or drought prevention.

Although dynamics in total agricultural area are limited (Figure 3.6), management of agricultural areas is likely to change. An increased use of fertiliser has been projected in certain regions in Europe, particularly higher nitrogen application per hectare in eastern European countries.

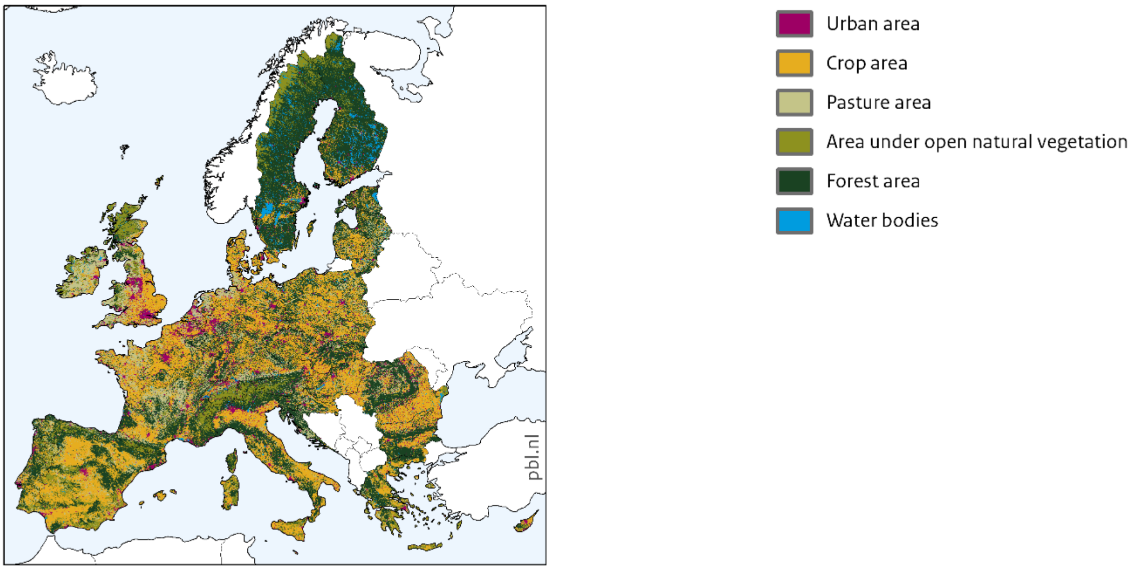
It has been assumed that intensification of land use goes along with the disappearance of green landscape elements at places where current agricultural field size is small (i.e. less than 10 ha) (Kuemmerle et al., 2013). Assumptions on forest management practices depend on local conditions. These assumptions have been kept constant towards 2050 (Hengeveld et al., 2012).



Source: PBL

Figure 3.6 Land use under the *Trend* scenario

Land use under the Trend scenario, 2050



Source: PBL

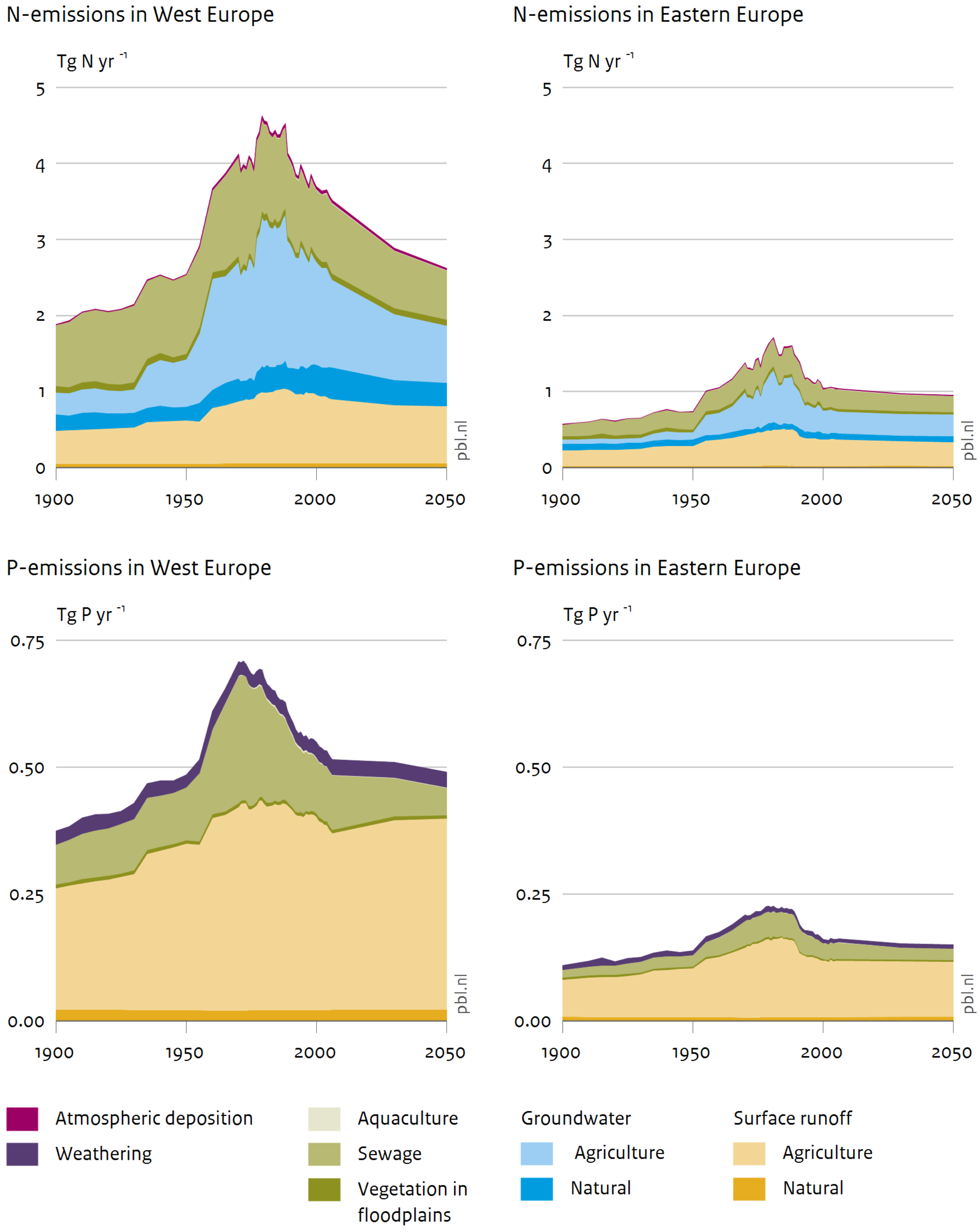
Figure 3.7 Land-use map of 2050 under the *Trend* scenario

3.2.3 Impacts on water quality

Currently, between 30% and 50% of surface waters have a poor ecological status. Most of them are affected by pollution from diffuse sources (EEA, 2012b). Since the early 1990s, nutrient levels in freshwater bodies are decreasing across the EU. The decrease in phosphorus levels is achieved by improvements in waste water treatment and reductions of phosphorus in detergents. Besides, reduction in overfertilisation in western Europe has led to decreasing N and P emissions. The trend of decreasing nutrient emissions to freshwater bodies continues towards 2050. However, agriculture remains an important source of nitrogen and phosphorous emissions to surface water. The main reasons are the substantial 'loading' of groundwater with nitrogen in the past by agriculture and loading of agricultural soils with phosphorous. Since the nitrogen fertilisation in western Europe is expected to be increasingly balanced with nitrogen uptake of crops, the nitrogen concentration of groundwater is considerably decreasing towards 2050. For eastern Europe, an increase in nitrogen use is expected, leading to continued pollution of water bodies (Alexandratos and Bruinsma, 2012).

The improvements in urban waste water treatment are expected to continue towards 2050, following the targets of the Urban Waste Water directive (EEC, 1991) and expected technological developments. The full implementation results in a 5% reduction of phosphorus load to rivers in the western part of the EU and 8% in the east (Figure 3.8). Surface runoff of phosphorous from agricultural soils will increasingly be the main source of phosphorus loading to surface water.

Emissions of N and P to waterbodies by source in the EU under the Trend scenario, 1900-2050



Source: PBL

Figure 3.8 Trends in N and P loads to water bodies by source

Main difference between western and eastern Europe is the N and P use of agriculture, the difference in surface under agriculture is the second explanatory factor. Western Europe includes EU15, Iceland and Norway. Eastern Europe includes EU12 and the former republic of Yugoslavia.

3.2.4 Impacts on hydromorphology

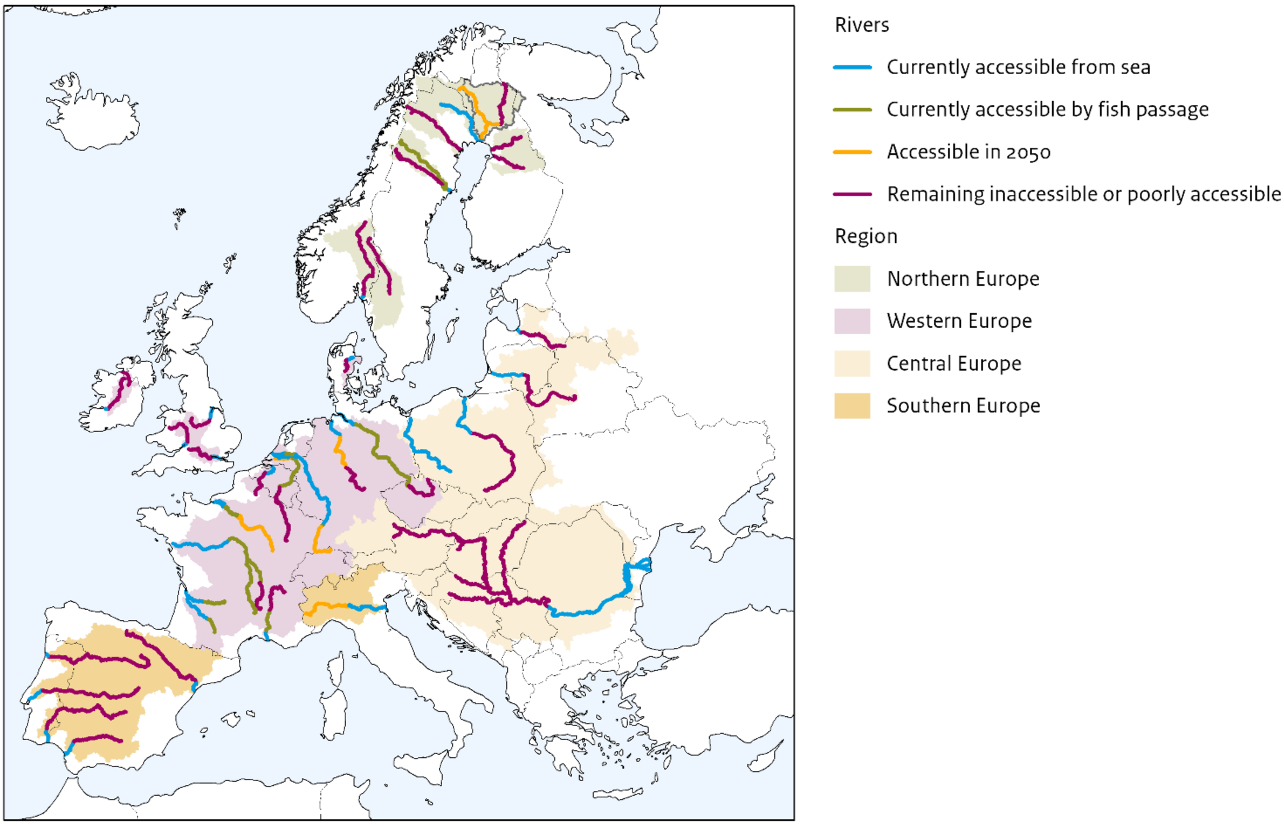
Changes in natural river flow (hydromorphology) are negatively affecting the status of water bodies (EEA, 2012b). Longer dry periods due to climate change will increase the need to store water for human consumption and irrigation. Besides, due to the increasing demand for renewable energy and energy storage, the hydropower production capacity is expected to increase. In Europe, 650 high dams are either planned or already under construction (Zarfl et al., 2014) and about 20,000 small hydropower plants are planned that will affect small rivers and brooks (Liu et al., 2013). One of the reasons for developing hydropower is the ability to store energy. Water is pumped back into the basin in periods of energy production surpluses, and the energy can be reproduced again when needed (e.g. when production of wind and solar energy is low).

Most of the main rivers have become inaccessible to migratory fish species because of the dams and sluices within them (Figure 3.9). Realising current plans to build fish passes (Erkinaro et al., 2011; ICPR, 2013; ICDPR, 2015; LIFE, 2015) will improve fish migration in some of the rivers (Table 3.2), especially in France, Belgium, the Netherlands and Germany, except for the Meuse. At the same time, new dams are planned to be constructed in southern and eastern Europe, further reducing the possibilities for fish to migrate. Although most new dams will have a fish pass, this will not compensate the original accessibility, because only a part of the fish will be able to find the fish pass (Croze et al., 2008; Calles et al., 2013). The large dams in the Danube, the Iron Gate dams, will remain a major barrier for fish migration. In small rivers, a further deterioration will take place due to many small hydropower plants.

Table 3.2 Restoration of main rivers in Europe, under the *Trend* scenario

	Accessible	Accessible via fish passes	Currently inaccessible	Restored in 2050	Inaccessible in 2050
Northern	390	480	3090	440	2650
Western	1820	2220	3570	1020	2550
Central	1030	0	1750	0	1750
Southern	710	0	3490	330	3160
	3950	2700	11900	1790	10110

Change of accessibility of rivers under the Trend scenario, 2005-2050



Source: PBL

Figure 3.9 The accessibility of large rivers for anadromous fish

3.2.5 Impacts on air quality

Emissions of sulphur and nitrogen compounds are expected to decline (Amann et al., 2014). Progressing implementation of air quality legislation and structural changes in the energy system will lead to a decline of SO_2 emissions in the EU towards 2030. After 2030, stabilisation occurs since no further reduction policies are assumed in the *Trend* scenario. In 2030, total SO_2 emissions will be almost 70% below the 2005 level. Most of these reductions will come from changes in the power generation sector. Also for NOx emissions, implementation of current legislation will lead to a reduction of about 60% between 2005 and 2030. These changes emerge from measures in the power generation sector and implementation of emission standards for road vehicles. With respect to NH_3 only slight changes in total emissions in the EU are expected up to 2050, although NH_3 emissions are also subject to targeted controls in the agricultural sector and will be affected as a side effect of emission legislation for road transport. Due to decreases in emissions, air quality will improve (lower concentrations) and, consequently, atmospheric deposition levels will decrease (EEA, 2016).

3.3 Impacts on biodiversity and ecosystem services

3.3.1 Negative trends for terrestrial species and ecosystems

The impacts of the *Trend* scenario for biodiversity were assessed using the BioScore 2.0 model, which calculates the probability of occurrence of more than 1300 species of birds, mammals, plant, habitat types and butterflies for each 5 by 5 km grid cell. These taxonomic groups and species represent an important part of Europe's biodiversity. Most of the species included are protected by the Birds or Habitats Directive. Both species that occur at specific locations as well as species occurring widely across the EU are included. Moreover, the species groups vary in sensitivity to environmental changes and the spatial scale of the changes. Plants, for example, are more vulnerable to changes at local scale and pressures, such as air pollution, whereas mammals are more vulnerable to fragmentation and other changes at landscape scale. Figure 3.10 shows the number of species in five classes, according to the change in the sum of their probability of occurrence, over all grid cells, between 2005 and 2050.

Although some species will benefit from the changes projected up to 2050, the majority is expected to show a moderate to strong decrease. Of the four species groups, vascular plants have the highest share of species with a decline in their probability of occurrence. Currently, this species group has the largest share of threatened species, also according to the Red List criteria (Bilz et al., 2011). This can be seen as an indication of the sensitivity of this species group for future changes.

Further decline in area and ecological quality for most terrestrial ecosystems

The current decrease in area, for a number of ecosystems, and decrease in ecological quality, for most natural habitats, is expected to continue (Figure 3.11). The extent of natural areas with open natural vegetation (e.g. marshland, heathland, grassland) decreases the most. The ecological quality of these types of open vegetation is expected to decline, as

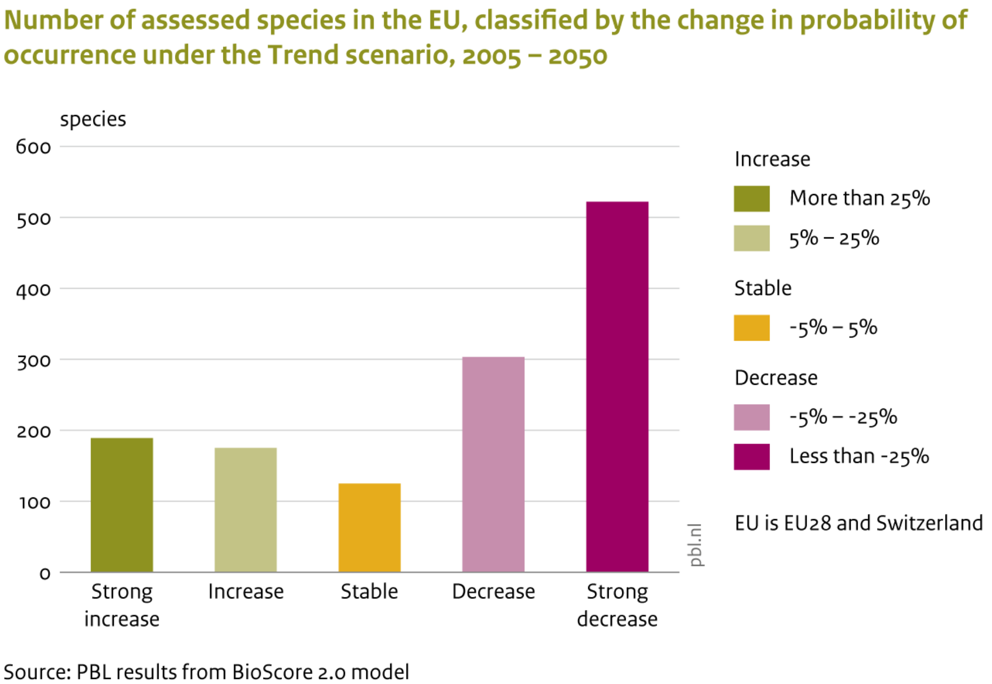
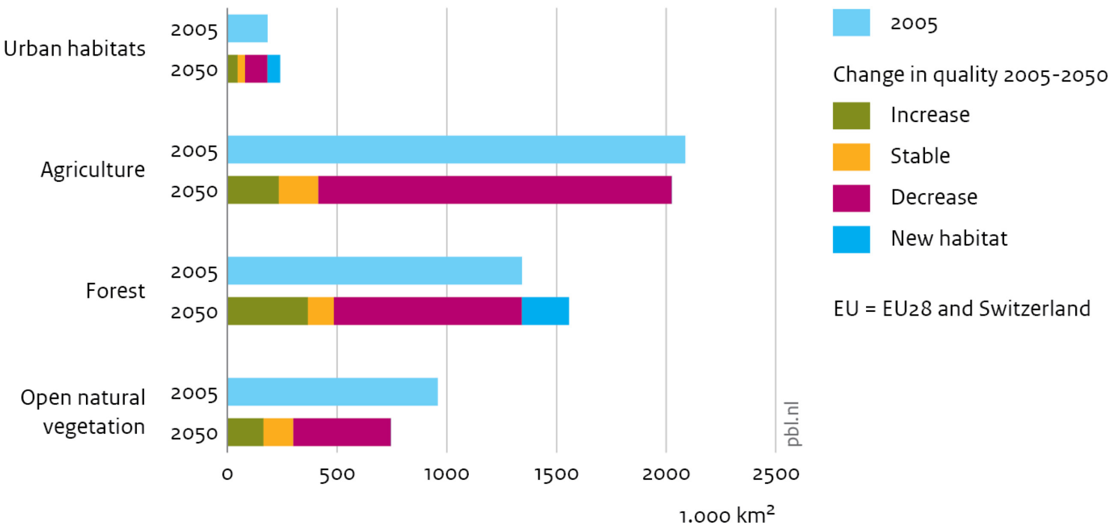


Figure 3.10 Number of selected terrestrial species in the EU, by change in the total probability of occurrence from 2005 to 2050 under the *Trend* scenario

well, in large parts of the area, due to climate change. Large parts of agricultural areas show negative changes in ecological quality. Forests increase in surface area and about a quarter of the area is also expected to gain in ecological quality. However, the ecological quality in half of the forest area is expected to decrease. Urban areas also increase in size, but the environmental pressure is increasing in a relatively large part of the area; ecological quality, therefore, is decreasing. Changes in all four ecosystems together lead to a net decrease in ecological value.

Change in quality and surface of terrestrial ecosystems under the Trend scenario in the EU

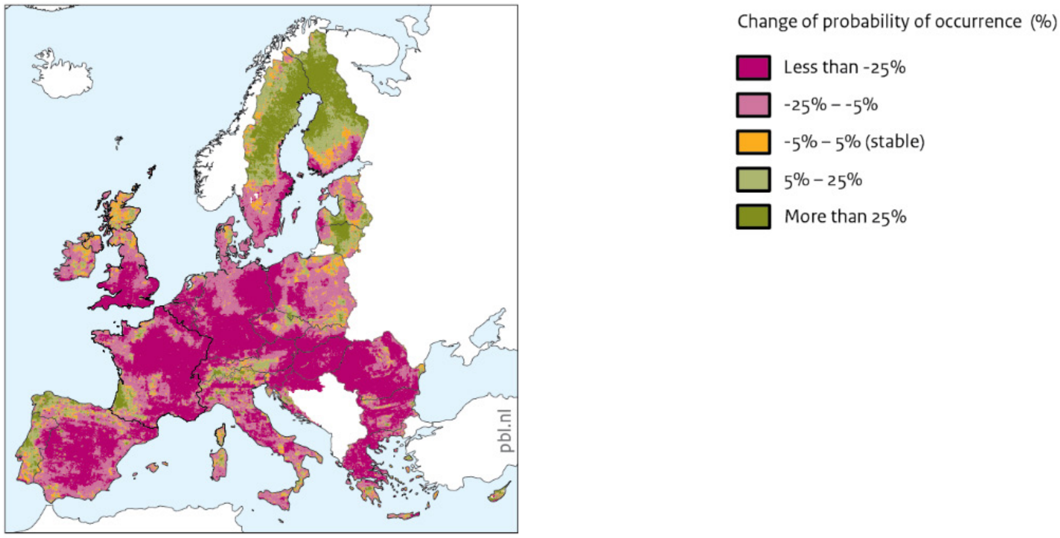


Source: PBL

Figure 3.11 Changes in quality and surface of ecosystems, under the *Trend* scenario

Change in ecosystem quality is based on changes in the average probability of characteristic species in each grid cell.

Change in probability of occurrence under the Trend scenario, 2005-2050



Source: PBL

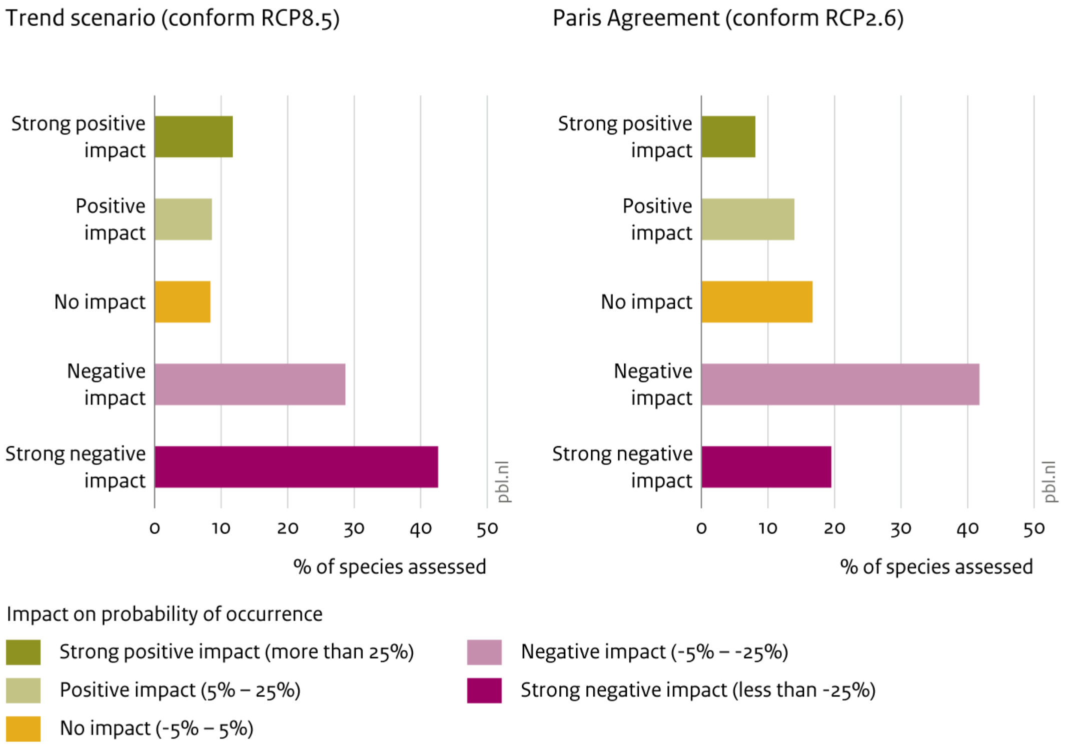
Figure 3.12 Changes in the sum of probability of occurrence of species

Regional differences in terrestrial biodiversity trends

There are differences in species change across Europe under the *Trend* scenario. The regional differences are caused by differences in the changes of pressures, such as climate change and changes in land use, and changes in environmental factors. Net loss of the diversity of species is found in most parts of Europe (Figure 3.12). Losses are largest in central parts of Spain, France, the southern part of the UK, central Europe and the Balkan. Regions that show a net improvement of the diversity of species are, among others, central and northern parts of Sweden and Finland, parts of the Baltic States and Poland, and mountain ranges such as the Alps.

Underlying these results are the different trends between the four ecosystem types. Declines of diversity of species can be found in forested areas as well as agricultural areas, that cover large parts of the EU (Figure 3.12). These are as well forested areas and agricultural areas. Areas with open natural vegetation that are turned into forest due to ecological succession, cause a decline in the probability of occurrence of species living in shrubs and open vegetation types, but has positive impact on species living in the forest. These areas are primarily located in northern Europe, Greece, Portugal and Spain. Moreover, positive impacts on the diversity of species in forest areas occur in mountainous regions, such as the Alps, and northern parts of Europe, and are due the expected shift of species caused by climate change. Positive impacts on species diversity in the Baltic states and Portugal are mainly due to the increased quality of agricultural areas.

Impact of climate change on species in the EU, 2005 – 2050



EU is EU28 and Switzerland

Source: PBL results from Bioscore 2.0 model

Figure 3.13 Impacts of climate change on species in 2050, under the *Trend* scenario and a climate scenario conform the Paris agreement (Representative Concentration Pathway 2.6; Van Vuuren et al., 2011a), which results in 2 degrees warming in 2100

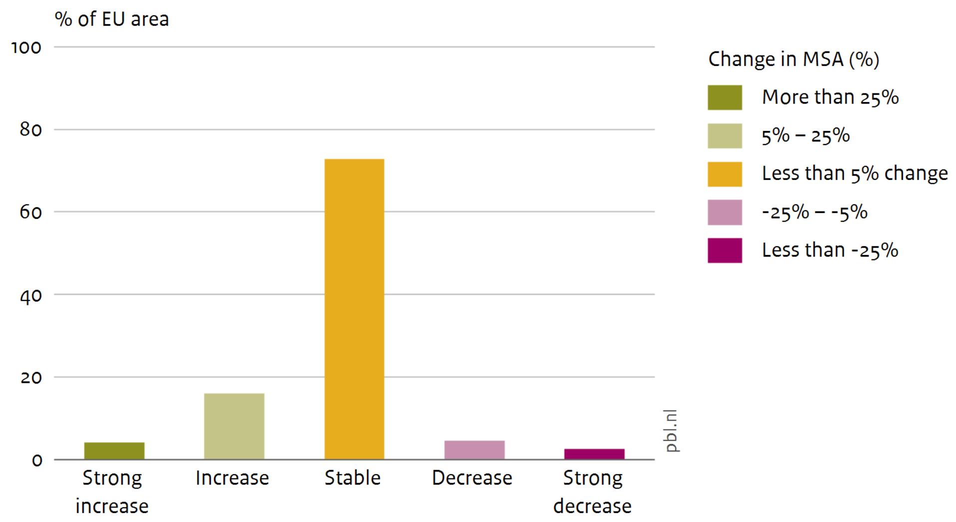
Climate change pressures have been analysed isolated from other pressures. The climate change prognosis used in the Trend *scenario is based on the RCP8.5 climate projection.*

Climate change important cause of the decline in terrestrial biodiversity

Figure 3.13 shows the isolated impact of climate change, from 2005 to 2050, on the assessed species. For this analysis, only changes in climate variables were taken into account. The left panel shows the impact on species when climate develops as projected under the *Trend* scenario, the right panel shows the alternative climate scenario leading to the Paris Agreement of 2 °C increase in 2100. Each species is classified according to the impact on its total probability of occurrence. The left side of Figure 3.14 shows that climate change contributes to a large and mainly negative extent, to the results under the *Trend* scenario.

More than 40% (520) of the species assessed are very negatively impacted by climate change. This result is about the same as that under the *Trend* scenario, in which all pressures are included (Figure 3.10). Only a minority of species is expected to benefit from climate change (Hendriks et al., 2016). The negative impact of climate change will be largest in fragmented landscapes and for species that are least capable of adapting to the changes in their local climate. In these landscapes and for these species, the risks of populations becoming isolated and disappearing on a local level, without being able to colonise new suitable habitats, are the highest (Opdam and Wascher, 2004).

Change in Mean Species Abundance in water bodies under the Trend scenario, 2005-2050



Source: PBL

Figure 3.14 Share of area water bodies in the EU with positive, stable or negative trends in aquatic biodiversity intactness under the *Trend* scenario (2005–2050)

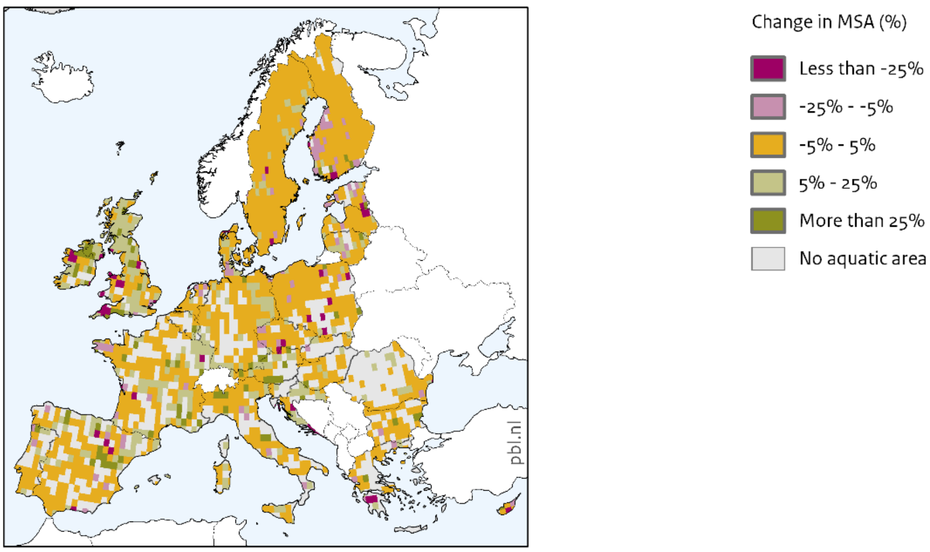
If the Paris Climate Agreement is taken into account in the climate change scenario (right panel of Figure 3.13), the negative effect is much smaller, compared to the *Trend* scenario without this agreement (left panel of Figure 3.13). In both cases, most species show a decline. However, the percentage of species on which climate change will have a strong negative impact is much lower under the scenario that includes the Paris Climate Agreement. The strong positive effect of climate change as experienced by some species is also less pronounced under this scenario.

3.3.2 Aquatic biodiversity

Overall, only limited changes in aquatic biodiversity intactness, or Mean Species Abundance (MSA) (Section 2.2.2), are expected under the *Trend* scenario (Figures 3.14 and 3.15). In more than 70% of the area water bodies, the change in MSA will be less than 5%. This can be explained by the fact that, on average, expected changes in agricultural land use and in nutrient loading in Europe are limited (Sections 3.2.1 and 3.2.2). However, improvements are expected in nearly 20% of the water surface.

Water bodies with positive trends are mainly located in regions where some agricultural land abandonment will occur (such as Scotland, Ireland and parts of France) and/or further nutrient load reduction (such as northern Spain and some mountainous regions). In other areas (about 8% of the total) a deterioration of the water quality is expected due to agricultural intensification. Deterioration is expected to occur in some eastern countries, such as the Baltic States and Poland, southern countries, such as parts of Spain and Greece and in England and southern Finland. In Spain and Greece, hydrological disturbances also contribute to the decrease in MSA.

Change in aquatic biodiversity under the Trend scenario in the EU, 2005-2050



Source: PBL

Figure 3.15 Expected changes in aquatic biodiversity intactness in European water bodies, under the *Trend* scenario (2005-2050)

The results are probably too positive, especially in southern and south-eastern regions, as climate change was not taken into account in the modelling. It is to be expected that climate impacts will, apart from a rise in water temperature, lead to changes in the magnitude of the water flow and, therefore, in the MSA within water bodies. Results differ from those of the terrestrial modelling, due to differences in pressure (e.g. the aquatic model makes no difference between forest and open natural habitats, and climate change is not yet included), in indicators (species groups), and in spatial resolution.

Impacts on fish migration

In most catchments in Europe anadromous fish populations are extinct due to overfishing, water quality, loss of habitat and migration barriers (De Groot, 2002). In many catchments water quality has improved and commercial fishery has reduced. Obstacles, together with habitat loss and intensified shipping, are the main restrictions to restore viable anadromous fish population in these improved rivers. Only the impact of dams on anadromous fish species has been assessed here, ignoring the state of the water quality in the future. However, the impact is not restricted to the obstacle itself: large reservoirs, altered discharge patterns, deposition of suspended matter in reservoirs and changed water temperature have also important consequences. These aspects have not been taken into account.

Table 3.4 shows the increase in accessibility for specific anadromous fish species, under the *Trend* scenario, in the main rivers. The accessibility is based on the maximum migration distance of each species (Annex I). The restoration of the Rhine, Seine and Po is expected to result in total accessible rivers, which leads to benefits for 9 of the 16 species. The restoration of the Kemijoki is focused on its main tributary Ounasjoki having important salmon spawning areas (Erkinaro et al., 2011). The accessibility of the Meuse is expected to be improved by opening of the Haringvliet, which will improve conditions for 8 species. Although accessibility of the main river does not guarantee accessible spawning areas in their tributaries, it is the first requirement for anadromous fish to be able to spawn.

Table 3.4 Improved accessibility for fish species under the *Trend* scenario

Species	Catchments with improved accessibility (% length accessible of total length)												Accessibility of other catchments (number of catchments)	
	Kemijoki		Meuse		Po		Rhine		Seine		Weser		0 - 80%	80 - 100 %
	Current	2050	Current	2050	Current	2050	Current	2050	Current	2050	Current	2050		
Russian sturgeon													1	0
Adriatic sturgeon					45	100							0	0
Ship sturgeon													1	0
Baltic sturgeon													1	2
Stellate sturgeon													0	0
Atlantic sturgeon			65	100	45	100	75	100	60	100	30	100	7	3
Allis shad			35	50			75	100	40	100	30	100	8	4
Twaite shad			65	100			100	100	60	100	30	100	8	6
Pontic shad													1	0
Whitefish	5	80					100	100			25	100	6	5
Houting			65	100			100	100					1	0
Beluga													1	0
River lamprey	3	60	35	50	45	100	75	100	40	100	20	60	16	6
Sea lamprey			35	50			75	100	40	100	20	60	9	6
Atlantic salmon	3	60	35	50			75	100	40	100	20	60	17	5
Sea trout	3	60	35	50			75	100	40	100	20	60	17	5

3.3.3 Mixed trends among ecosystem services

The impacts on ecosystem services are mixed among services, since they rely on different ecosystems and because dynamics in land use are different between regions. Average changes range from a decrease of nearly 4% (pollination) to, an increase of 15% (erosion prevention).

Erosion prevention

Under the *Trend* scenario*,* soil erosion risk decreases by 15%. Largest absolute decreases can be found in the south-eastern and southern parts of the EU (Figure 3.16), due to ecological succession and abandonment of agricultural areas. The erosion risk, however, remains large, with the vegetation providing poor erosion control, in central and southern Europe. In these regions, the erosion risk is estimated at a respective 126 and 60 t/ha/y in soil loss, on average. Agricultural intensification might lead to a small increase in erosion, but this was not accounted for in the model. The area under arable agriculture, permanent crops and sparse vegetation cover in erosion-sensitive areas is decreasing under the *Trend* scenario by 3%, between 2000 to 2050 (71 x 10^3 km^2 area in 2050)

Carbon sequestration
In the EU, national carbon emission reduction targets can be compensated for by carbon sequestered by soil and vegetation. By 2050, carbon sequestered by soil and vegetation increases in Europe, particularly in the eastern and south-eastern part of the EU (Figure 3.16). This increase is 12% in total. It is mainly the results of agricultural abandonment and increasing forest cover, with forest being the main carbon sink. Northern and central Europe remain the regions where most carbon is sequestered.

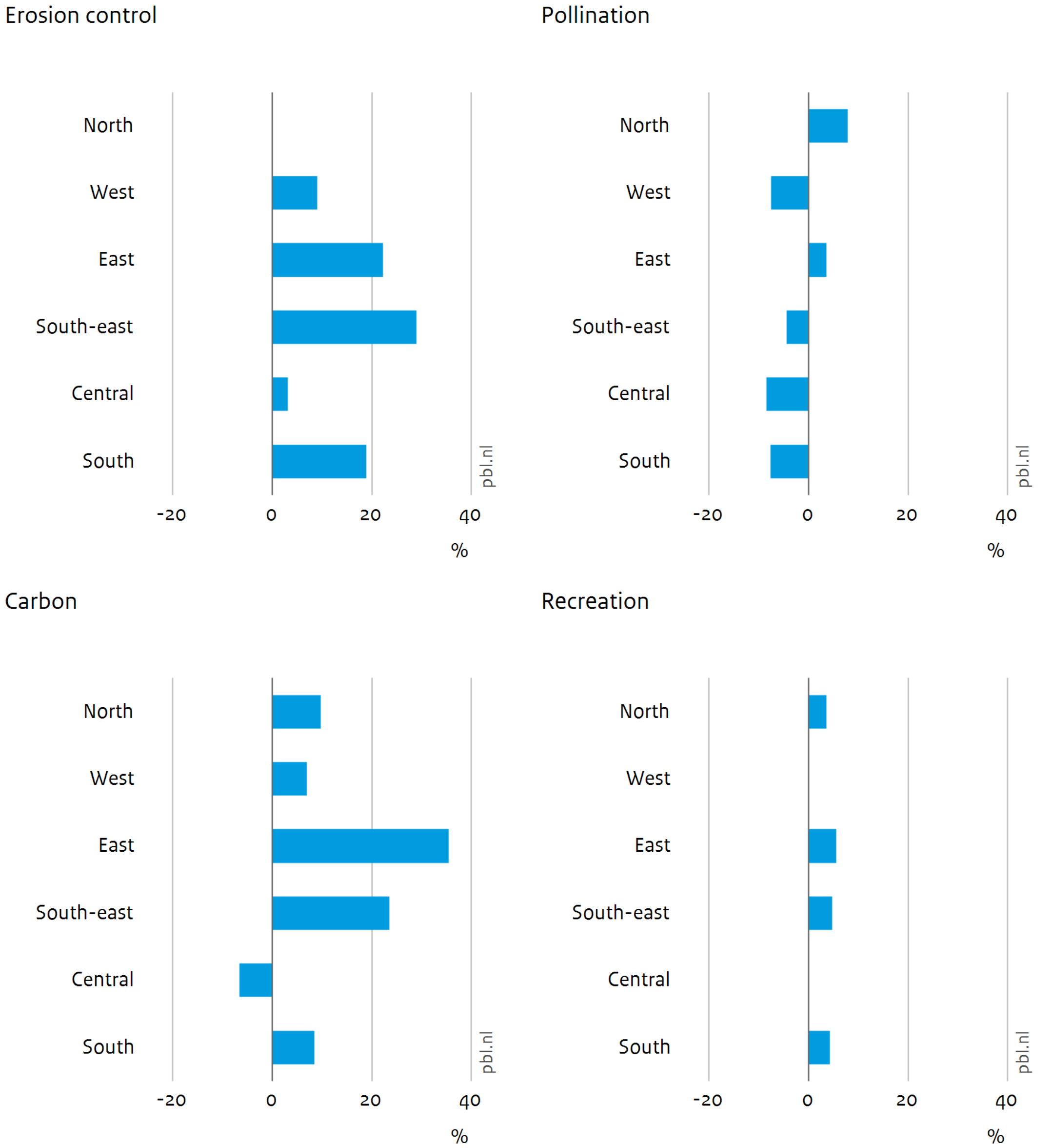
Natural pest control
Natural pest control supports agricultural production. Sufficient patches of nature (e.g. forest, natural grassland) or green landscape elements (e.g. tree lines) are needed as suitable habitats for natural pest predators nearby agricultural areas. As this service acts very locally, a spatial match between supply (i.e. habitat for natural pest species) and demand (i.e. agricultural areas benefitting from natural pest control) is important, and both are taken into account in the model. Although, at the moment, natural pest control is insufficient across the EU, the delivery of this service shows only a marginal decrease towards 2050, with less than 1% on average. Only 35% of croplands (482 x 10^3 km^2) have sufficient natural elements in their surroundings under the *Trend* scenario for 2050, ranging from 25% in South-east EU to 65% in North EU .

Pollination
Pollination (Figure 3.16) supports agricultural production similarly to natural pest control. This service also acts very locally, hence a spatial match between supply (i.e. habitat for pollinators) and demand (i.e. agricultural areas with crops benefitting from pollinators) is important. Therefore, both supply and demand are taken into account in the modelling. The decline in the ecosystem service of pollination is larger than in natural pest control, with a decline of about 3.5% of the average value of the pollination index. The decline in pollination, by 2050, is also being caused by agricultural intensification, as this likely will coincide with the decrease in the number of patches of nature and green landscape elements nearby agriculture that are suitable habitats for pollinators. The average pollination index decrease in most regions towards 2050 (Figure 3.16). Similar to natural pest control, average pollination levels are the lowest in western and south-eastern Europe, and the highest in eastern and northern Europe.

Recreation
The supply of recreation services of the landscape will increase to some extent across Europe by 2050, mainly due to regrowth of trees on abandoned agricultural land and in forest and nature reserves. The demand for recreation services will increase too during the next decades, due to the growth and the ageing of the population. However, there will be a growing regional mismatch between supply and demand. The increase in supply will primarily occur in sparsely populated regions under threat of declining population such as northern Europe and the Mediterranean region (Figure 3.16). On the other hand, there will be hardly any growth of recreation capacity in the metropolitan regions with expanding populations such as Ile de France, Warsaw and Madrid. In these regions, the mismatch between demand and delivery increases.

Water retention
Flood regulation was not analysed within the Nature Outlook project. However, it does play a role in the perspectives on nature (Chapter 4). Therefore, an overview of the results from the Volante A2 scenario to 2040 is presented here (Stürck et al., 2015).

Relative change in ecosystem services per EU region under the Trend scenario, 2000-2050



Source: PBL

Figure 3.16 Relative change in delivery of ecosystem services between 2000 and 2050 under the *Trend* scenario

North: Sweden and Finland; West: Belgium, Denmark, France, Germany, Ireland, Luxemburg, The Netherlands and UK; East: Czech Republic, Estonia, Latvia, Lithuania, Poland, Slovakia; South-east: Bulgaria, Croatia, Hungary, Romania and Slovenia; Central: Austria and Switzerland; South: Greece, Italy, Portugal, Spain.

Note that for recreation only the supply is taken into account in the rate of change. There is a net decline if the demand for recreation is included.

Water retention by vegetation to control flooding is provided locally and regionally. Areas benefitting from water retention are downstream urban and agricultural areas. Flood regulation shows a mixed trend across Europe and is expected to decline by about 5% in total by 2040. Afforestation and ecological succession following land abandonment, for example in the Mediterranean, result in an increase in the amount of water retained, while cropland intensification (e.g. in western Europe) results in decline, because cropland has a lower water-retention capacity than areas with natural vegetation. Decline in water retention is expected to occur in western, central and eastern Europe. This means an increased flood risk in (the downstream areas of) these regions, such as the Netherlands, lower parts of Germany and Hungary. A slight increase or retention is expected in Finland, Sweden and parts of the Mediterranean. Under the *Trend* scenario, 5×10^3 km^2 of surface with steep slopes (> 10%) and at high elevation levels (>500 m), is expected to be under urban fabric, (permanent) crops and pastures, while other land-uses with higher water retention capacities would be recommendable.

Cropland or urban settlement in flood-prone areas will increase by 3% between 2000 and 2050. These land-use types are likely to lead to large damage costs in relation to flooding. In contrast, pasture and natural grassland could be used to store water during such events. However, these are expected to decline by 9% at these locations, under the *Trend* scenario.

4 Perspectives on nature

People value nature in different ways and have a range of motives for engaging in nature-related efforts. The perspectives described (Dammers et al., 2017) capture this variation in four stylised storylines. Each perspective shows one desirable future when following a certain set of guiding values. The storylines of the perspectives were elaborated into quantitative and spatially explicit assumptions plotted in detail on a map of the EU, representing the bio-physical state of nature across the EU. The elaboration in this report, does not include specified policy strategies to reach the desired state (see Dammers et al. (2017) for an elaboration on strategies and governance modes).

For each of the perspectives, GIS was used to convert the assumptions into a set of maps. The maps are adaptations of the EU maps of 2050 under the *Trend* scenario and include a map on land use, agricultural intensity, forest management, deposition and water abstraction. The GIS rules used to develop each map can be found in Annex III.

The spatial explicit adaptations of the land use management under the *Trend* scenario were used to assess the expected impacts on biodiversity and ecosystem services under the perspectives compared to the *Trend* scenario. This means that a positive change is not necessarily positive with respect to the current situation. Impacts on biodiversity are shown in two classes: common species and endangered species. Ecosystem services that are included are recreation, natural pest control, water retention, erosion control and carbon sequestration in peat soils, and the provisioning services timber, crop and livestock production. The expected impact on biodiversity and ecosystem services differs between perspectives, because each perspective contain different nature-related interventions.

Impacts on biodiversity and ecosystem services have been assessed based on a semi-quantitative analysis, which included land-use and land-use management changes and impact tables. For biodiversity, the impact tables were based on expert judgement and represent the suitability of each type of land use, including management, for common and endangered species (see Annex IV). The results in the following sections indicate the area of the EU which is expected to be positively affected in the different perspectives for common or endangered species.

For regulating services, the impact under the various perspectives is indicated by means of the ‘gap’ between the scenarios and the *Trend* scenario. This gap is defined as the area in which there is demand for the service — for example, permanent cropland for natural pest control and pollination — but where that service is not provided. For the ecosystem service of recreation a workshop with experts has been organized (Annex V). To estimate changes in this service, interventions under the perspectives that apply to the urban area, such as greening of the urban area, were also included. The impacts on agricultural production are based on the current productivity across regions and the land-use change and land-use management changes that occur in the perspectives. Impacts on wood production were calculated using the EFISCEN model (Chapter 2).

Changes in land use and management also have impacts on greenhouse gas emissions and thus on climate change. This means that climate change will vary across the perspectives.

However, since the changes in the perspectives are expected to have, relatively, very marginal impacts on the amount of greenhouse gases emitted globally, these impacts were not taken into account. Besides, under some of the perspectives, especially under *Working with Nature*, far-reaching policies in varying domains, such as climate policies or food policies, that are needed for a transition in society in this perspective could have been included. It was decided, however, to limit interventions related to these kinds of policies and stay with the state of nature envisaged in the perspective. In this way, a bias between the perspectives was avoided.

4.1 Strengthening Cultural Identity

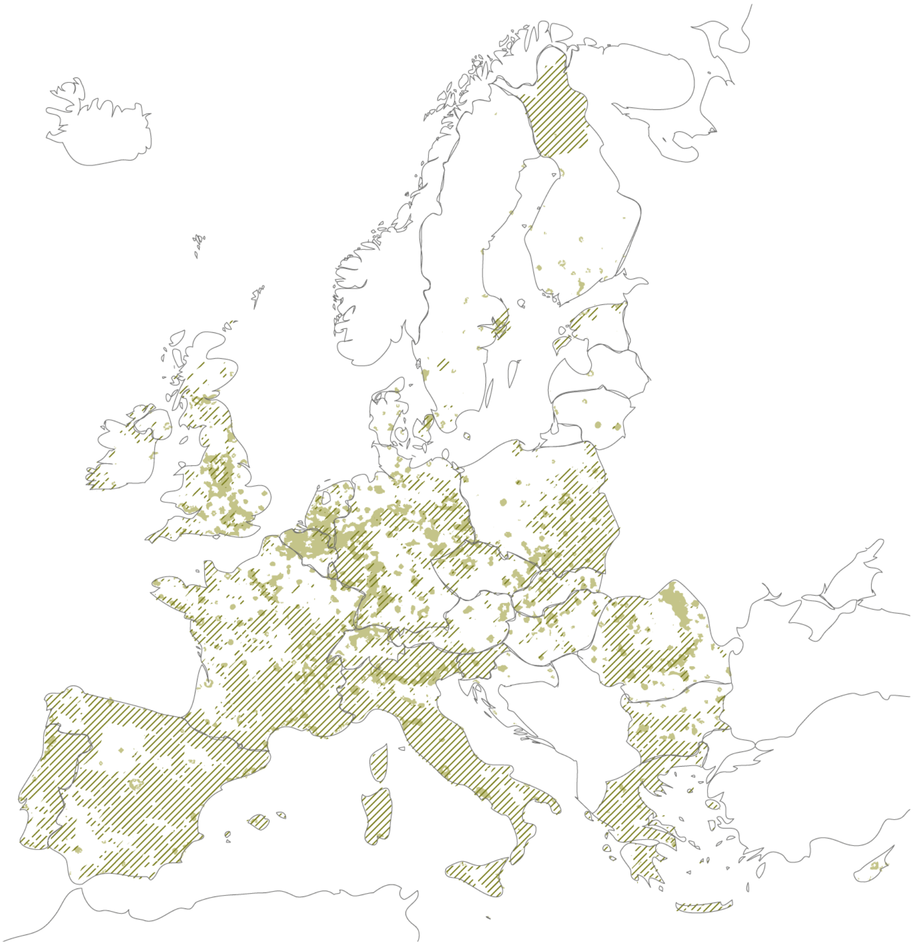
4.1.1 Summary of the perspective

In *Strengthening Cultural Identity*, people identify with the place where they live. They feel connected with nature and the landscape, and consider these as integral parts of their local and regional communities and as essential to their well-being. The connection between people and nature is restored and enhanced. In 2050, under this perspective, European landscapes are highly valued for their beauty, cultural diversity and their role in community building. Nature is used and shaped to contribute to good and sustainable living and to provide recreational environments, as well as to produce regional products. Many investments are made in maintaining and developing urban green-blue infrastructures, accessible nature areas, and rural landscapes.

4.1.2 Targeted areas

This perspective is locally oriented. Therefore, one of the regions where nature, and landscapes in particular, is highly valued, is the zone around cities, near people’s homes. Communities and citizen groups take care of valuable ***landscapes for recreation***, that are developed in the so-called urban zone. The urban zone consists of grid cells that have at least 10% urban area within a 10-km distance. Within this zone, the continued urbanisation and loss of green under the *Trend* scenario, is being counteracted. Instead, those landscapes intended for recreation provide ample possibilities for leisure, recreation and other activities (Figure 4.1). Therefore, up to 20% of the area of the landscapes in the urban zone has been designed as highly attractive and accessible green and blue spaces. In addition, agricultural areas in this zone are managed in a multifunctional way, with less intensive farming and an increase in green elements of up to 5% of the area. Patches with nature within the urban zone are conserved, and ecosystem succession is halted to maintain the identity of the landscape. Forests in the neighbourhood of cities are managed for multiple purposes and are open for recreation. Space for housing is provided in the ***peri-urban regions***, around small cities and villages, outside the urban zone, within an hour traveling distance from large cities (not shown in Figure 4.1).

Strengthening Cultural Identity



Source: PBL

Figure 4.1 Interventions under *Strengthening Cultural Identity*

Housing in peri-urban zones is not shown. Local landscapes are of importance under Strengthening Cultural Identity*. These areas are not restricted to the areas shown in Figure 4.1, and do exist everywhere across Europe. For reasons of consistency it was decided to develop a EU map of this perspective too, which shows the most characteristic landscapes from an EU point of view.*

Semi-natural and traditional landscapes, such as areas with extensively used pastures, have been preserved or redeveloped. These ***preserved landscapes*** are defined as the most characteristic landscapes of agriculture and forests, based on Tieskens et al. (2017), and recreation and national parks, based on the category ´national parks and monuments' in the IUCN database (Dudley, 2008). In both the characteristic landscapes and the recreation and national parks, ecological succession on grassland areas and urbanisation are halted to maintain traditional values. Agriculture management in these areas aims at the preservation of characteristics of the landscapes through the decrease in intensity and a more multi-functional use of croplands and pastures. Forest management becomes more natural in these areas. Increased production of local energy using small scale hydropower increases the fragmentation of rivers and streams. Rivers are restored only in case of an added value for tourism, such as angling activities.

Table 4.1 Land use according to *Strengthening Cultural Identity*

	Area (% of total EU area)	Difference compared to *Trend* scenario (in percentage points)	Management type, in % of total EU area		
			Intensive	Medium/ multifunctional	Extensive
Urban area	5%	-0.1 pp			
Cropland	31%	-0.1 pp	1.4% (-1.2*)	12.9% (0.9*)	16.7% (0.2*)
Pasture	13%	0.0 pp	5.3% (-0.8*)	6.9% (0.8*)	0.5% (0.0*)
Forest	36%	-0.1 pp	6.3% (-0.8*)	17.4% (-4.2*)	11.7% (5.0*)
Open natural vegetation	12%	0.3 pp			
Water bodies	3%	0.0 pp			

* difference compared to *Trend* scenario, in percentage points.

The interventions described above will lead to minor changes in the various areas (Table 4.1). Changes occur in land-use intensity in agriculture or forestry, due to the recreational landscapes in urban zones, for example, where a more extensive agricultural management is assumed. Besides, agriculture in characteristic landscapes have been preserved from abandonment. These areas are extensively managed too. The area of extensive forestry is increasing, due to the assumed management restrictions in the characteristic landscapes that will be preserved. Most of these areas are expected to be managed in a multifunctional way in the *Trend* scenario. Decreases in agricultural intensification in this perspective lead to a lower nitrogen and phosphorous emissions.

4.1.3 Impacts on biodiversity

The impacts of the interventions taken in this perspective are expected to have a positive effect on biodiversity. Common species will benefit from the increase of parks and green and blue elements within urban zones, and from the attractive landscapes for recreational purposes. Since these areas are rather small, these interventions result in small benefits for common species. The emphasis of conserving and enhancing cultural important landscapes in this perspective, results in more farmland with high nature values and a positive effect for agricultural species and corresponding habitats. Compared to the *Trend* scenario less afforestation occurs and therefore the habitats of species related to forests are smaller than under the *Trend* scenario. However, the extensive management of forests in the urban zone and of characteristic landscapes has a positive impact on species related to forests. The expected impact is larger for endangered species than for common species, as, for the latter, the amelioration is considered to be minimal in the large parts of these forests that change from mixed-objective forestry to close-to-nature forestry. Species living in open natural vegetation that require large extensively managed or undisturbed nature areas are not likely to benefit, because under this perspective there are no specific interventions to protect these habitats. Aquatic biodiversity might profit, locally, from these interventions, but not on a larger scale. Small angling-driven restoration projects will have local benefits for popular migrating fish species, such as salmon and sea trout.

Table 4.2 Net change in habitat conditions for terrestrial biodiversity, under *Strengthening Cultural Identity*

Habitat	**Net surface showing positive impacts for terrestrial species (% of total EU area)**	
	Common species	Endangered species
Urban areas	-0.1%	-0.1%
Cropland	1.2%	1.2%
Pasture	0.1%	2.3%
Forest	0.7%	4.9%
Open natural vegetation	0.3%	0.3%

4.1.4 Impacts on regulating services

The interventions made from this perspective, strengthen community values and will have a small positive impact for ecosystem services in mixed landscapes, such as pollination and natural pest control. Landscape conservation interventions increase pollination and natural pest control in approximately 8% of cropland areas where these mechanisms were insufficient, according to the *Trend* scenario. The expected regrowth of vegetation, under the *Trend* scenario, will be positive for erosion control and water retention, whereas the conservation of the open character of characteristic agricultural landscapes is expected to have a negative impact on erosion control and water retention in upland areas. Permanent vegetation, forest in particular, plays an important role in the delivery of erosion control and water retention. The agricultural area that is erosion-sensitive, is expected to be 25% larger than under the *Trend* scenario (Table 4.3). Upland agricultural areas – assumed to retain water at a very low level (Section 3.3.3) – are 14% larger than under the *Trend* scenario (Table 4.3), due to the conservation of characteristic landscapes.

Table 4.3 Impacts on ecosystem services under *Strengthening Cultural Identity*

Ecosystem service	**Area with insufficient supply in the *Trend* scenario (x 1000 km^2)**	**Change of area with insufficient supply (perspective compared to *Trend* scenario)**
Erosion control	71	3%
Peat conservation	11	1%
Pest control	897	-8%
Water retention	5	14%
Water storage	70	-1%

4.1.5 Impacts on cultural services

Overall, *Strengthening Cultural Identity* has a strong positive effect both on attractiveness and accessibility (Table 4.4). Many people can benefit from nature interventions under *Strengthening Cultural Identity*, since about two thirds of European citizens live in and around the metropolitan areas. The attractiveness of these areas and of the EU's characteristic landscapes will increase strongly. In metropolitan and other urban areas, greening considerably increases the possibilities for all citizens to enjoy nature, makes nature more attractive, and reduces disturbances, such as due to noise and crowdedness, compared to the situation under the *Trend* scenario. Furthermore, local landscape characteristics are strengthened by the incorporation and rehabilitation of historical landscape features. Due to landscaping efforts to create new green structures and restore abandoned buildings and sites, some projects have the potential to become landmarks or hotspots for leisure activities. In characteristic landscapes, active land management and local laws preserve regional specific landscape features that are under threat of either land abandonment or urban sprawl. The drawback of this perspective is the green suburbanisation, that is needed to fulfil demand for housing, which will slightly decrease the attractiveness of peri-urban areas.

Table 4.4 Impacts of interventions in the targeted areas on recreation under *Strengthening Cultural Identity*

	Impact on attractiveness in the targeted area[1]	Impact on accessibility in the targeted area in the targeted area[2]	Population concerned[3] (% of EU total)
Recreational landscapes in urban zone	1.3	1.5	68%
Characteristic landscapes	1.3	1	59%
Housing in peri-urban regions	-0.3	-1	21%
Green in cities	1.7	2	75%

[1] Average of the expert judgement about three indicators that relate to attractiveness: -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)
[2] Average of the expert judgement about three indicators that relate to accessibility: -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)
[3] Population living within 5 km of the targeted area

4.1.6 Impacts on provisioning services

Impacts on provisioning services, such as agricultural production and forestry, lead to approximately 9% decrease in crop production and 2% decrease in livestock production (Table 4.5). This decrease is mainly caused by the management restrictions for croplands in the urban zone and for pastures in characteristic landscapes. The harvest level in forestry under *Strengthening Cultural Identity* is nearly identical to the *Trend* scenario. The development of forest area is slightly smaller due to the conservation of characteristic landscapes and the share of unmanaged forest reserves is comparable. Despite the change of approximately 5% of the EU area to the extensive forest management types, the average removal of wood from the forests across the EU is the same as in the *Trend* scenario.

Table 4.5 Impacts on provisioning services under *Strengthening Cultural Identity*

	Change in production level compared to the *Trend* scenario 2050 (=100%)	Change due to land-use change	Change due to management changes
Crops	-9%	-1%	-8%
Livestock	-2%	0%	-2%
Wood	0%	0%	0%

4.2 Allowing Nature to Find its Way

4.2.1 Summary of perspective

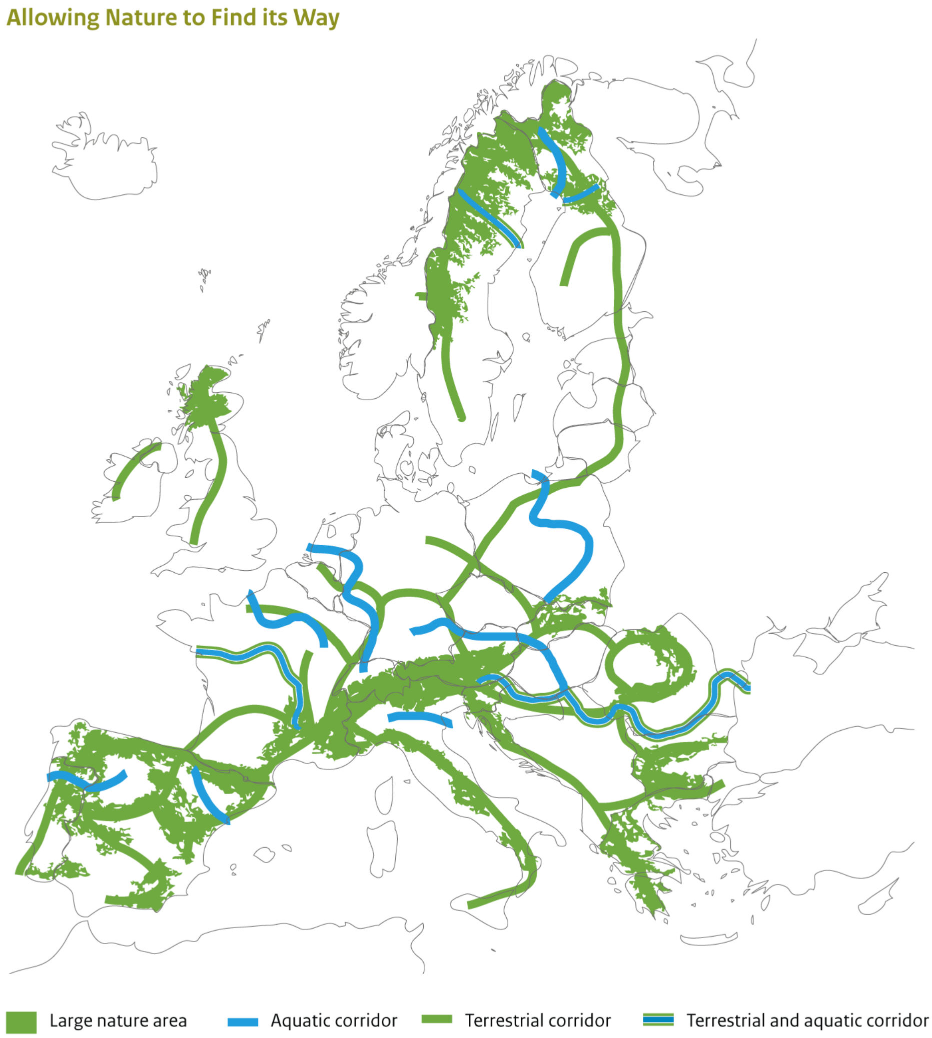
In *Allowing Nature to Find its Way*, nature is appreciated for its intrinsic value and believed to be resilient when given enough room. By 2050, a large network will be established existing of large undisturbed nature areas, connected by corridors. Natural processes provide the dynamics to sustain complete natural systems and healthy populations of species. Common ground for nature development is found by relating nature development to the socio-economic agenda. This requires a receptive government, which implies joint vision building. The EU has taken the initiative, as the extended nature network transcends individual Member State borders.

4.2.2 Targeted areas

By 2050, large nature areas consist of self-regulating natural systems, which include sustainable populations of top predators and large fish species, some of them reintroduced. Europe is characterised by unpolluted nature reserves that are connected through a European nature network, consisting of ***large nature areas*** (over 10,000 km^2 each[5]; Figure 4.2). The dynamics of self-regulation turns these areas into forest (ecological succession) or reverts them back to pioneer systems (e.g. after flooding events or forest fires) (Pickett and White, 1985). In large nature areas, farmland is converted back to nature to enlarge the nature area and reduce external impacts within the area. Through local management and management on the scale of river basins, water stress is eliminated in Natura 2000 areas, strict nature reserves, wilderness areas and wetlands in large nature areas. Forest management in large nature areas in mountainous areas is envisaged to be natural. Urbanisation in the large nature areas is not allowed.

The large nature areas are connected by ***aquatic*** and ***terrestrial corridors***. The locations of the ***terrestrial corridors*** were determined using a) the Green Belt (http://www.ecologicalnetworks.eu/html/maps/GreenBelt.php), b) PEEN maps (Bouwma et al., 2002; Biro et al., 2006; Jongman et al., 2006), c) connectivity maps created for the fragmentation input of the BioScore model (Section 2.2.4), and d) maps of corridors for large animals (maps 4.2 and 4.4 in EEA (2014). Up to 30% of the area in green corridors consists of nature. Agriculture in corridors is restricted to extensive management, such as lower nitrogen application and an increase in green elements by up to 10%.

[5] To determine the size of nature areas under the *Trend* scenario grid cells of all kinds of nature types, and forest types were included, including intensively managed forests. Further in the analysis, these intensively managed forests were excluded from the large nature areas.



Source: PBL

Figure 4.2 Targeted areas in Allowing Nature to Find its way

Buffer zones are not shown on the map.

A selection of rivers is included in the network as ***aquatic corridor***, such as the Danube and the Loire. Natural dynamics have been reintroduced in these rivers where possible, by allowing them to meander. These rivers, including their banks, function as corridors for aquatic and terrestrial species. The combined corridors ('terrestrial and aquatic corridors' in Figure 4.2) are promising with respect to nature areas along their sides, as defined in the Pan-European Ecological Network (Bouwma et al., 2002; Biro et al., 2006; Jongman et al., 2006) and with respect to their potential for fish migration (Van Puijenbroek and Kroes, 2015). Barriers for migrating species within the corridors are, as far as possible, taken out. Fish passes now lower the remaining bottlenecks in rivers, for example near the two dams in the Iron Gates and the Gabčikovo Dam in the Danube. Banks of rivers and lakes have largely been greened, reducing barriers for many species and providing natural gradients. Agriculture along these river sides has been displaced, and wetlands are restored. In those rivers and lakes, the ecological water quality is high.

Small Natura 2000 areas and *strict nature reserves and wilderness areas* (Dudley, 2008) outside the nature network, are used as stepping stones for species to migrate. In those areas, nature management mitigates external pressures and prevents ecosystem

Table 4.6 Land use according to *Allowing Nature to Find its Way*

	Area (% of total EU area)	Difference compared to *Trend* scenario (in percentage points)	Management type, in % of total EU area		
			Intensive	Medium/ multifunctional	Extensive
Urban area	5%	-0.1 pp			
Cropland	30%	-1.2 pp	2.1% (-0.4*)	12.1% (0.1*)	15.7% (-0.8*)
Pasture	12%	-1.2 pp	4.6% (-1.5*)	6.6% (0.5*)	0.4% (-0.1*)
Forest	33%	-2.4 pp	4.6% (-2.5*)	16.5% (-5.1*)	12.1% (5.3*)
Open natural vegetation	17%	4.8 pp			
Water bodies	3%	0.1 pp			

* difference compared to *Trend* scenario, in percentage points.

succession. Intensive forest management is prohibited and urbanisation is not allowed. A ***buffer zone*** of 500 meters is established surrounding those areas (not shown in Figure 4.2), in which agricultural management is restricted to low inputs, and reduces negative impacts on those nature areas.
The dynamics of self-regulation in the large nature areas lead to an increase in the area 'open natural vegetation', including natural grassland, heathland and moorland and sparsely vegetated areas (Table 4.6). This increase can be substantial compared to the *Trend* scenario and occurs at the cost of forest area. Changes from cropland into nature particularly concern the extensively farmed areas. Restricted management in buffer areas surrounding Natura 2000 areas outside the nature network causes a decrease in the intensively farmed areas, particularly pastures. Forests are managed in a natural way, to a larger degree than under the *Trend* scenario.

4.2.3 Impacts on biodiversity

The combined impact of all interventions taken in this perspective results in a considerable improvement for common and endangered species (Table 4.7). The size of the large nature areas keeps most external influences at a distance in large parts of the areas. The large connected nature areas provide enough habitats for populations of top predators. Abiotic and biotic processes allow nature to find its way and provide good conditions for old-growth forest species and generalists as well as specialists species of natural areas. Corridors that connect the large nature areas increase the resilience of ecosystems. Especially, the habitats of species living in marshland, moors, heathland and natural grasslands will increase considerably in area and quality compared to the *Trend* scenario. Therefore, species and habitats belonging to these ecosystems will benefit. Agricultural biodiversity is positively affected due to the restricted management in the buffer zones surrounding Natura 2000 areas. Although the total woodland area is expected to decrease, due to natural processes, such as cyclic succession, the overall quality of woodlands is likely to increase, because of the additionally formed natural gradients and large increase in unmanaged forests. The most occurring management change in forest is the one from mixed-objective forestry to unmanaged nature reserves. Therefore, endangered species of the forest, particular old-growth forests, are expected to profit. Aquatic biodiversity, including migratory fish species,

Table 4.7 Net change in habitat conditions for terrestrial biodiversity, under *Allowing Nature to Find its Way*

Species habitat	Proportion of EU area showing positive impacts for terrestrial species	
	Common species	Endangered species
Urban areas	-0.1%	-0.1%
Cropland	-0.7%	1.9%
Pasture	-0.7%	1.4%
Forest	0.1%	5.3%
Open natural vegetation	4.8%	4.8%

will benefit from the restoration of rivers in the nature network and from the realisation of buffer zones, since water quality and connectivity will improve, considerably.

4.2.4 Impacts on regulating services

Interventions under this perspective are in particular positive for erosion control, peat conservation and water retention (Table 4.8). The area under agricultural activities is substantially smaller in erosion-sensitive areas, due to the development of large nature areas without these activities. Besides, the vegetation in the large nature areas retain water and these locations are promising from a water retention perspective. In total, the area under agricultural activities in areas with insufficient water retention is 64% smaller than in the *Trend* scenario. Cropping activities in peat land areas remain in most cases, resulting in a 17% less area that has insufficient peat conservation. Nature and restrictions for agriculture in the corridors and buffer zones are likely to have a small positive impact on natural pest control.

Table 4.8 Impacts on ecosystem services under *Allowing Nature to Find its Way*

Ecosystem service	Area with insufficient supply in the *Trend* scenario (x 1000 km^2)	Change of area with insufficient supply (perspective compared to *Trend* scenario)
Erosion control	71	-67%
Peat conservation	11	-17%
Pest control	897	-4%
Water retention	5	-64%
Water storage	70	0%

4.2.5 Impacts on cultural services: recreation

The impacts of interventions under *Allowing Nature to Find its Way* vary from somewhat negative to somewhat positive (Table 4.9). There is a slight improvement in the attractiveness and accessibility of the landscape in the buffer zones surrounding Natura 2000 areas located in the neighbourhood of most of the European population. Contrary to this improvement is the cessation of the human management of a vast area of nature reserves, pastures and forest in favour of natural processes, which will locally have a strongly negative effect on both attractiveness and accessibility. Most recreationists and tourists prefer well managed, safe environments that allows for a variety of activities during one trip (shopping, cultural events, nature experience, sports and relaxation) (Van den Berg and Koole, 2006; Van den Berg and Konijnendijk, 2012). Regarding these preferences, the new wilderness areas are messy, chaotic and not varied at all and will look less well maintained than in the *Trend* scenario. Besides, the mean distances between home and green destinations are larger than in the *Trend* scenario, since the large nature areas are mainly located in remote areas. Weighed by the population affected, the attractiveness will decrease slightly as these changes affect the living environment of only quarter of the European population.

Table 4.9 Impacts on recreation under *Allowing Nature to Find its Way*

	Impact on attractiveness in the targeted area[1]	Impact on accessibility in the targeted area in the targeted area[2]	Population concerned [3] (% of EU total)
Large nature areas	-0.5	-0.7	24%
Terrestrial and aquatic corridors	0.7	1.0	1%
Terrestrial corridors	0.7	1.0	7%
Buffer zones protecting nature areas	0.7	0.3	63%

[1] *Average of the expert judgement about three indicators that relate to attractiveness: -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)*
[2] *Average of the expert judgement about three indicators that relate to accessibility: : -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)*
[3] *Population living within 5 km of the targeted area*

4.2.6 Impacts on provisioning services

Under *Allowing Nature to Find its Way* a decrease of crop production is expected, mainly due to restrictions in management in corridors and in the buffer zones around Natura 2000 areas (Table 4.10). Negative impacts on livestock production are smaller. The unmanaged forest area increases considerably, from 12% to more than 30% of the total forest area. This increase is concentrated in countries with large mountainous areas, such as Austria, Switzerland, Romania, Spain and France, where the large nature areas are located. This development increases the shortfall of wood production with respect to demand to 104 million m^3 harvest per year, compared to 35 million m^3 harvest per year in the *Trend* scenario.

4.3 Going with the Economic Flow

4.3.1 Summary of perspective

Going with the Economic Flow reflects people’s freedom to use nature for their own purposes. From this perspective, nature is considered a resource for economic growth, although private actors also have various other motives for conserving nature. A basic network of nature reserves is publicly funded and managed via trusts; other nature areas are

Table 4.10 Impacts on provisioning services under *Allowing Nature to Find its Way*

	Change in production level compared to the *Trend* scenario 2050 (=100%)	Change due to land-use change	Change due to management changes
Crops	-12%	-3%	-9%
Livestock	-4%	-2%	-2%
Wood	-13%	-4%	-8%

privately funded. Outside the reserves, nature is considered an accessory to other land uses, based on initiatives by businesses and individuals.

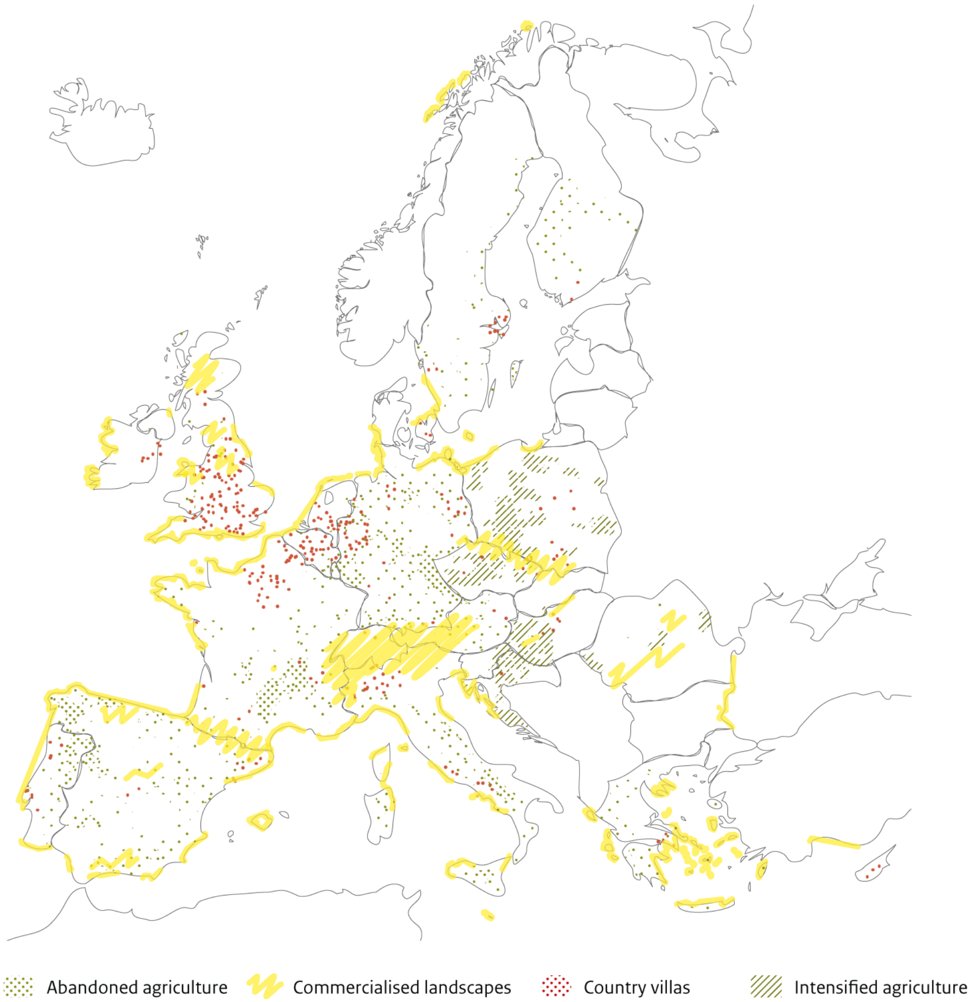
4.3.2 Targeted areas

Nature under this perspective is mainly protected by private initiatives. Nature is being conserved or developed, mostly in landscapes that have large value for tourism. These landscapes are commercialised, particularly in the form of ***private parks.*** These parks are assumed to occur at 2% of the EU area. Here, businesses and/or individuals are willing to pay for nature (Figure 4.3). Succession in these private parks is halted and negative external pressures are mitigated. Intensive forest management is excluded from these parks. Within traveling distance from densely populated regions, ***country villas*** are built in nature, except for Natura 2000, and in agricultural landscapes, where the residents can enjoy the pleasant environment.

The Common Agricultural Policy has been transformed following liberal principles. Liberalisation of agricultural policy, including abolishment of subsidies for farmers, is assumed to support trends of intensification and farm enlargement, and abandonment in areas less attractive to farming (Rienks et al., 2008; Nowicki et al., 2009; Pedroli et al., 2015). Therefore, increased ***intensification of agriculture*** takes place in regions with suitable conditions, in which agricultural areas are dominated by large-scale, intensive farming, and increased ***abandonment*** is occurring in other regions (Verburg et al., 2013). This intensification leads in eastern Europe to an increased N and P use compared to the *Trend* scenario and removal of green elements in intensive agricultural areas throughout the EU. In areas where extensive agriculture is no longer profitable and agricultural land is abandoned, nature develops without active nature management. Agricultural abandonment doubles compared to the rate in the *Trend* scenario. In animal husbandry, cattle is mostly stabled. At the edges of accessible nature, houses, offices, restaurants and hotels are built. Along coastlines the amount of resorts, restaurants and hotels is large to fulfil the demand for recreation.

In 2050, rivers are canalised to a large extent, creating optimal conditions for shipping, energy production (hydropower, cooling water) and irrigation. Surface water quality is influenced by the intensification of agriculture and the stabled animal husbandry. The current Natura 2000 sites are protected and serve as a backbone of nature conservation. External influences are mitigated within the reserves, taking local measures locally; forest management is natural. Outside private parks and the nature reserves, forest management is intensified and management of nature is abolished.

Going with the Economic Flow



Source: PBL

Figure 4.3 Targeted areas under *Going with the Economic Flow*

Private parks are expected to occur in the commercialised landscapes.

Changes in land use under *Going with the Economic Flow* reflect the abandonment of agricultural areas, namely a slight decrease in the agricultural area and an increase in the area covered by forests (Table 4.11). Within the area of pasture and cropland, the proportion of intensively managed land increases compared to the *Trend* scenario, while the area under medium and extensive management decreases. The change in forest management shows the net result of forests outside nature areas that are more intensively used, and forests in landscape parks that will be less intensively used. The increase in country villas causes a minor increase in area of open natural vegetation.

Table 4.11 Land use according to *Going with the Economic Flow*

	Area (% of total EU area)	Difference compared to *Trend* scenario (in percentage points)	Management type, in % of total EU area		
			Intensive	Medium/ multifunctional	Extensive
Urban area	5%	-0.1 pp			
Cropland	30%	-0.9 pp	3.7% (1.1*)	11.4% (-0.6*)	15.1% (-1.4*)
Pasture	12%	-0.6 pp	6.7% (0.6*)	5.2% (-0.9*)	0.3% (-0.2*)
Forest	37%	1.0 pp	6.6% (-0.5*)	22.7% (1.2*)	7.2% (0.5*)
Open natural vegetation	12%	0.5 pp			
Water bodies	3%	0.0 pp			

* difference compared to *Trend* scenario, in percentage points.

4.3.3 Impacts on biodiversity

The interventions of this perspective are slightly beneficial for species associated with forests and open natural vegetation. Species related to agricultural areas, however, are negatively impacted (Table 4.12). Private parks and country villas will locally have a positive impact for common species. However, it is difficult to foresee the location of the areas that will be protected by private initiatives; therefore, the impact on biodiversity is rather uncertain. Agricultural species are negatively impacted due to the further intensification in areas suitable for agriculture and increase of land abandonment in others. Abandonment has a negative effect on species associated with the open agrarian landscape and a positive effect on – most times more common – species that favour forests or shrubs with eutrophic conditions. The absence of nature management in the areas where abandonment takes place, can be expected to have a negative effect on species and habitats protected under the Birds and Habitats Directives that are sensitive to external pressures and depend on nature management in these areas.

Intensification is also expected to have negative impacts on aquatic biodiversity, while estates or private parks do only have small positive impacts on common species. Increased use of water for irrigation and power generation can have considerable negative impacts on connectivity, wetlands, water availability and natural discharge of rivers, resulting in negative impacts on riverine species.

Table 4.12 Net change in habitat conditions for terrestrial biodiversity under *Going with the Economic Flow*

Species habitat	**Proportion of EU area showing positive impacts for terrestrial species**	
	Common species	Endangered species
Urban areas	-0.1%	-0.1%
Cropland	-2.1%	-1.4%
Pasture	-1.0%	-0.2%
Forest	1.6%	0.5%
Open natural vegetation	0.5%	0.5%

4.3.4 Impacts on regulating services

Erosion control, upland water retention, peat conservation and natural pest control are likely to be positively impacted by the retreat of agriculture and the spontaneous regrowth of shrubs and forests, that is assumed under this perspective (Table 4.13). The positive impact on natural pest control is also caused by the development of country villas that appear as semi-natural areas. In other areas, increased intensification of agriculture will have negative impacts on services such as natural pest control and erosion control, due to the removal of green elements and small patches of natural vegetation and continued high use of external inputs (not included in Table 4.13).

Table 4.13 Impacts on ecosystem services under *Going with the Economic Flow*

Ecosystem service	**Area with insufficient supply in the Trend *scenario* (x 1000 km^2)**	**Change of area with insufficient supply (perspective compared to Trend *scenario*)**
Erosion control	71	-63%
Peat conservation	11	-6%
Pest control	897	-5%
Water retention	5	-11%
Water storage	70	0%

4.3.5 Impacts on cultural services: recreation

Most of the interventions under *Going with the Economic Flow* are likely to result in a strong decrease of both attractiveness and accessibility of the landscape in the surroundings of many people (Table 4.14). Only the development of new estates and privately-owned city parks or nature reserves could have a slight positive effect on the attractiveness, depending on the applied management of these areas. However, accessibility is limited, for many European citizens, by way of entrance fees or strictly private use, which is particularly problematic in metropolitan areas, where parks, forests and nature reserves are already

Table 4.14 Impacts on recreation under *Going with the Economic Flow*

	Impact on attractiveness in the targeted area[1]	Impact on accessibility in the targeted area in the targeted area[2]	Population concerned[3] (% of EU total)
Abandonment	-1.0	-1.0	21%
Private parks	0.5	-0.3	61%
Country villas	0.3	-1.3	18%
Intensive agricultural areas	-2.0	-0.5	15%
Increased recreation	-1.2	0.5	25%
Restricted access in city parks	0.3	-1.0	38%

[1] Average of the expert judgement about three indicators that relate to attractiveness: -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)
[2] Average of the expert judgement about three indicators that relate to accessibility: : -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)
[3] Population living within 5 km of the targeted area

intensively used. The increased abandonment of agricultural land and the intensification of land use under this perspective will locally have the largest impacts on attractiveness of the landscape. These processes may each affect the recreation area of about one fifth of the EU citizens.

4.3.6 Impacts on provisioning services

Impacts on provisioning services under *Going with the Economic Flow* are highest for crops, due to the intensification of cropland in eastern European countries (Table 4.15). Livestock production is also positively impacted. Decreases of production is mainly caused by the abandonment of agricultural areas. Forestry is assumed to intensify outside nature areas, while extensive management types are assumed within private parks and the Natura 2000 areas. These two developments result in a small, net decrease of the intensity of forest management.

Table 4.15 Impacts on provisioning services under *Going with the Economic Flow*

	Change in production level compared to the *Trend* scenario 2050 (=100%)	Change due to land-use change	Change due to management changes
Crops	12%	-3%	15%
livestock	4%	-1%	5%
Wood	1%	2%	-1%

4.4 Working with Nature

4.4.1 Summary of perspective

In *Working with Nature*, the sustainable use of nature is essential, to ensure that it provides and will continue to provide services for the benefit of current and future generations. A paradigm shift to a holistic approach was followed by a transition towards a green society, including the ways in which people behave. This transition has been set in motion by 'green' frontrunners from society, business, research, and government. They invest in research, engage in innovation networks and the pricing of the external costs related to production and consumption.

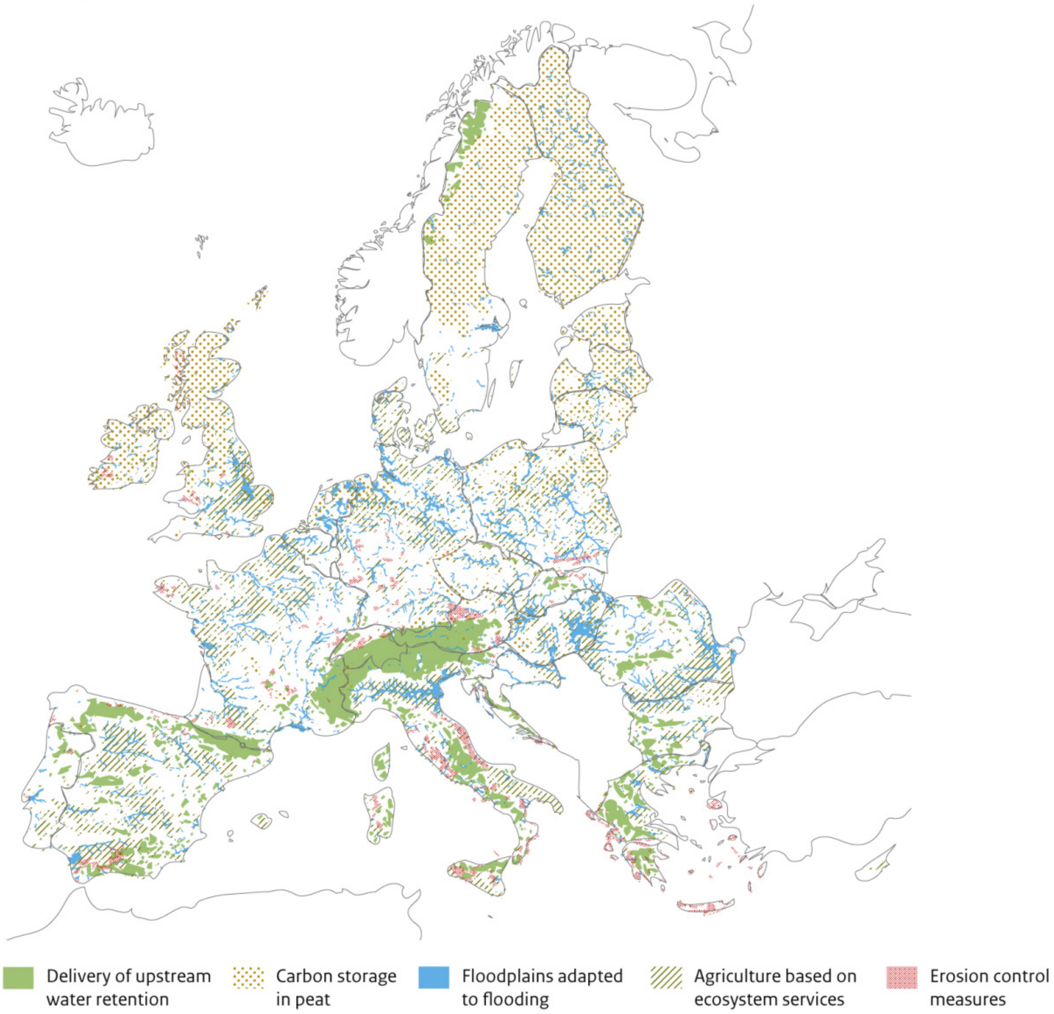
4.4.2 Targeted areas

In 2050 agriculture is transformed to a sector that make the best use of the services delivered by nature. ***Natural pest control and pollination*** in croplands and orchards are provided by nature (Figure 4.4). For natural pest control about 20% semi-natural areas in the surroundings of the fields are needed (Bianchi et al., 2013). In all croplands that have lower percentages, semi-natural areas and green elements are added in their surroundings.

Erosion is prevented in agricultural areas in ***erosion-sensitive areas*** (Pérez-Soba et al., 2010). At least 30% of the area should be covered with nature to prevent erosion. ***Peat areas*** (FAO et al., 2009) are valued in this perspective for their CO_2-storage and uptake function. In these peat areas, water levels are kept sufficiently high to avoid peat land degradation. Therefore, these areas are not suitable for urbanisation and intensive agriculture. Forests are managed for an optimal use of ecosystem services, except within Natura 2000 areas and on steep slopes. On those sites forests are managed in more natural ways.

Nature-based solutions are used in river basins to avoid peak flows, that are expected to increase due to climate change. Upstream areas of the river basins are covered with forests for ***water retention***. This upstream area is defined as all areas with a slope larger than 10% and an elevation higher than 500 m (Burek et al., 2012). Downstream, flood-prone areas are only used extensively to avoid any damage at high water levels. In such cases, those areas can be actively used to store water. Reforestation is prevented to avoid obstacles in the river's flow. ***Flood-prone area*** is defined as all areas with a high flood risk around middle reaches and downstream areas (Pérez-Soba et al., 2010).

Working With Nature



Source: PBL

Figure 4.4 Spatial assumptions under *Working with Nature*

N- and P-use efficiency in agriculture is increased in the eastern part of the EU which lowers the surplus of N and P per hectare. To avoid emissions to water, buffers zones are used around water bodies. To decrease N volatilisation, best available techniques are used, leading to a decrease of 30% in N deposition compared to the *Trend* scenario. Natura 2000 areas are not specifically targeted by management. Irrigation efficiency is increased, due to better soil quality, together with technical measures. Waste water is treated as much as possible. Urban waste water is treated up to 80% nutrient removal in the eastern part of the EU and up to 85% in western EU. In rural regions, water quality is improved because of the use of helophyte filters. Development of dams for hydropower or water irrigation is carefully planned; it is allowed in some rivers, while in others, developments are prohibited. To mitigate impacts of the dams allowed, they are combined with fish passes to allow for fish migration.

Table 4.16 Land-use change according to *Working with Nature*

	Area (% of total EU area)	Difference compared to *Trend* scenario (in percentage points)	Management type, in % of total EU area		
			Intensive	Medium/ multifunctional	Extensive
Urban area	5%	-0.1 pp			
Cropland	28%	-3.5 pp	1.9% (-0.7*)	9.4% (-2.6*)	16.4% (-0.1*)
Pasture	14%	1.4 pp	5.4% (-0.7*)	7.8% (1.7*)	1.0% (0.4*)
Forest	38%	2.0 pp	0.0% (-7.1*)	29.9% (8.3*)	7.2% (0.4*)
Open natural vegetation	12%	0.2 pp			
Water bodies	3%	0.0 pp			

* difference compared to *Trend* scenario, in percentage points.

Differences in land use between Working with Nature and the *Trend* scenario show the results of optimising land use for the selected ecosystem services (Table 4.16). Cropland is alternated with natural vegetation to optimise pollination and natural pest control. To achieve about 20% natural area within cropland areas, 10% of cropland under the *Trend* scenario, which is 3.5% of the EU area, is needed. Most of these areas are medium intensively used in the *Trend* scenario. The additional pasture areas are used as water retention buffer in flood-prone areas, or are situated in peat areas, where this is the only agricultural activity allowed. Forest areas increase for upland water retention. Almost all forests are multifunctional, which is reflected in the distribution between forestry management types.

4.4.3 Impacts on biodiversity

Common species benefit from most of the initiatives to promote ecosystem services. The interventions within this perspective do not take targeted intervention to solve bottlenecks for endangered species, resulting in limited improvements for this group (Table 4.17). The increase of natural elements within the agrarian landscape, that act as sources for natural pest control and pollination and the associated reduction in the use of pesticides, are expected to have positive impacts for — mostly common — species that depend on semi-natural habitats. However, common species associated with cropland are negatively impacted by most types of land conversion, from cropland to pasture or forests. These conversions do not impact endangered species, since these species hardly occur in those more intensively farmed cropland areas (fertiliser use in excess of 100 kg N/ha; Kleijn et al., 2009). Forest area and the area under open natural vegetation are larger than in the *Trend* scenario due to erosion control and water retention interventions. Besides, most forests are managed in a multifunctional way instead of intensive forestry, which has a positive impact on common species.

For endangered species, the positively impacted area is small. Within flood-prone areas both storing of water and biodiversity go hand in hand, to a certain extent at least. Aquatic species profit from the amelioration of water quality, resulting from an increased nutrient efficiency and efficient irrigation practices in agriculture. Conditions for migrating fish species

Table 4.17 Net change in habitat conditions for terrestrial biodiversity under *Working with Nature*

Species habitat	Proportion of EU area showing positive impacts for terrestrial species	
	Common species	Endangered species
Urban areas	-0.1%	-0.1%
Cropland	-2.7%	0.1%
Pasture	1.7%	0.5%
Forest	9.0%	0.1%
Open natural vegetation	0.2%	0.2%

are improved due to catchment restoration plans and technological measures for upstream and downstream migration.

4.4.4 Impacts on regulating services

This perspective focuses on using nature's processes and services and aims at fully solving the insufficient supply of regulating ecosystem services (Table 4.18). The changes therefore all have a positive impact on the regulating ecosystem services included. However, not all the assumed interventions strengthen each other. Natural pest control and pollination are not influenced by the other interventions, since they do hardly occur in the cropland areas with insufficient habitats for pollinators or predators. In contrast, additional natural and semi-natural areas for erosion control also slightly increase water retention, and vice versa.

Table 4.18 Impacts on ecosystem services, under *Working with Nature*

Ecosystem service	Area with insufficient supply, under the *Trend* scenario (x 1000 km^2)	Change in area with insufficient supply (perspective compared to *Trend* scenario)
Erosion control	71	-100%
Peat conservation	11	-100%
Pest control	897	-100%
Water retention	5	-100%
Water storage	70	-100%

4.4.5 Impacts on cultural services: recreation

On average, the interventions under *Working with Nature* are likely to increase the attractiveness and accessibility of the landscape for recreation (Table 4.19). The introduction of nature-based solutions for water retention, erosion prevention, pollination and carbon sequestration in the countryside, slightly increases the variation in landscape character and reduces human disturbances. The addition of landscape elements on the edges of croplands partly occurs within close reach of the homes of three quarters of the European population. Other nature-based solutions are introduced in remote areas such as mountains, peat bog areas, and therefore only lead to a limited increase in accessibility. Interventions for water retention, the reduction of (heat) stress and water purification in metropolitan areas will have a strong impact on the clear majority of the population. Although these interventions, such as green walls, small ponds and bio swales, will be visible in the neighbourhood of most people, they hardly add space for recreational activities, as their sizes are limited. Larger elements such as purification swamps, roof gardens, allotment gardens and water retention lakes, would allow for recreational use depending on suitability.

Table 4.19 Impacts on recreation under *Working with Nature*

	Impact on attractiveness in the targeted area[1]	**Impact on accessibility in the targeted area in the targeted area[2]**	**Population concerned[3] (% of EU total)**
Water retention in flood-prone areas	0.7	0.7	43%
Afforestation in erosion-sensitive areas	0.2	0.0	16%
Greening cropland for natural pest control	0.7	0.8	73%
Conserving peatlands for carbon sequestration	1.0	0.5	5%
Upland water retention	0.0	0.2	4%

[1] Average of the expert judgement about three indicators that relate to attractiveness: -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)
[2] Average of the expert judgement about three indicators that relate to accessibility: : -2 = large decrease, 0 = no change, 2 = large increase (see Annex V)
[3] Population living within 5 km of the targeted area

4.4.6 Impacts on provisioning services

Under *Working with Nature,* an 11% decrease in crop production can be expected (Table 4.20). This is caused by the conversion of agricultural areas into natural habitats, in order to increase natural pest control and pollination. Impacts on yields of including regulating ecosystems services in agricultural practices have not been taken into account. Management restrictions in flood-prone areas and peat areas affect a very small area, and production losses do not show up in Table 4.20. However, the conversion of cropland into pastures in these areas could increase production by 2%. Moreover, the increase in nitrogen use efficiency in agriculture is assumed to have no impacts on the production. In forestry, changes in intensity levels do slightly decrease the wood production, while the increase in areas cause a slightly higher wood production as under the *Trend* scenario.

Table 4.20 Impacts on provisioning services under *Working with Nature*

	Change in production level compared to the *Trend* scenario 2050 (=100%)	Change due to land-use change	Change due to management changes
Crops	-11%	-11%	0%
Livestock	2%	2%	0%
Wood	1%	2%	-1%

4.5 Comparing the four perspectives

Comparing the four perspectives shows the consequences of differences in focus on nature, for various indicators (Table 4.21) and across regions. As might be expected all perspectives are ranked on top for the indicator they focus on.

Focus on development and conservation of landscapes under *Strengthening Cultural Identity* is beneficial for recreation value, and can have benefits for both common as well as endangered species groups. Impacts on crop production are considerable, mainly resulting from management restrictions in the landscapes of urban zones.

Interventions from *Allowing Nature to Find its Way* are expected to have considerable positive impacts on endangered species and on some regulating services. However, most nature is at a considerable distance from people and not that attractive for most people. Crop production is particularly affected by the management restrictions in buffer zones around Natura 2000 areas. Excluding agricultural activities from large nature areas has only small impacts on agricultural production, but extensification of forestry in these areas does have large negative impacts on wood production.

Leaving nature to private initiatives – without coordination – such as *Going with the Economic Flow*, can be expected to be negative for species. Although the private initiatives can be positive, they do probably not compensate the negative impacts from intensification and abandonment of agricultural areas on species. Agricultural production is expected to attain higher yields per hectare in the eastern parts of the EU, leading to a considerable increase in crop production.

The focus on regulating ecosystem services, as under *Working with Nature*, is expected to be positive for common species, but is hardly improving endangered species. Only some of the services are of interest from a recreational point of view; in particular, those that require a mixed landscape. Crop production is considerably reduced by the amount of green area and semi-natural vegetation used for natural pest control. Forestry, on the other hand, can profit from the enlarged forest areas for other ecosystem services, such as water retention.

The regions targeted differ between the perspectives. Nature for regulating services is everywhere (*Working with Nature*), and so is nature that forms our cultural identity (*Strengthening Cultural Identity*). However, the last one is more prominent in densely populated areas and areas moulded by history. Private initiatives under *Going with the Economic Flow*, can be expected in the nearby periphery of economic and population centres, too. However, initiatives may also be expected to develop at the most beautiful locations further away. Regional differentiation, under *Allowing Nature to Find its Way,* is partly the inverse of the last two: core areas are located in the regions where most economic activities

Table 4.21 Ranking of the four perspectives for different indicators

	Strengthening Cultural Identity	**Allowing Nature to Find its Way**	**Going with the Economic Flow**	**Working With Nature**
Common species	3	2	4	1
Endangered species	2	1	4	3
Regulating Services	4	2	3	1
Recreation	1	3	4	2
Primary production	2*	4	1	2*

1 indicates the impact of the perspective lead to the most positive value for the assessed indicator.

** The difference between* Strengthening Cultural Identity *and* Working with Nature *regarding primary production is minimal.*

are unattractive. The wish for wild nature in proximity of people and the desire to keep stepping stones for species across the EU, are a reason to engage the economically attractive and densely populated regions too in this perspective.

5 Synergies and conflicts

The previous chapter assesses the perspectives, separately, on their impacts on biodiversity and ecosystem services. For some objectives, conservation or development of nature is more appropriate in certain locations than in others. The spatial elaboration of the perspectives has been based on the most promising locations for the goal of the interventions (see Chapter 4). Therefore, interventions do not occur equally across the EU. In some regions, this will lead to multiple interventions under different perspectives, while in other regions only one intervention is applied. Some of these interventions might aim for comparable changes in the landscape. This can be useful to face the identified future challenges (Chapter 3) as increasing the connection between societal preferences and nature policy will enhance engagement in nature-related efforts. However, not all combinations of interventions will strengthen each other. Some might lead to conflicts, too. This chapter indicates the opportunities for combinations of interventions.

5.1 Combining perspectives: synergies and conflicts

In Table 5.1 the compatibility of the different interventions taken in the four perspectives is presented. The compatibility between two interventions was assessed based on three characteristics: envisaged land use, required management and public accessibility. This could be: synergetic, synergetic when carefully planned, or conflicting (See Figure 2.3). For example, characteristic landscapes are targeted under *Strengthening Cultural Identity* because of their contribution to the local identity. The same kind of landscapes can also be valued for their extensive agriculture use and might act as buffer zones around large nature areas and Natura 2000 sites in *Allowing Nature to Find its Way*. Another example is land abandonment in *Going with the Economic Flow* which could be combined with enlarging nature areas (*Allowing Nature to Find its Way*) if occurring at the same place. However, the large nature areas may require restoration of main ecological function to ensure a robust ecosystem, while in *Going with the Economic Flow* these nature areas are left to their own devices without any initial management.

Although compatibility varies between combinations, some general observation can be made. Certain interventions under *Going with the Economic Flow* can be combined with interventions under the other perspectives with respect to ecological aims. Limitation of public access, however, is a conflicting issue, for the majority of these combinations, specifically when combined with interventions under *Strengthening Cultural Identity*. Although abandonment increases opportunities for combinations with other interventions, intensification of other agricultural areas shows lots of conflicts in these areas. Combinations from *Allowing Nature to Find its Way* and *Working with Nature* show mostly synergies, although the dynamic character of *Allowing Nature to Find its Way* may conflict with the specific aims for ecosystem services under *Working with Nature*, such as water retention and optimal discharge in flood-prone areas. Landscape care from *Strengthening Cultural Identity* and delivery of ecosystem services under *Working with Nature* from small nature areas or elements are a compatible combination in most cases.

Table 5.1 The compatibility between interventions taken within the perspectives

		Strengthening Cultural Identity				*Allowing Nature to Find its way*				*Going with the Economic Flow*			
		Landscape care in urban zone	Characteristic landscapes	Recreational / national parks	Housing in peri-urban regions	Large nature areas	Terrestrial corridors	Aquatic corridors	Buffer zones	Private parks	Intensive agricultural areas	Country villas	Abandonment
Allowing Nature to Find its way	Large nature areas	Purple	Purple	Purple	Purple								
	Terrestrial corridors	Blue	Blue	Blue	Purple								
	Aquatic corridors	Blue	Blue	Blue	Purple								
	Buffer zones protecting nature areas	Green	Green	Blue	Purple								
Going with the Economic Flow	Private parks	Bright green	Bright green	Bright green	Purple	Bright green	Bright green	Bright green	Bright green				
	Intensive agricultural areas	Purple	Purple	Purple	Blue	Purple	Purple	Purple	Purple				
	Country villas	Bright green	Bright green	Purple	Purple	Purple	Bright green	Bright green	Bright green				
	Abandonment of agricultural areas	Blue	Purple	Blue	Blue	Blue	Blue	Blue	Blue				
Working with Nature	Upstream water retention	Blue	Blue	Blue	Purple	Green	Green	Green	Blue	Bright green	Purple	Bright green	Blue
	Conservation of peat soils	Purple	Green	Green	Purple	Green	Green	Green	Blue	Bright green	Purple	Purple	Blue
	Use of natural pest suppressing mechanisms and pollination	Blue	Green	Blue	Blue	Purple	Blue	Blue	Green	Bright green	Purple	Bright green	Blue
	Water retention in flood-prone areas	Blue	Blue	Blue	Purple	Blue	Blue	Blue	Green	Bright green	Purple	Purple	Purple
	Erosion control	Purple	Green	Blue	Purple	Green	Green	Green	Green	Bright green	Purple	Bright green	Green

Purple: conflicting interventions that cannot be combined in one landscape.
Bright green: Interventions that are synergetic for environmental indicators when carefully planned, but that foresee a different level of accessibility.
Blue: Interventions that are synergetic for environmental indicators when carefully planned and agree on accessibility.
Green: interventions that are synergetic for environmental indicators and accessibility.
Colours correspond with Figure 2.3

Table 5.2 Top 5 of positive combinations

	Combination of interventions*	Percentage of EU land surface
1	Characteristic Landscapes (SCI) and Cropland with regulating ecosystem services (WwN)	27%
2	Buffer zones (ANFW) and Cropland with regulating ecosystem services (WwN)	21%
3	Characteristic Landscapes (SCI) and Erosion control in sensitive areas (WwN)	12%
4	Large nature areas (ANFW) and Erosion control in sensitive areas (WwN)	12%
5	Large nature areas (ANFW) and Peat areas (WwN)	11%

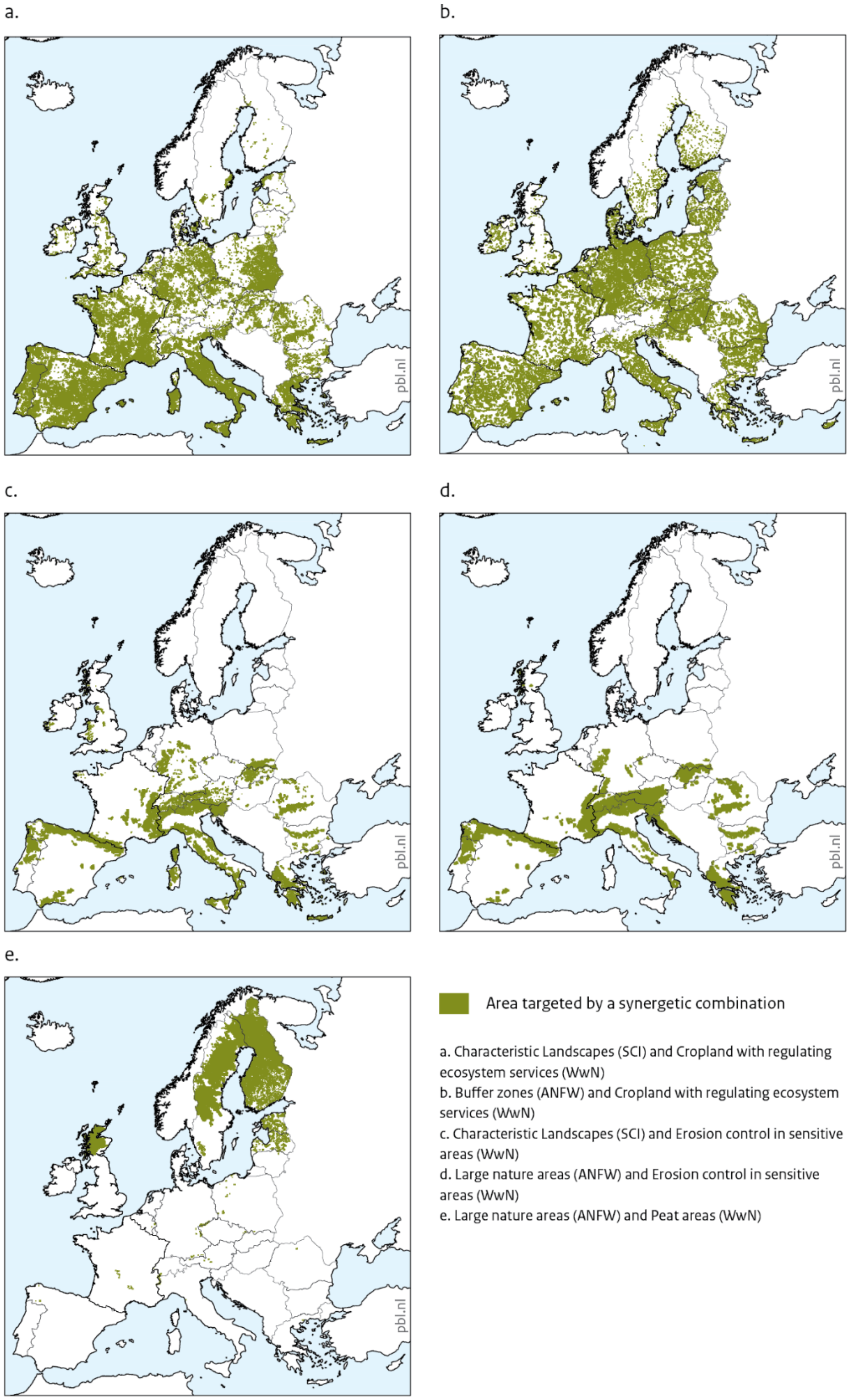
**SCI: Strengthening Cultural Identity; WwN: Working with Nature; ANFW: Allowing Nature to Find its Way.*

Interventions have been targeted at the most promising locations. Whether interventions that are compatible are targeted at the same locations depends on local characteristics, such as population density, rivers, slopes and suitability for agriculture. At least 10% of the EU area is of interest for all four perspectives, while less than 20% of the EU territory is of primary interest from one perspective only. Table 5.2 and 5.3 show the most important positive and conflicting combinations, based on area.

The conservation of characteristic landscapes and the use of regulating ecosystem services in agriculture is assumed to be the combination that potentially occurs most widely throughout the EU. The characteristic agricultural landscapes have been defined here by field size, green elements and intensity. The green lines, flowery grass margins or ditches can serve as habitat for predators or pollinators, whereas a low intensity creates good circumstances for these services too. Agriculture based on ecosystem services can – in its turn – add to the conservation of landscapes. Most of these areas are located in the southern and eastern parts of the EU (Figure 5.1a). The same arguments apply to the combination of buffer zones surrounding Natura 2000 areas and the use of regulating ecosystem services. Locations where these interventions can be combined are small areas and located across the EU (Figure 5.1b).

Green elements and the small-scale nature of characteristic landscapes can also serve to control erosion. In 12% of the EU area, the characteristic landscapes overlap with erosion-sensitive areas. The same applies to the large nature areas in *Allowing Nature to Find its Way*. The natural vegetation would increase the erosion control. Both combinations occur in the mountainous regions of the EU and Switzerland (Figure 5.1c and d). In the northern parts of the EU, the large nature areas and the conservation and restoration of peat go together (Figure 5.1e).

Spatial distribution of the five mostly occurring synergetic combinations



Source: PBL

Figure 5.1 Spatial distribution of the five mostly occurring synergetic combinations

Table 5.3 Top 5 of conflicting combinations

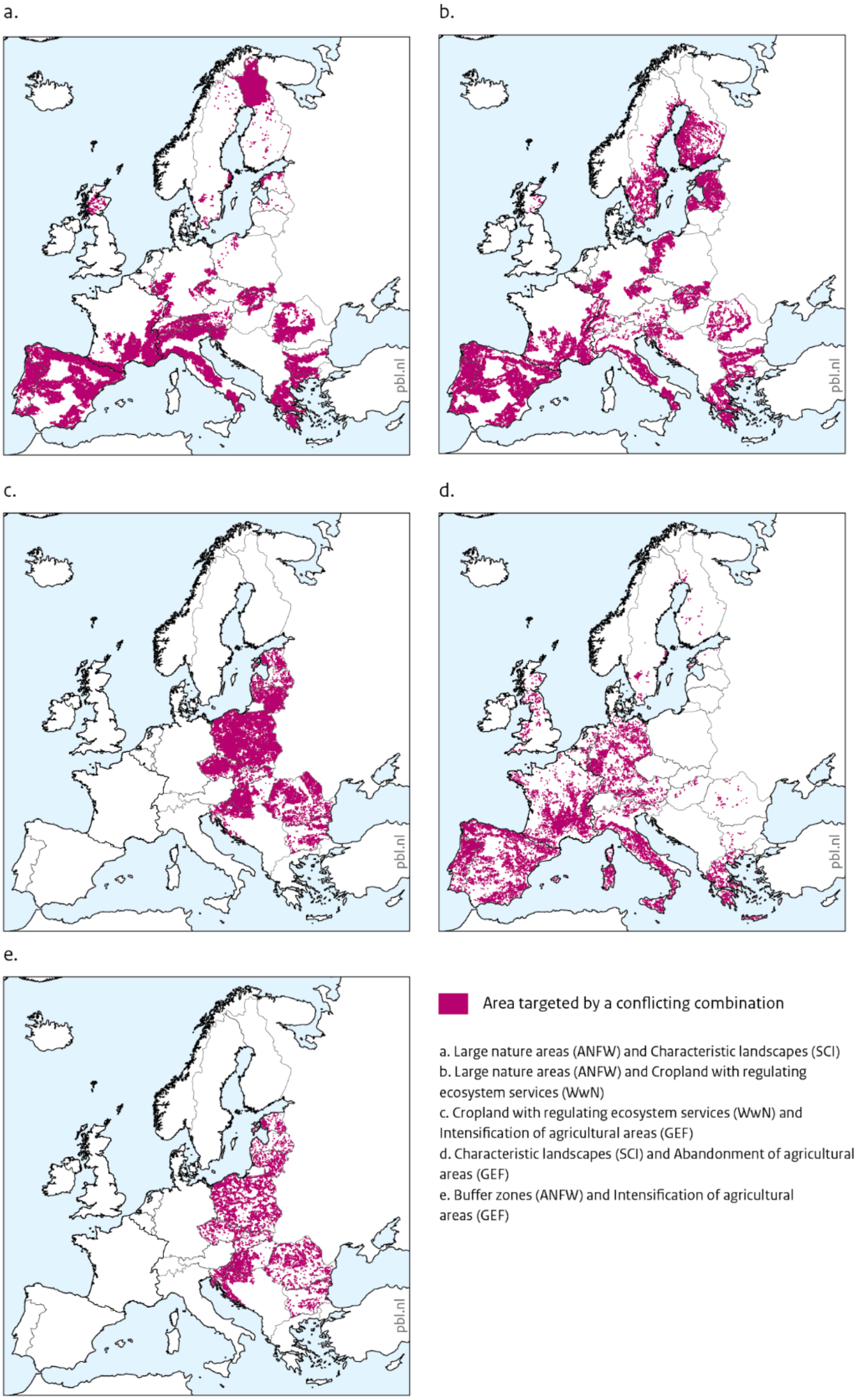
	Combination of interventions*	Share EU surface
1	Large nature areas (ANFW) and Characteristic landscapes (SCI)	20%
2	Large nature areas (ANFW) and Cropland with regulating ecosystem services (WwN)	17%
3	Cropland with regulating ecosystem services (WwN) and Intensification of agricultural areas (GEF)	11%
4	Characteristic landscapes (SCI) and Abandonment of agricultural areas (GEF)	11%
5	Buffer zones (ANFW) and Intensification of agricultural areas (GEF)	9%

** ANFW: Allowing Nature to Find its Way; SCI: Strengthening Cultural Identity; WwN: Working with Nature; GEF: Going with the Economic Flow.*

Besides synergies, some combinations are incompatible (Table 5.3). The large dynamic nature areas from *Allowing Nature to Find its Way* are difficult to combine with the nature from *Strengthening Cultural Identity* and *Working with Nature*. These two are both based on nature used by humans, historically or presently, while under *Allowing Nature to Find its Way* this interaction is avoided in the large nature areas. These incompatibilities of interventions mainly occur in the mountainous areas of the EU and Switzerland, except for the higher mountain ranges. Other conflicting interventions rise between characteristic landscapes and abandonment of agricultural areas. This combination occurs in a scattered spatial pattern, mainly in the southern part of the EU. All these conflicting interventions underline the choice between conserving agricultural landscapes mixed with nature and natural elements or leaving areas to the dynamics of nature, either coordinated and planned or where humans retreat their activities.

Another conflicting combination is that of the use of regulating ecosystems in agriculture on the one hand, and intensification and enlargement of agricultural practices on the other hand. This combination is similar to the one of Buffer zones and Intensified agricultural practices (no. 5 in Table 5.3), although the spatial structures and interactions are different. These two conflicting combinations occur in the eastern parts of the EU, where an increase in input use in agriculture is expected (Figure 5.2c and 5.2e). When considering enlargement of scale in agriculture too, particularly in the EU's north-western agricultural areas, the same conflicting combination would occur in these areas. These conflicts underline the different pathways that can be followed in the intensive agricultural areas of the EU.

Spatial distribution of the five mostly occurring conflicting combinations



Source: PBL

Figure 5.2 Spatial distribution of the five mostly occurring conflicting combinations

Besides synergetic or conflicting combinations, combinations occur that could go together, but need careful planning or reflection about the public accessibility. These combinations could offer unexpected opportunities for nature – partly they already exist in current practice. Based on area the top 5 of combinations would be the following:

1. Increased abandonment of farmlands (*Going with the Economic Flow*) and cropland with regulating ecosystem services (*Working with Nature*): Abandoned fields could serve as habitat for pollinators and predators. However, abandonment is not occurring in a coordinated way, and the croplands using ecosystem services can be expected to be prone to abandonment too.
2. Private parks in commercialised landscapes (*Going with the Economic Flow*) and characteristic landscapes (*Strengthening Cultural Identity*): Biophysically, these interventions are easy to combine. However, their philosophies with respect to access and citizens' participation differ fundamentally. The commercialised landscapes are one of the options to finance the required management when aiming at the conservation of characteristic landscapes.
3. Private parks in commercialised landscapes (*Going with the Economic Flow*) and cropland with regulating ecosystem services (*Working with Nature*): Assuming that private parks would conserve characteristic landscape elements, and that agriculture is practiced within the park, this could be a useful combination.
4. Private parks in commercialised landscapes (*Going with the Economic Flow*) and large nature areas (*Allowing Nature to Find its Way*): Although philosophies about public access are different, private parks could offer opportunities to finance large nature areas or to increase economic opportunities for local communities around large nature areas.
5. Large nature areas (*Allowing Nature to Find its Way*) and increased abandonment of farmlands (*Going with the Economic Flow*): This combination is one of the arguments of the rewilding movement in the EU. Although abandonment does occur without coordination, local circumstances such as slopes and quality of soils could lead to large areas that can be included in a European network.

5.2 Regional opportunities

One of the main challenges in nature policies is to ensure sufficient space and good conditions for nature. This challenge is related to different drivers across the EU, that can roughly be classified in:

1. pressures from urbanisation and economic activities, mostly in currently densely populated areas;
2. pressures from agricultural production, mostly in intensively farmed regions, such as the north-western part of the European Union;
3. pressures from depopulation, one of the main reason in mountainous areas for the decrease of landscapes and species associated with man-made landscapes.

Aiming for nature that contribute to the identity of a community (*Strengthening Cultural Identity*) requires other conditions than nature that, primarily, delivers services (*Working with Nature*). Therefore, the definition of 'good conditions' in the challenge formulated above differs between the perspectives on nature, depending on the desired state of nature from their view. From the assessment of combinations in the previous section, one could derive opportunities and conflicts for different regions within the EU. Many combinations listed in Section 5.1 occur in the mountainous areas of the EU, for which all perspectives have different ways of dealing with challenges (e.g. depopulation) and opportunities (e.g. touristic value). Another type of region for which all perspectives have their own view on local circumstances, are the densely populated regions of the EU[6]. Synergies, conflicts and opportunities for these two regions are discussed in the sections below.

Example: mountainous areas

The first example deals with mountainous areas where agriculture is less profitable and depopulation may pose a challenge. All perspectives envisage nature in these areas, but in different forms. Some of the proposed interventions under the various perspectives are synergetic, others are not. Under *Allowing Nature to Find its Way,* people intend to restore natural processes by establishing large, interconnected nature areas, restoring natural dynamics, and relocating agricultural enclaves. Under *Working with Nature,* people value many of these areas for their natural capital, which provides many useful ecosystem services to society, such as the provisioning of wood, biomass, carbon sequestration, water retention and the prevention of erosion in mountainous areas. Under *Going with the Economic Flow,* some of the mountainous areas are expected to receive attention from the private sector, mainly because the touristic value is high, or because they appeal to private landowners to build luxurious housing. Other areas that are not that attractive, are at risk of being abandoned. These areas also include the characteristic landscapes that are targeted in *Strengthening Cultural Identity* to be conserved for their expression of the cultural identity of local communities in the EU.

The private parks which are expected to be created under *Going with the Economic Flow*, can be combined with landscape conservation objectives under *Strengthening Cultural Identity*, although the principles about accessibility differ between these two. The private parks could also serve to provide wildlife experiences on the periphery of large nature areas. Regulating services requiring small-scale nature, such as natural mechanisms to suppress pests and diseases, can easily fit into the characteristic landscapes. The dynamics of natural processes, however, as envisaged in *Allowing Nature to Find its way,* will lead to the disappearance of today's landscapes and their cultural identity. And regulating ecosystem services (under *Working with Nature)* requiring extensive forests, for example for water retention, may conflict with historical agricultural landscapes (under *Strengthening Cultural Identity*).

Example: densely populated regions

The second example deals with the interventions in densely populated areas, under the various perspectives. All perspectives include pro-nature interventions within and around cities. Therefore, combinations could be made, although designs vary substantially between the perspectives. Under *Working with Nature*, the number of parks and green and blue spaces are increased, in order to mitigate the urban heat island effect and to purify and retain water. Green and blue elements can be expected in areas surrounding cities, providing habitats for predator species to achieve natural pest suppression, as well as for pollinators, or serving as flood plains to store water. Several corridors and greenways stretch from large nature areas of *Allowing Nature to Find its way* right into the heart of urban areas, providing nature at people's doorstep. Attractive urban green areas are in demand in *Strengthening Cultural Identity*, especially if they have a good recreational infrastructure. The countryside villas in *Going with the Economic Flow* are attractive for those who can afford it.

Most of the interventions that apply to these regions are highly mutually compatible and are beneficial in a more or lesser extent to all other perspectives. Natural elements in the landscape can provide ecosystem services, serve as corridor, and increase the identity of the landscape. The same applies to country villas if accessibility of the countryside is considered.

[6] The combinations in densely populated regions do not show up in Table 5.2 and 5.3, since these rankings are based on the area covered. Although these combinations apply to smaller areas they could occur in the surroundings of a large share of the EU population.

Conflicts arise where in *Going with the Economic Flow* the currently attractive landscapes around cities are needed for a more intensive agriculture, losing part of its cultural identity (*Strengthening Cultural Identity*), the ecosystem services it provides (*Working with Nature*) or the required conditions for corridors and stepping stones (*Allowing Nature to Find its Way*). Furthermore, an optimal landscape to ensure flood protection, carbon sequestration or green infrastructure within intensive agricultural areas is not the optimal landscape for recreation (*Strengthening Cultural Identity*) or dynamic nature (*Allowing Nature to Find its Way*).

With some adjustments, compatibility between conflicting perspectives could be enhanced. Strict conditions for agriculture can be applied in a zone directly around urban areas, to ensure the value of the agricultural area for recreation. This leaves enough room further away from the urban area for agricultural intensification. Another option is to only allow countryside villas (*Going with the Economic Flow*) where the demand for public green space is least.

6 Discussion

This report analyses the impact on biodiversity and ecosystem services of perspectives on nature across the EU (see also Dammers et al., 2017). These perspectives have been elaborated in the context of a *Trend* scenario. Besides, the *Trend* scenario was used to identify whether additional efforts beyond 2020 would be needed to reach the EU vision on conservation and restoration of Europeans' biodiversity and ecosystem services. The results show that probability of occurrence of many species of various taxonomic groups will further decrease towards 2050. Species, of which the lion's share is mentioned in the Birds and Habitat Directives or included on the Red Lists of protected species (Hendriks et al., 2016). Climate change appears to become a major pressure to species.

The perspectives explore *desirable* futures and, as such, they can be considered normative scenarios, in contrast to the *Trend* scenario, which explores a *possible* future and can be considered a descriptive or exploratory scenario. The impacts of the perspectives on biodiversity and ecosystem services indicate that a varying focus on nature leads to different benefits and trade-offs. Combining elements of the perspectives indicate synergies, conflicts and opportunities between them, and could help to widen the options to reach the vision laid down in the EU Biodiversity Strategy.

6.1 *Trend* scenario and robustness of conclusions

Given the fact that the future is always uncertain, results of scenario analyses should be used with care. Various studies have stressed the need to address uncertainties and, for example, to assess multiple trend scenarios. In this study only one *Trend* scenario has been assessed, since the focus of this study is on varying perspectives present within society. The *Trend* scenario is used as a reference and, more importantly, to assess future challenges with respect to realisation of the 2050 vision for biodiversity and ecosystem services. Thus, uncertainty analyses were focused on testing the robustness of the results.

One of the main pressures on biodiversity appears to be climate change (see Chapter 3.3.1), therefore, the influence of uncertainties due to the chosen climate change scenario were assessed to test the robustness of this challenge. Although, climate models do not fully agree on the projected patterns of change, expectations on the direction of temperature and precipitation change within Europe are shared (Kovats et al., 2014). The climate variables in the BioScore model relate to these two factors (Hendriks et al., 2016). In the *Trend* scenario temperature change is expected to continue to a level of 4 degree warming in 2100. This is in line with other studies, such as the projected climate change in the *Baseline* scenario of the OECD's Environmental Outlook (OECD, 2012) – a scenario without new policy action, too. New additional policy interventions as a follow up of the recent Paris Agreement of 2015 are not included in these studies. Such additional policy interventions will likely decrease the level of greenhouse gases emitted and lead to a smaller temperature increase in the coming decades. The alternative climate scenario, which includes the additional policies, projects a global temperature increase of 2 °C by 2100 (Van Vuuren et al., 2011b). Calculations with BioScore indicate that such change would lead to a less severe decrease in biodiversity than calculated for the *Trend* scenario, but expected impacts will remain negative for the larger part of the considered species, which is supported by other studies (Huntley et al., 2007; Settele et al., 2008; Rasmont et al., 2015).

Although BioScore neglects certain expected feedback and relationships, including these could enlarge as well as decrease the effect of climate change. The ability of species to adapt to climate change would decrease the impact of climate change, but this ability is largely unknown and therefore not taken into account in BioScore. Observed changes in plant communities in European mountainous regions show that species can, for example, shift towards higher altitudes enabling species to survive (Kovats et al., 2014). For birds, changes in breeding periods, migration times and breeding habitats also have been observed. Such changes might help species to cope with climate change. By not including such adaptations, BioScore may have overestimated the impacts of climate change.

Underestimation of impacts rise from ignoring the additional impact of barriers for migrating to new suitable habitat patches. The BioScore model calculates the amount of suitable habitat per species. Climatic conditions are an important factor in determining habitat suitability, but the model does not take into account the difficulties for species to colonise new suitable habitats. Various studies have shown that limitations of dispersal capability might increase the negative effects of climate change (e.g. Schlöss et al., 2012). Modelling climate-change impacts without incorporating migration barriers may underestimate effects on species occurrences (Thomas et al., 2004; Thuiller et al., 2004; Schlöss et al., 2012; Santini et al., 2016; Visconti et al., 2016). Moreover, BioScore excludes effects of climate change driven extreme weather events (i.e. increase in fire outbreaks, flooding) that also would aggravate impacts of climate change.

Even though various studies have shown that also land-use change, management and environmental conditions have had, and can have important impacts on Europe's biodiversity (e.g. Janssen et al., 2016), it is expected that the amount of land-use changes for agriculture as well as pollution, specifically air pollution, will decrease on average in the EU (Figure 3.4; Alexandratos and Bruinsma, 2012; Amann et al., 2014; EEA, 2015b). Nevertheless, locally other pressures than climate change can play an important role in biodiversity loss, whereas bold changes in policy directions could alter expectation about land use or emissions. Local pressures are probably underestimated, since EU wide knowledge and data availability at the lower scale level is scarce (see next section). Altogether, the expectation that climate change will be increasingly important relatively to other pressures seems to hold, which indicate that the additional efforts needed to reach the expressed vision in the EU Biodiversity Strategy are increasing. A further improvement of environmental and spatial conditions in nature areas to increase robustness and resilience of ecosystems, is a no-regret option for counter balancing the negative consequences of climate change.

With respect to ecosystem services, additional effects of climate change have not been examined. Most of the included ecosystem services models focus on land-use changes (Petz et al., 2016) and do not take climate change into account to analyse the supply of ecosystem services. Therefore, ecosystem services supply might have been overestimated, particularly, given the large impact of climate change on species. If species that provide the services react in a way that is similar to that of the species we modelled to assess the impact on biodiversity, climate change will have a negative impacts on these ecosystems services, too.

6.2 Spatial scale of effects

In this outlook study, the impacts on biodiversity and ecosystem services are assessed on a European scale. As impacts will vary across Europe, the models need to address underlying spatial variation. The BioScore model assesses the impact of pressures on species at a coarse scale of 1 X 1 kilometre. However, some species depend on conditions that are even more local, such as the microclimate, soil nutrient status, soil pH, presence of green elements or vegetation gradients. Ecosystem services, such as pollination and natural pest control may also vary within grid cells, depending on the presence of small green elements and local land management. However, the Corine Land Cover map, which is used in the models, only describes very general classes of land cover. Small-scale inland wetlands next to small rivers and ponds, for example, are lacking as a result of the map's resolution. Also, small open spaces in forests do not appear on the land-use map. Using such input information with limited spatial variation might result in an underestimation of species from habitat types that are small by definition. Since the regression models of BioScore link species occurrence data to large-scale land-use maps, a small but positive relationship can be found, for example, between the amount of forests and the suitability for typical grassland species (Hendriks et al., 2016). By using these regression functions, an increase in forests in the *Trend* scenario will lead to an increase in grassland species, based on the assumption that, in the new forests, small patches of open grassland will be present, too. By using more spatial detailed information on drivers and species occurrences, regression modelling can be more precise. However, such information is barely available on a European scale (Hendriks et al., 2016). Changes in climate also vary within grid cells, but, as stated before, the predicted patterns of local changes are uncertain. Predictions of patterns only converse on larger geographical scales. Most studies, for example, predict a species shift towards the northern part of Europe (e.g. Thuiller et al., 2004).

6.3 Assessing consequences of the four perspectives

The four perspectives present future states of nature and pathways that may be followed to realise these states if desired. Since the perspectives explore desirable futures, they can be considered to be normative scenarios, in contrast to the *Trend* scenario which explores a possible future and can be considered a descriptive scenario. Normative scenarios are used, when preferable futures, or futures fulfilling a specific target or challenge are sought (Börjeson et al., 2006). Most normative (or prescriptive) scenarios achieve policy goals or describe a prespecified future, presenting a picture of the world achievable (or avoidable) only through certain interventions. The prespecified future of the four perspectives used in this study has been developed during the project based on stakeholders' input, literature review and the essays of four renown philosophers (Dammers et al., 2017; Mommaas et al., 2017).

In order to illustrate the perspectives and describe the consequences for the challenges, the storylines were mapped and impacts on land use and biodiversity and ecosystem services were assessed. However, working with maps, numbers and models is hampered because there is not in all cases a one-to-one translation possible from the perspectives' guiding values to biophysical assumptions. Moreover, spatial specific or quantitative assumptions can only include a limited set of possible interventions. To avoid the suggestion of accuracy in this study, impacts of changes on biodiversity and ecosystem services were based on semi-quantitative assessment – rules of thumb, estimated by experts. Using such expert panels is a useful method in ecological assessments (Martin et al., 2005). However, since the number of experts for the assessment was limited and no sensitivity analyses on the results were conducted, the results of the assessment should only be used as rough indications of the impact on biodiversity and ecosystem services.

Moreover, a fair assessment should consider not just biodiversity and ecosystem services, but a whole set of indicators covering the variety of values underlying the four perspectives. Indicators representing these normative values in a proper way would for example be:

- *Strengthening Cultural Identity*: the number of successfully boosted local identities, the number and/or area of highly valued landscapes or species, perceived connectedness with places;
- *Allowing Nature to Find its Way*: the area of intact, functioning ecosystems, available space for dynamic processes, good ecological quality, status of the European 'big five', such as the European bison, wolf, brown bear, wolverine and lynx;
- *Going with the Economic Flow*: amount/value of private pro-nature initiatives, share of nature-based tourism in the economy, profits from sustainable land use;
- *Working with Nature*: sufficiency of ecosystem services delivery, sustainable use of biological processes.

However, most of these indicators are not available yet and certainly not included in the available economic or biophysical models. Thus, the effect of the packages of interventions assumed in each perspective could not be assessed in terms of the guiding values and aims of the perspective. As such, the assessment of the perspectives is only partial and limited to current policy indicators: biodiversity and ecosystem services.

6.4 Using perspectives in a policy context

Normative scenarios can be used in various ways in a policy context. Firstly, they can provide examples of what society may be like in the future and widen the perceptions of what is considered possible (Dreborg, 1996; Van der Heijden, 1996). For example, as many people value nature that occurs in historical man-made landscapes, addressing the 'sense of place' motivation (*Strengthening Cultural Identity*) could support the conservation of species of man-made historical EU landscapes. Thinking this way may reveal new options for engaging society in nature protection.

Secondly, stimulating thinking about barriers that may be encountered in pursuing a goal, is another use of normative scenarios, and various studies have been set up to help illustrating the transformations needed to achieve challenges (Börjeson et al., 2006). For example, the ongoing migration to urban regions at the expense of rural areas lead to more EU citizens living in an urban environment in 2050. Connecting people in urbans areas with nature will be crucial for their support for nature-related efforts. Providing a good urban green infrastructure is expected to be greatly appreciated by the public (Hegetschweiler et al., 2017) with opportunities related to cultural ecosystem services, such as recreation, health (Vries et al., 2003), and adaptation to climate change (Demuzere et al., 2014).

Thirdly, normative scenarios can be used to shed light on gaps between current policies (business-as-usual) and policies and interventions that would be required, as well as illuminate conflicts between different societal goals and visions (Höjer and Mattsson, 2000). For example, analyses with BioScore suggest that even additional climate policy intervention, leading to a global temperature rise of 2 °C by 2100, would lead to negative impacts on biodiversity. As such, it seems that climate targets are not in line with biodiversity targets. Therefore, it would be important to include impacts of climate change on biodiversity when considering adaption and mitigation strategies. Both strategies have impacts on nature in general, biodiversity and ecosystem services. On the one hand, the likely increase in the production of renewables has its impact on landscapes, solar and wind in particular (Wolsink, 2007), and on biodiversity and ecosystem services, mainly due to biomass and hydropower (Bertzky et al., 2010; Van Oorschot et al., 2010; Jackson, 2011; EEA, 2012b; Van Puijenbroek and Kroes, 2015).

These impacts can also be expected in regions that are economically less viable and where other anthropocentric pressures could be expected to decrease. On the other hand, impacts of climate change on biodiversity can be expected to be considerable too, and one has to be aware that increasing the share of renewable energy production is one of the indispensable ways to partially counteract climate change and remain within a warming of 2 degrees in 2100 (Van Vuuren et al., 2011b). At the same time, the expected climate changes might stress the need to discuss nature conservation strategies. This may require a 'new attitude' (Dickinson et al., 2015), in which management embraces change in ecosystems and supports the response of ecosystems and species to climate change. This could be done by increasing ecosystem quality, taking restoration measures to increase resilience, and enable migration, instead of conserving present values.

There are multiple ways in which perspectives can be used in the discussion on the follow up of the EU Biodiversity Strategy. Given the variety of socio-economic trends across EU regions together with the wide range of perspectives on nature, it seems that there are ample opportunities for increased engagement of society and sectors. Examples of such opportunities are nature for recreation in densely populated areas and nature for flood management along rivers. Although positive effects on endangered species are not self-evident in these cases, research shows possibilities for shaping interventions in such ways that endangered species do increase (for example Baptist et al., 2004). There may also be indirect synergies, for example by rising awareness or engagement. Interventions for increasing ecosystem services, often directly related to peoples' wishes, can also help to maintain a basic level of biodiversity outside nature reserves, although this will not always be a solution to halt the loss of endangered species. However, at the same time, regions with large nature areas, rich in endangered species, are often the most interested from an economic/recreational and historical point of view.

Thus, it seems that aiming at a variety of nature, and thereby using the different motives of people to engage in protecting our future natural capital might have large chances. Such approach might help greening the agricultural policies, water management or forestry and increasing multifunctionality of the green infrastructure.

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Annex I

Table AI-1 Current status of all, long distance, anadromous fish species of the EU

Species	English name	Maximum migrating distance (km) [1,2]	No. of catchment where species is[3]			Inclusion in Habitat Directive (no. Annex)	International Red list status
			present	extinct	No data		
Acipenser gueldenstaedtii	Russian sturgeon	2200 in Danube	1	0	0	V[4]	CR[5]
Acipenser naccarii	Adriatic sturgeon	600 in Po	1	0	0	II IV	CR
Acipenser nudiventris	Ship sturgeon	2200 in Danube	1	0	0	V	CR
Acipenser oxyrinchus	Baltic sturgeon	900 in Vistula	0	4	0	V	
Acipenser stellatus	Stellate sturgeon	2200 in Danube	1	0	0	V	CR
Acipenser sturio	Atlantic sturgeon	850 in Rhine	1	15	0	II IV	CR
Alosa alosa	Allis shad	700 in Rhine	7	7	4	II V	LC
Alosa fallax	Twaite shad	190 in Wye, UK	10	3	5	II V	LC
Alosa immaculata	Pontic shad	1700 in Danube	1	0	0	II V	VU
Coregonus maraena	Whitefish	700 in Baltic river	2	0	12	V	VU
Coregonus oxyrinchus	Houting	700 in Rhine	2	1	0	II IV	EX
Huso huso	Beluga	2200 in Danube	1	0	0	V	CR
Lampetra fluviatilis	River lamprey	700 in Rhine	10	7	11	II V	LC
Petromyzon marinus	Sea lamprey	700 in Rhine	10	3	6	II	LC
Salmo Salar	Atlantic salmon	1000 in Elbe	17	8	1[5]	II V	LR/Lc
Salmo trutta	Sea trout	700 in Rhine	No data[6]	No data[6]	No data[6]		LC

[1] Kottelat and Freyhof (2007);
[2] Froese and Pauly (2016);

[3] The total of these three columns refer to the number of catchments where the species occurred originally;
[4] Annex II: species for which core areas of their habitat must be protected in Natura 2000 sites. Annex IV species: a strict protection regime must be applied across their entire natural range within the EU, both within and outside Natura 2000 sites. Annex V species: Member States must ensure that their exploitation and taking in the wild is compatible with maintaining them in a favourable conservation status (EEC, 1992).
[5] IUCN codes: EX: Extinct, CR: Critical endangered, EN: Endangered, VU: Vulnerable, NT: Near threatened, LC: Least concern, LR/lc: Lower risk. Because of its extinction, Baltic sturgeon was not evaluated in the Red list.
[6] These indicators could not be determined for *Salmon trutta*, since this species has been reintroduced in many catchments.

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Annex II

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Annex III

Changes in land use for each of the perspectives

For each perspective, the desired state of nature across the EU was translated into EU maps. For each of the assumptions (Table AIII-1), GIS-rules were defined and used to adapt EU maps of the *Trend* scenario and derive future maps for each of the four perspectives. The GIS-rules were based on a variety of maps from other sources. Thee derived maps included a map on land use, agricultural intensity, forest management, deposition and water abstraction. To keep the perspectives within credible ranges, the resulting areas of urban area, cropland, pasture and forest plantations were kept within the uncertainty ranges shown in Chapter 3.1.

As each perspective contains multiple assumptions, changes of maps were executed in successive steps. The output map of step x was the input map of step x+1 and the input map of step 1 was always the land-use map resulting from the *Trend* scenario in 2050. All changes are made using ArcGIS 10.1 and its tools. In the following chapters the successive steps, the defined GIS-rules and used maps from other sources are described.

For all perspectives, two supportive maps were used:

1. A random map: A map with random numbers between 0 and 1. This map was created, using the tool 'Create random raster'. This map was used to randomly select cells in masks that will change in a different land-use type in a perspective.
2. A map with dominant land-use type: For each grid cell (1 x 1km) the dominant landscape is determined by counting the number of cells around it that belong to a) Urban, b) Agriculture or c) Nature. A radius of 15 kilometres is used to identify the dominant land-use type.

Table AIII-1 Assumptions in the four perspectives

		Strengthening Cultural Identity	***Allowing Nature to Find its Way***	***Going with the Economic Flow***	***Working with Nature***
State of nature		Nature nearby and in traditional and cultural landscapes	European nature network formed by large nature areas and corridors	Privately owned nature	Nature defined by the delivery of services
Targeted areas		- Urban zones in densely populated areas; - Characteristic landscapes; - National parks and monuments (CDDA2 &3); - Villages in peri-urban areas.	- Large nature areas (> 10,000 km^2); - N2000, strict nature reserves and wilderness areas (CDDA1); - Green and blue corridors; - Buffer zones around N2000 and large nature areas.	- Private parks; - Country villas; - Marginal agricultural areas; - Suitable agricultural areas.	- Erosion-sensitive areas; - Flood-prone areas; - Croplands with insufficient natural pest control and pollination; - Peat areas; - Upstream areas.
Nature	Nature management	- Management to guarantee recreational values in the urban zones; - Management to conserve current landscapes in characteristic landscapes, CDDA2&3 and prevent succession.	- No management in the large areas, allowing for natural dynamics; - Nature management in N2000 areas outside the nature network.	- Management to prevent succession in private parks; -External negative pressures are locally mitigated in protected areas nature.	
	Nature development /design	- 20% of urban zone is designed as recreational parks: mixed grasslands/forest/water landscapes. In the rest of the zone a multifunctional agricultural landscape is created.	- European nature network, including N2000, CDDA1. Nature areas larger than 10,000 km^2 are created; - Between large nature areas, terrestrial corridors are created of 5 km width and at least 30% nature.	- Green spaces in and around cities vary from small public gardens and parks that are accessible for everyone, to larger well-designed parks or country villas, that are only accessible for their owners	- Afforestation of erosion-sensitive areas; - Flood-prone areas in low lands exist of extensively farmed grassland that can be used for storing water; - Cropland: if natural and semi-natural areas, including green elements < 20%, increase in such natural areas by 15%;

		Strengthening Cultural Identity	*Allowing Nature to Find its Way*	*Going with the Economic Flow*	*Working with Nature*
			River corridors include nature of a width of 1km.	or for people who pay an entrance fee.	- Upstream areas are turned into forests/peatland to retain water.
Agriculture	Land use	- Agricultural areas converted into highly recreational landscapes.	- Small agricultural areas located in large nature areas are converted into nature.	- Increased abandonment of marginal agricultural areas.	- Increase of semi-natural and natural habitats in agricultural areas to guarantee habitats for predators (pest control) and pollinators.
	Management	- Medium intensive management of cropping fields in urban zones and around cities, that are not located in the urban zone; - Medium intensive (crops) and extensive (grass) management in characteristic landscapes.	- Extensive management in buffer zones protecting N2000 areas and CDDA1 areas (500m around) and in the corridors between large nature areas.	- Increased intensification of suitable agricultural areas, particularly in eastern EU countries.	- Increasing efficiency of N-use in eastern EU-countries; - Extensive management on peat areas and in flood-prone areas.
	N and P use	- Restricted N and P use in urban zones and in characteristic landscapes.	- Restricted N and P use in N2000 & CDDA1 areas, in buffer zones of 500m around these areas, and in corridors between large nature areas.	- Increased N and P use in eastern EU countries.	- Decreased N and P use in eastern EU countries achieved by higher N and P efficiencies. - Restricted N use in peat areas and flood-prone areas.
	Green elements	- Additional green elements in urban zones and around cities outside the urban zone: up to 5% of the area.	- Additional green elements in corridors: up to 10% and in buffers up to 5% of the area.	- Removed in areas where increased intensification takes place.	- Additional green elements in cropland areas, that have less than 20% (semi-)natural areas in their surroundings: up to 5% of the area.
Forestry	Management	- More natural forest management in urban zones and characteristic landscapes	- Natural forest management in large nature areas in mountainous areas; - No intensively managed	- Natural forests in N2000 & private parks; - Outside these areas, forests are managed in a multifunctional or intensive way.	- All forests are managed in a way that enhances the optimal balance of ecosystem services.

		Strengthening Cultural Identity	*Allowing Nature to Find its Way*	*Going with the Economic Flow*	*Working with Nature*
			forests in Natura 2000 and CDDA1 areas.		- Continuation of natural management in forests in N2000 areas and on steep slopes.
Urbanisation	Land use	- Urbanisation of the country side, around villages in peri-urban regions, instead of agglomeration around current large cities.	- No urbanisation in Natura 2000, CDDA1 and large nature areas.		- No urbanisation in flood-prone areas or peat areas.

Strengthening Cultural Identity

Land use

Step 0: Preparation for step 3
In this step, villages and cities within a 60 minutes travelling distance from large cities were selected as potential locations to reallocate the removed urban area of step 1 in their near surroundings. In the 2050 land-use map of the *Trend* scenario, the small villages were selected. The raster map containing urban areas were converted into polygons. From this map, all urban polygons smaller than 4 km^2 were selected. From these, the villages within a 60 minutes travelling distance from major urban settlements (of 50,000 inhabitants or more) were selected. Around those villages, the directly connecting cells in every direction were selected for step 3.

Step 1: Definition of urban zone and preservation of the landscape in this zone
An *urban zone* was defined, containing regions with a high population density (Figure AIII-1a), i.e. those grid cells with at least 10% urban area within a distance of 10 km, in the base year 2005. The sum of all urban cells in a 5 x 5 km cell was counted with the *aggregate* tool. Subsequently, the *focal statistics* tool was used to sum the urban area within a distance of 10 km of each 5 x 5 km grid cell. Grid cells with at least 10% urban area around them were added to the urban zone.

The urbanization under the *Trend* scenario in this zone was prevented under *Strengthening Cultural Identity*. In this step, the new urban land use under the *Trend* scenario in the period to 2050 was altered into the land use of 2005 (30,365 km^2), and reallocated to other areas in step 3.

Step 2: Today's culturally important landscapes are preserved.
Three maps were used to select today's characteristic landscapes (Figure AIII-1b): 1) agricultural landscapes (index > 0.4), 2) forest landscapes (index > 0.5), areas in the landscape character index (Tieskens et al., 2017), and 3) 'national parks and natural monuments or features' (categories 2 and 3 in the *Common Database on Designated Areas* according to Dudley (2008) (Figure AIII-1c). For these areas, the type of land use was maintained up to 2050. The urban area lost in this step was not reallocated to other areas.

Step 3: Urbanization of the peri-urban region
Per country, urban land-use was reallocated to grid cells that would potentially be available for urbanisation, that were defined in step 0. Other constraints for reallocation the urban area were, grid cells:

1. Had no overlap with urban pixels in the land-use map of 2050 under the *Trend* scenario;
2. were outside the urban zone, to prevent urban expansion in highly populated areas; and
3. were outside the highly characteristic agricultural and forest areas, according to the landscape character index, and CDDA 2 and 3 areas, as these areas are preserved for their cultural value.

Available pixels were randomly selected, using the random map (see introduction of this annex). In this step, an area of 28,362 km^2 urban area was reallocated (Figure AIII-1d). Due to the use of random values in this step and the choice to reallocate urban land use per country , the area of reallocated urban land use is approximately 2000 km^2 smaller than the area where the conversion to urban land use was prevented in step 1.

Step 4: Recreational landscapes in the urban zone
In the *urban zone* (Figure AIII-1a), parks were created, at locations where, in 2050, nature is scarce under the *Trend* scenario. In case, less than 20% of the area in a unique region of the urban zone-map consisted of nature, we added nature, to make up the total of 20%. This was done by converting agriculture into open water (20%), natural grassland (40%) or forest (40%). In this step, 5729 km^2 of forest, 2791 km^2 of water and 5679 km^2 of nature were added (Table AIII-2). Following this method resulted in a larger area of water in southern Europe than could be expected, taking water availability into account in these regions.

Table AIII-2 shows the land-use changes aggregated to the categories urban area, cropland, pasture, forest and open natural vegetation. Overall, the assumptions in *Strengthening Cultural Identity* lead to a decrease in urban area and forests and an increase in open natural vegetation, compared to land use under the *Trend* scenario. Open water is not included in Table AIII-2.

Table AIII-2 land-use changes during the development of land use in *Strengthening Cultural Identity*.

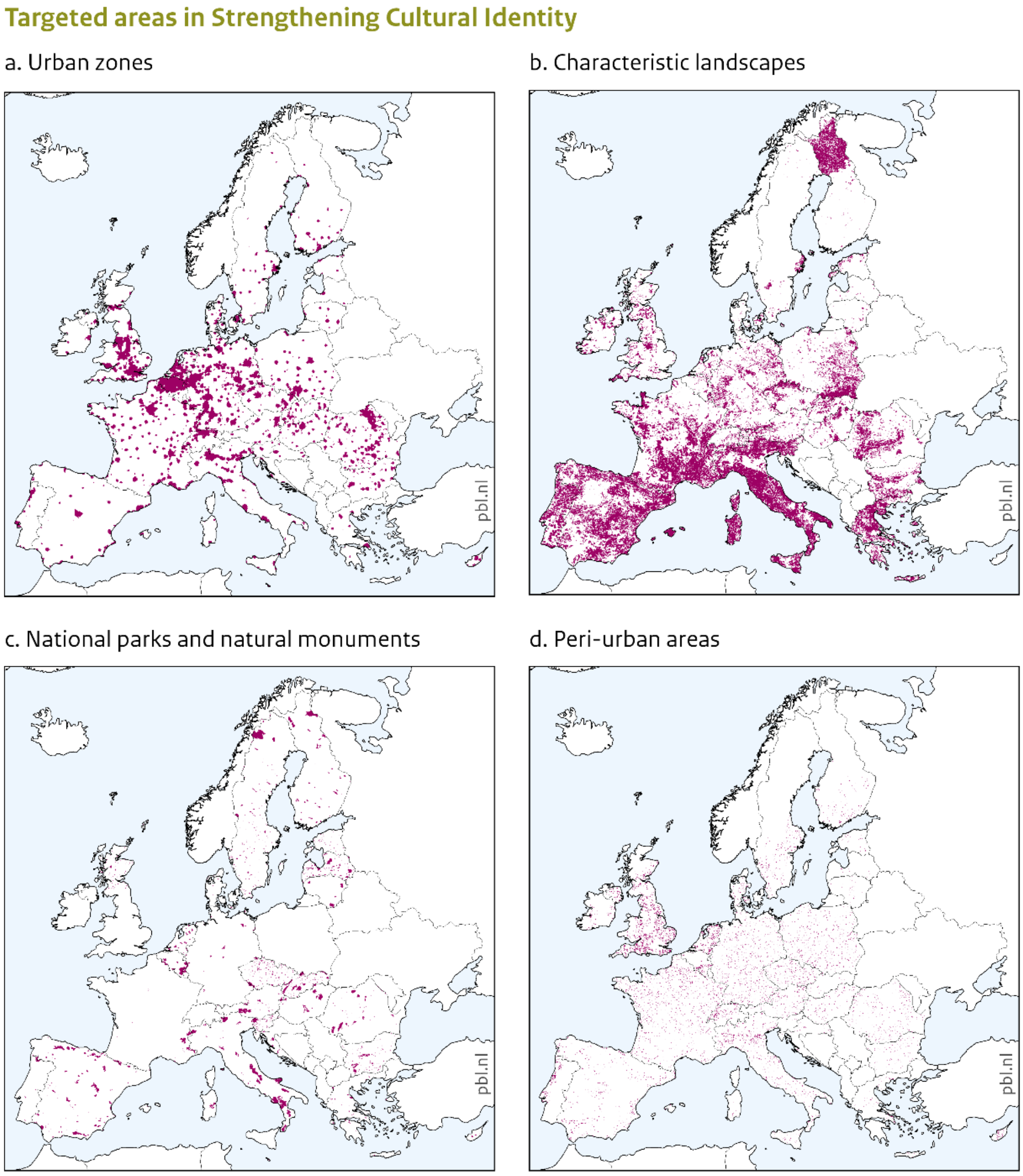
	Urban area	Cropland	Pasture	Forest	Open natural vegetation
Step 1	-30365 (-13%)	10944 (1%)	9903 (2%)	3222 (0%)	6296 (1%)
Step 2	-34842 (-14%)	21403 (2%)	10766 (2%)	-6857 (0%)	9530 (1%)
Step 3	-6480 (-3%)	7416 (1%)	3523 (1%)	-11799 (-1%)	7341 (1%)
Step 4	-6480 (-3%)	-3067 (0%)	-193 (0%)	-6070 (0%)	15811 (2%)

Environmental pressures

In *Strengthening Culture Identity* management intensity is assumed to be moderate to low in the *urban zone* and *characteristic landscapes*. Table AIII-3 shows the GIS rules for management intensity under *Strengthening Cultural Identity*.

Table AIII-3 Assumptions under *Strengthening Cultural Identity*

Pressure	Location modified	Rule
N application	Urban zones	Cropland = max 150 kg N/ha
	Characteristic landscapes	Cropland = max 100 kg N/ha Grassland = max 30 kg N/ha
Forest management intensity	Urban zones and Characteristic landscapes	FMA 3-5 become FMA 2



Source: PBL

Figure AIII-1. The selected areas under *Strengthening Cultural Identity*

Allowing Nature to find its Way

Land use

Step 1: Definition of large nature areas, where natural dynamics have free rein
In large nature areas (all areas with natural land-use types >10,000 km^2, excluding areas under intensive forest management; Figure AIII-2a) natural dynamics are assumed to lead to a mix of open and closed ecosystems. In *strict nature reserves and wilderness areas* (Common Database on Designated Areas category Ia & Ib areas (Dudley, 2008)) elsewhere,

nature management prevents ecological succession. The particular land use, in these two types of areas, was maintained, from 2005 onwards. In this step, 193,680 km^2 of other types of land use were converted into open natural vegetation, mainly at the expense of forests.

Step 2: Nature and agriculture are strictly separated in large nature areas
Agricultural land within these large nature areas was converted into nature. For this step, the dominant landscape map was used. Each grid cell was changed into the dominant nature type if: a) land use was agricultural, b) more than 50% of the surrounding areas consisted of nature, and c) less than 25% of the surrounding areas consisted of agriculture. In this step, 83,607 km^2 of agriculture was converted into nature (forest or open natural vegetation), and the dominant nature type, using the dominant land-use type map, was assigned to the grid cell.

Step 3: A European nature network: corridors connecting the large nature areas
The large natural areas were connected by terrestrial corridors (Figure AIII-2b). The locations of these corridors were based on four maps a) Green Belt: (http://www.ecologicalnetworks.eu/html/maps/GreenBelt.php), b) PEEN maps (Bouwma et al., 2002; Biro et al., 2006; Jongman et al., 2006), c) connectivity maps created by LARCH-SCAN and based on aggregated LU nature types of the current situation (Hendriks et al. 2016) and d) corridor maps for large animals (maps 4.2 and 4.4) (EEA, 2014). From these maps, corridors were selected that would connect the large natural areas. When multiple small corridors would run to the same area, only a selection of the corridors was included. The corridor that was supposed to lead to the least implementation efforts regarding required surface and land-use change was selected. The corridors should avoid urban areas as much as possible. This selection was done manually. Two cells were added along each side of a corridor, resulting in a corridor of 5 km wide.

Secondly, at least 30% of the corridor area should consist of natural types of land use, to optimise its function for species migration. In case less than 30% of the area of a corridor consisted of natural types of land use, the share of nature within the corridor as increased up to 30%. Only cells with an agricultural land-use type under the *Trend* scenario were randomly selected and changed into nature, using the random map (see introduction of this annex). Three of every five cells were converted into forest, the other two into semi-natural area. The *focal statistic*-tool was used to select the cells in the corridor with the surrounding areas consisting of nature for less than 30%. A radius of 2 km was used (a total of 13 cells within the circle). Table AIII-4 shows the share of the area converted into nature area with respect to the share of nature present. Urban land-use grid cells were excluded from such conversion. In this step, 6431km^2 of agricultural land were converted into various types of natural land use.

Table AIII-4 Converted area into nature, within the corridors, in relation to the share of nature present

Share of nature within a 2-km radius (%)	Nature added (%)
0	35
8	26.25
16	17.75
25	8.75
33	0

Step 4: Aquatic corridors in the European nature network
Rivers were selected as aquatic corridors (Figure AIII-2c) when the banks of a certain river has potential for terrestrial nature development and the river itself has potential for fish migration. The rivers with potential for terrestrial nature development were selected from the 'PEEN' rivers (Bouwma et al., 2002; Biro et al., 2006; Jongman et al., 2006). Only rivers with potential for fish migration were selected (Van Puijenbroek and Kroes, 2015). The rivers selected as aquatic corridor were the Loire and Sava, and the Donau from Belgrade onwards, where the Sava discharges into the Donau. In addition, the Kemijoki, Iiljoke and Vindeälven were added, based on expert judgement.
On the river banks of the selected rivers, nature is expected to develop in a natural way. Grid cells classified as any of the agricultural land-use types adjacent to the rivers were selected. These cells were converted into inland wetlands if the majority of grid cells within 5 km^2 would be agriculture under the *Trend* scenario in 2050. Otherwise, they were reclassified into the predominant class of nature within 5 km^2. Such predominance was calculated within a 5 km^2 cell using block statistics. When no predominance was found, the range was extended to 10 km, and calculated using focal statistics. In this step, 1218 km^2 of agricultural land was converted into various types of natural land use.

Table AIII-5 shows the changes in land use aggregated to five categories. Overall, the assumption under *Allowing Nature to Find its Way* lead to a decrease in urban area and cropland, pasture and forest, and an increase in open natural vegetation, compared to the land use under the *Trend* scenario.

Table AIII-5. Deviations in land use in *Allowing Nature to Find its Way*, compared to the *Trend* scenario

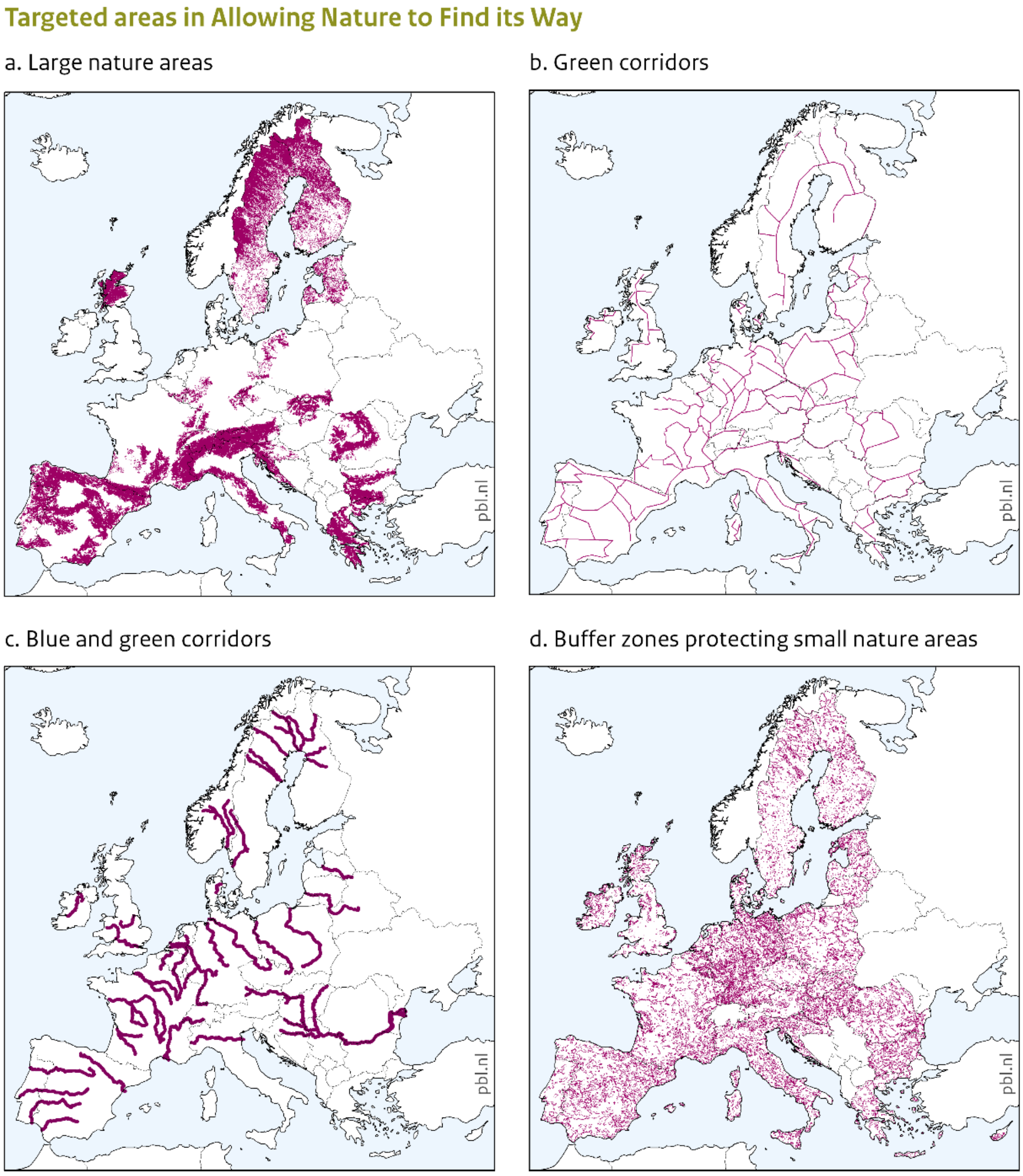
	Urban area (km^2 (%))	Cropland (km^2 (%))	Pasture (km^2 (%))	Forest (km^2 (%))	Open natural vegetation (km^2 (%))
Step 1	-5102 (-2%)	-5679 (0%)	-6545 (-1%)	-176354 (-11%)	193680 (29%)
Step 2	-5102 (-2%)	-47093 (-3%)	-48738 (-9%)	-111843 (-7%)	212776 (32%)
Step 3	-5102 (-2%)	-51679 (-4%)	-50583 (-9%)	-108033 (-7%)	215397 (33%)
Step 4	-5102 (-2%)	-52437 (-4%)	-51043 (-9%)	-107331 (-7%)	215913 (33%)

Environmental pressures

In *Allowing Nature to Find its Way* management intensity is assumed to be low in Buffer zones, protected areas and large nature areas. Table AIII-6 shows the GIS rules applied to the management intensity maps under *Allowing Nature to Find its Way*.

Table AIII-6 Assumptions with respect to environmental pressures in *Allowing Nature to Find its Way*

Pressure	Location modified	Rule
N-application	Corridors	Cropland = max 100 kg N/ha Grassland = max 50 kg N/ha
	Buffer zones (Figure AIII-2d) & N2000 & CDDA1	Cropland = max 100 kg N/ha Grassland = max 30 kg N/ha
Forest management intensity	Forests in large nature areas in mountainous areas (higher than 500 m)	FMA1
	Other CDDA1 & N2000	FMA 4 and 5 become FMA 3



Source: PBL

Figure AIII-2. The selected areas under *Allowing Nature to Find its Way*

Going with Economic Flow

Land use

Step 1: Establishment of private parks
Under this perspective, private parks are established and management is aimed at conserving the current landscapes. For these areas, land use was kept constantly from 2005 onwards. To select private parks areas, we used a map of geotagged photo uploads to Panoramio (Google photoservice) containing landscape pictures (Tieskens et al., 2017). To achieve the aim of having around 2% of the EU29's land surface as private parks, cells with a photo upload of 11 images per km^2 or more were selected (Figure AIII-3a).

Step 2: Country villas close to large cities
It is assumed that 0.19% of the EU29 area is covered with country villas, under this perspective (Figure AIII-3b). Large cities were selected, consisting of grid cells around which at least 50% would be urban, within a of 10-km distance. The method to select these cells was similar to that used in step 1 of *Strengthening Cultural Identity*. The country villas were placed randomly on agricultural area within a distance of 50 km of these cities, using the random map (see introduction of this annex). The selected grid cells without a natural land-use classification were subsequently reclassified as natural.

Step 3: Additional abandonment due to a more liberal Common Agricultural Policy
Under the *Trend* scenario, the total abandoned agricultural area is 2% of the total land surface in the EU29. Under this perspective, land abandonment is expected to double. The areas where land abandonment was believed to increase were based on the significant locations of agricultural abandonment under the A1 scenario from Verburg et al. (2013). Grid cells that are part of N2000 areas or private parks were excluded. To double the abandoned area, we selected 36% of the cells for which, according to Verburg et al. (2013), the probability of being abandoned is higher than 0.99 (Figure AIII-3c). These grid cells were reclassified to the dominant natural land-use type in the surrounding area, within a 5-km radius. This dominant natural land-use type was determined by using block statistics. When there was no dominant land-use type, the radius was expanded to 10 km, using focal statistics

Table AIII-7 shows the land-use changes aggregated to five categories, for each step. Overall, the assumptions under this perspective lead to a decrease in urban area, cropland and pasture and an increase in forests and open natural vegetation, compared to the land use under the *Trend* scenario.

Table AIII-7. Land-use changes during the development of the land-use map of *Going with the Economic Flow*

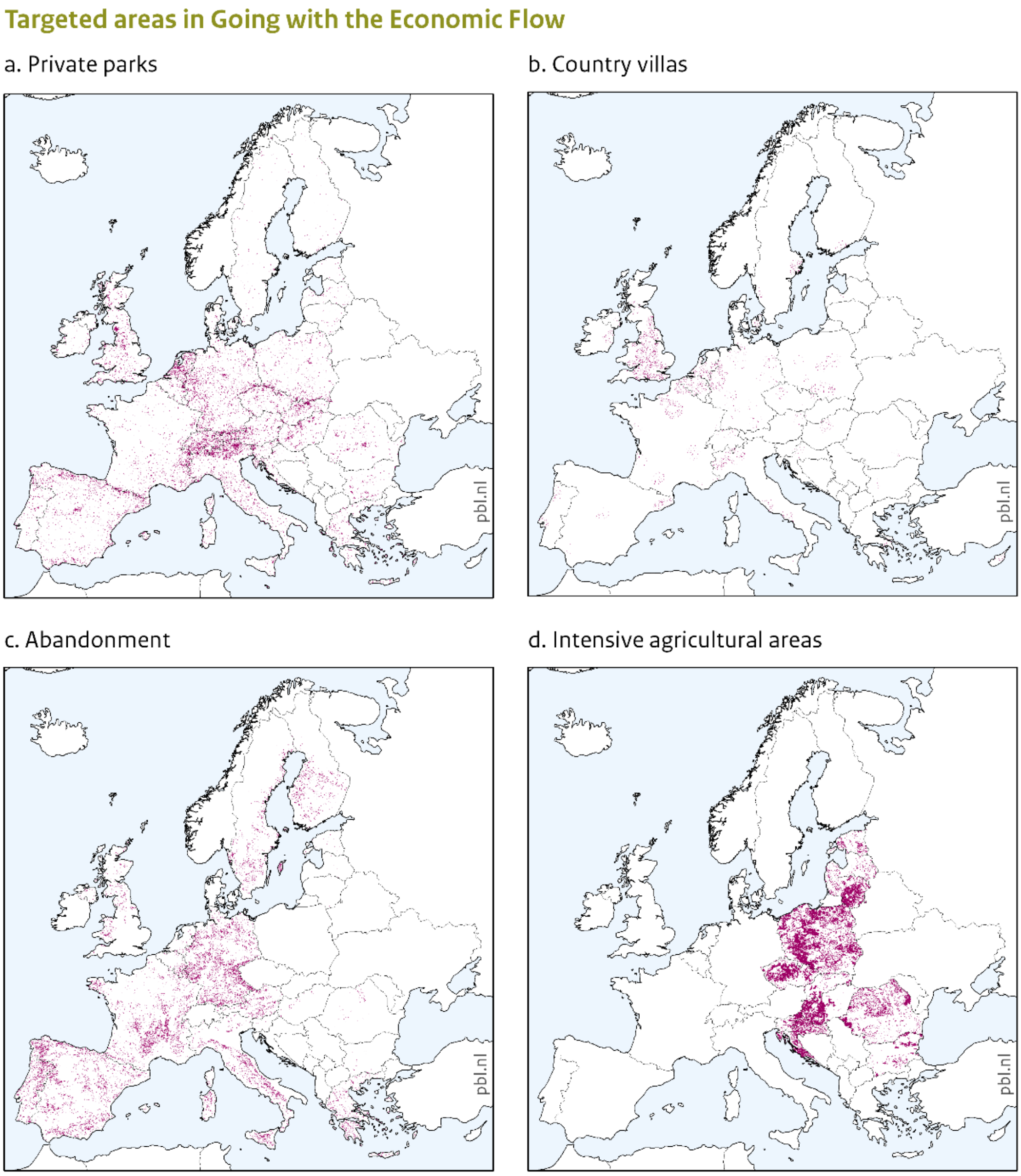
	Urban area	Cropland	Pasture	Forest	Other nature
Step 1	-2876 (-1%)	1129 (0%)	1778 (0%)	-1962 (0%)	1931 (0%)
Step 2	-2876 (-1%)	-3137 (0%)	-170 (0%)	-1962 (0%)	8145 (1%)
Step 3	-2876 (-1%)	- 39266 (-3%)	-24756 (-4%)	46516 (3%)	20382 (3%)

Environmental pressures

In *Going with the Economic Flow* management intensity is assumed to intensify in agricultural areas in Eastern EU countries. Forest management is assumed to be low in N2000 areas and private parks and moderate to intensive outside these areas. Table AIII-8 shows the GIS rules for management intensity under *Going with the Economic Flow*.

Table AIII-8 Assumptions under *Going with the economic flow*

Pressure	Location modified	Rule
N-application	Agricultural area increasingly intensively managed (Figure AIII-3d)	N use in intensive agriculture in eastern Europe increases up to values of intense management in western Europe
Forest management intensity	N2000 and private parks	FMA 3-5 become FMA 2
	Outside N2000 and private parks	FMA 1 and FMA 2 become FMA 3



Source: PBL

Figure AIII-3. The selected areas under *Going with the Economic Flow*.

Working with Nature

Land use

Step 1: No urbanisation in peat areas
First, peat areas were selected by selecting all cells with a classification equal to or higher than 8 from the Harmonized World Soil Database (FAO et al., 2009), and for Switzerland and Croatia, all grid cells with an organic carbon content higher than 30%, based on the European Soil Database (Hiederer, 2013) (Figure AIII-4a). Urbanisation in peat areas is prevented under this perspective. Therefore, the land-use classification for all new urban areas on peat soils in the *Trend* scenario's land-use map of 2050 was reclassified to that of the year 2005 (Figure AIII-4a).

Step 2: No urbanisation or afforestation of flood-prone areas
A mask was developed that consists of all areas with a high flood risk (Figure AIII-4b) (Pérez-Soba et al., 2010). Switzerland and Croatia are not present in this map. No areas with a high flood risk were selected in Switzerland as it is assumed that Switzerland mainly consists of upstream areas. The major rivers in Croatia, Sava, Drava and Danube, however, have a high chance of flooding (ICPDR, 2015). Therefore, a zone of 3 km around these rivers was added as high flood risk. The classification of land use in the flood-prone areas (Figure AIII-4b) was also reclassified to that of the year 2005.

Step 3: Extensive use of flood-prone areas
In this step, agricultural land in flood-prone areas was reclassified as extensive pasture. This was done by converting all arable land in flood-prone areas into pasture. A total of 67,246 km^2 of arable land is converted into extensive pasture.

Step 4: Afforestation in erosion-sensitive areas
To prevent erosion, nature was added on agricultural land in erosion-sensitive areas (Figure AIII-4c) (Pérez-Soba et al., 2010). In such erosion-sensitive areas, at least 30% of the area should be nature to minimise erosion. The procedure followed for increasing the share of nature was the same as that for the green corridors in *Nature Finds its Way*. The added natural areas consisted of 60% forest and 40% open natural vegetation (CLUE code 3). These two land-use types were chosen at random, by using the random map (see introduction of this annex).

Step 5: Increase of semi-natural areas in cropland areas
Natural pest control calls for about 20% semi-natural areas in the surrounding fields (Bianchi et al., 2013). For all cropland areas, the share of the area of green elements was increased up to 5%. In case the natural area within 2 km of each grid cell was less than 15%, the share of natural area was increased by 10%. This resulted in a share of 15% to 30% semi natural area (including the 5% green elements) in all large-scale cropland areas (Figure AIII-4d). The natural land-use types that contribute to pest control and pollination are forest, nature areas, inland wetlands, heathland and moorland. Using focal statistics, the number of nature cells within a two-cell distance were counted (radius of 2 km). The procedure for increasing the share of natural area is the same as that used for the green corridors under *Allowing Nature to Find its Way*. The created natural land use was randomly classified as forest (50%) or semi-natural areas (50%). Under the *Trend* scenario, the total area with low natural pest control and pollination, in the year 2050, is 794,411 km^2. Of this area, 78,877 km^2 are converted into a natural type of land use (Table AIII-9).

Step 6: Expansion of forests in upland areas to retain water
Increased water retention in upstream areas is presented on the land-use map by additional forests in these areas. Agricultural land was converted into forest (Figure AIII-4e), based on the afforestation scenario according to Burek et al. (2012). The land use for all areas with a slope of more than 10% and an elevation of over 500 m was reclassified as forest. Peat areas were excluded, since plantation of trees could lead to low groundwater level in these areas. The land use in urban areas, glaciers, snow-covered areas and sparsely vegetated areas, which are mostly above the tree line, was not reclassified as forest. This was done for all areas where the demand for flood regulation is larger than 0 according to Stürck et al. (2014).

Table AIII-9 shows the changes in land use aggregated to five categories. Overall, the assumptions under *Working with Nature* lead to a decrease in urban area and cropland and an increase in pasture, forest and open natural vegetation, compared to under the *Trend* scenario.

Table AIII-9. Deviations in land use in *Working with Nature* compared to the *Trend* scenario

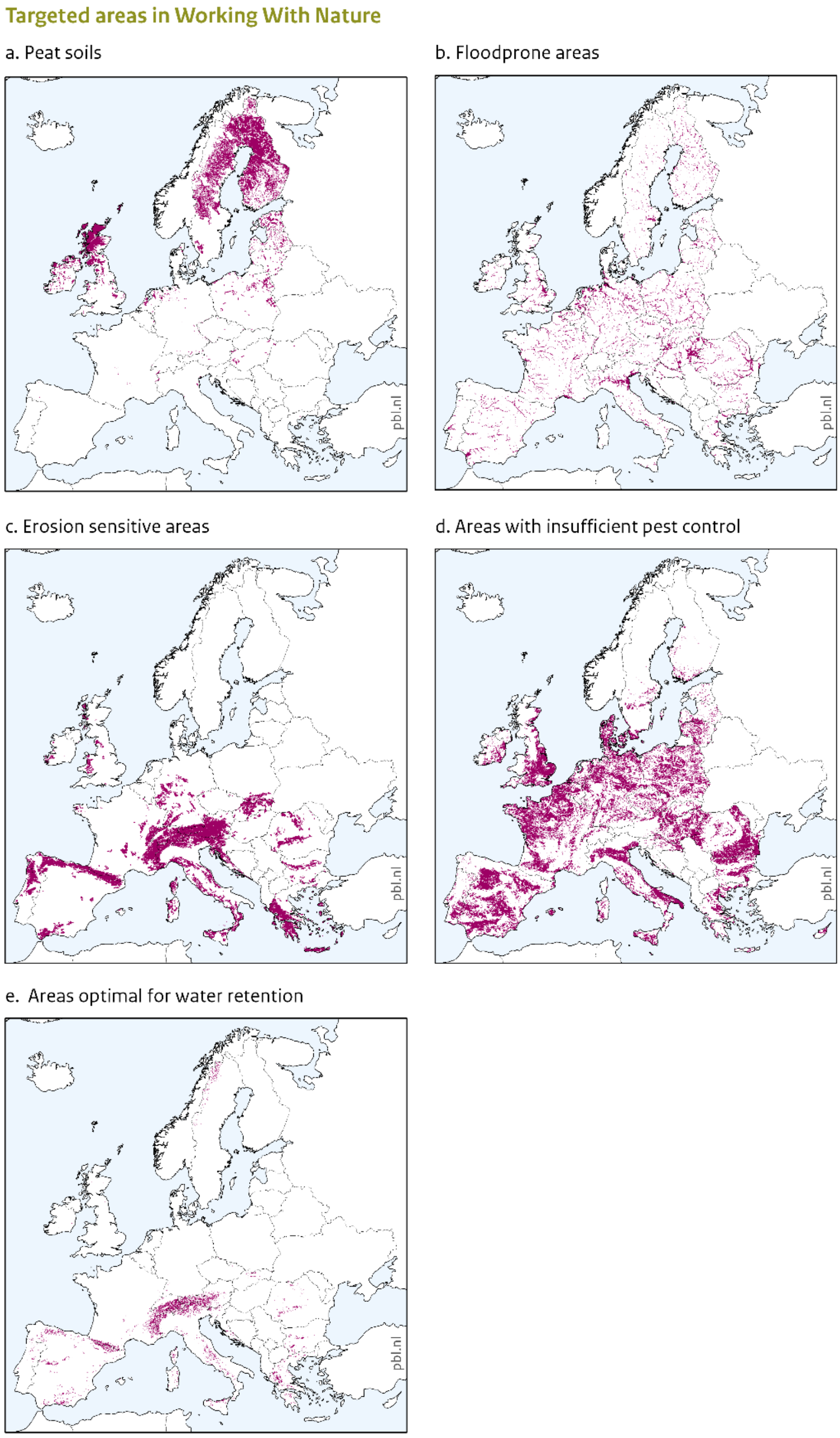
	Urban area	Cropland	Pasture	Forest	Other nature
Step 1	-1234 (-1%)	196 (0%)	854 (0%)	156 (0%)	28 (0%)
Step 2	-3424 (-1%)	308 (0%)	1985 (0%)	-127 (0%)	1258 (0%)
Step 3	-3424 (-1%)	-66938 (-5%)	69231 (12%)	-127 (0%)	1258 (0%)
Step 4	-3424 (-1%)	-72325 (-5%)	65947 (12%)	5088 (0%)	4714 (1%)
Step 5	-3424 (-1%)	-151202 (-11%)	65947 (12%)	44416 (3%)	44263 (7%)
Step 6	-3424 (-1%)	-152976 (-11%)	62686 (11%)	86721 (3%)	6993 (1%)

Environmental pressures

Under *Working with Nature*, management intensity is assumed to be multifunctional in forest areas. Nutrient use efficiency of crops, i.e. the rate of nutrient uptake by the crop compared to the nutrient application, is assumed to increase across the EU to today's top levels. In certain agricultural areas, management intensity levels are low to moderate to ensure the delivery of ecosystem services. Table AIII-10 shows the GIS rules for management intensity under *Working with Nature*.

Table AIII-10 Assumptions under *Working with Nature*

Pressure	Location modified	Rule
N application	Peat areas	Grassland = max 50 kg N/ha
	Flood-prone areas	Grassland = max 50 kg N/ha
	Eastern Europe (EU13)	Less N use, due to increasing efficiency (based on output of the IMAGE-Global Nutrient model)
Forest management intensity	All forests, excluding FMA 1 and 2 in N2000 and on steep slopes	FMA3



Source: PBL

Figure AIII-4. The selected areas under *Working with Nature*

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Annex IV

Impacts of land-use changes on species groups

The impact of the perspectives on biodiversity, compared to under the *Trend* scenario, was assessed based on the suitability of the various land-use types for species' occurrence and the effect of various levels of management intensity in agricultural areas and forests. Land conversion was assumed to directly affect species associated with five groups of land use: urban species, species associated with croplands, species associated with pastures, forest species and species living in open natural vegetation. Changes in management intensity was used for croplands, pastures and forest to distinguish between impacts on common species and endangered species. For urban areas and open natural vegetation, no information on intensity of use is available. Therefore, no specific impacts on common species or endangered species were distinguished. For each of the species groups the suitability of each land-use type and management intensity was determined (Table AIV-1). In the assessment of the perspectives, the change in conditions for each of the species groups, compared to the *Trend* scenario, was summed over the total EU.

Table AIV-1 Suitable (s) land-use types/management for common and endangered species

			Urban species		Species associated with cropland		Species associated with pastures		Forest species		Species associated with open natural vegetation	
	Intensity level (kg N/ha)	Forest management approach*	common	endangered	common	endangered	common	endangered	common	endangered	common	endangered
Urban area			s	s								
Cropland	0–100				S	s						
	>100–200				s							
	>200–300											
	>300											
Pasture	0–30						s	s				
	>30–100						s					
	>100–200						s					
	>200–300											
	>300											
Forest		FMA1							s	s		
		FMA2							s	s		
		FMA3							s			
		FMA4										
		FMA5										
Open natural vegetation											s	s

*FMA1: Unmanaged nature reserve; FMA2: Close-to-nature forestry; FMA3: Mixed-objective forestry; FMA4: Intensive even-aged forestry; FMA5: Short-rotation forestry.

Annex V

Summary of impacts of the perspectives on outdoor recreation services

The impacts were evaluated in four steps (see X-axis of Table V-2):
Step 1: The expert judgement about the expected change in the supply of outdoor recreational ecosystem services for each measure (see Y axis of Table V-2) by two indicators with each three sub-indicators. This was executed in a two-day workshop with recreation experts. First, the group of experts discussed the methodology and concluded on the indicator set. Next, they evaluated the change of supply of outdoor recreational services per intervention of all the perspectives. Interventions applying to the urban area were also taken into account. The results are given for each sub-indicator on a five-point scale (Table V-1).

Table V-1 Definition of five-point scale

Class	Change compared to *Trend* scenario 2050
-2	<-20%
-1	- 20% - -5%
0	-5% - 5%
1	5% - 20%
2	> 20%

Step 2: The calculation of the mean supply at indicator level
Step 3: The calculation of the demand for outdoor recreation services: a GIS analysis was executed to measure the population size within 5 km of the impact area. A 100*100 m grid of population density was used. The percentage of the European population with 5 km of the impact area is an indicator ranking the measures with respect to each other.
Step 4 Calculation of the supply of outdoor recreational services weighted by demand.

Table V-2 Results of expert judgement on outdoor recreation services

Interventions	Step 1: Expert judgement – Recreational attractiveness per indicator: Attractiveness landscape	Special features	Absence of disturbances	Accessibility per indicator: Infrastructure and facilities	Proximity	Public space or not	Step 2: Average supply: Recreational attractiveness	Accessibility	Step 3: Demand: Inhabitants within 5 km (share of EU population)	Step 4: Supply weighted by demand: Weighted Attractiveness	Weighted Accessibility
Strengthening Cultural Identity											
Development of recreational landscapes in urban regions	2	1	1	1.5	2	1	1.3	1.5	68%	0.9	1.0
Preservation of characteristic landscapes	2	1	1	1	1	1	1.3	1	59%	0.8	0.6
Urbanisation of peri-urban regions	0	0	-1	-1	-1	-1	-0.3	-1	21%	-0.1	-0.2
Urban intervention: Introduction of more green on people’s doorstep in all districts of cities	2	1	2	2	2	2	1.7	2	75%	1.3	1.5
Allowing Nature to Find its Way											
Large nature areas	-1.5	-1	1	-1	-2	1	-0.5	-0.7	24%	-0.1	-0.2
Bluegreen corridors	1	0	1	1	1	1	0.7	1.0	1%	0.0	0.0
Green Corridors	1	0	1	1	1	1	0.7	1.0	7%	0.0	0.1
Buffer zones protecting small nature areas	1	0	1	0	1	0	0.7	0.3	63%	0.4	0.2
Urban intervention: Enlarging city parks to wilderness parks	-1	-1	0	0	-1	0	-0.7	-0.3	19%	-0.1	-0.1

	Step 1: Expert judgement						Step 2: Average supply		Step 3: Demand	Step 4: Supply weighted by demand	
	Recreational attractiveness per indicator			Accessibility per indicator							
Interventions	Attractiveness landscape	Special features	Absence of disturbances	Infrastructure and facilities	Proximity	Public space or not	Recreational attractiveness	Accessibility	Inhabitants within 5 km (share of EU population)	Weighted Attractiveness	Weighted Accessibility
Going with the Economic Flow											
Abandonment of agricultural areas	-2	0	-1	-2	-2	1	-1.0	-1.0	21%	-0.2	-0.2
Privately-owned parks	1	1.5	-1	1	0	-2	0.5	-0.3	61%	0.3	-0.2
Country villas in metropolitan regions	1	0	0	-2	0	-2	0.3	-1.3	18%	0.1	-0.2
Intensification of agriculture	-2	-2	-2	-0.5	-1	0	-2.0	-0.5	15%	-0.3	-0.1
Increased recreation	-2	0.5	-2	1.5	0	0	-1.2	0.5	25%	-0.3	0.1
Urban intervention: Introduction of entrance fees in city parks	1	1	-1	0	-1	-2	0.3	-1.0	38%	0.1	-0.4
Working with Nature											
Extensification of flood-prone areas	0	1	1	1	1	0	0.7	0.7	43%	0.3	0.3
Afforestation in erosion-sensitive areas	0	0	0.5	0	0	0	0.2	0.0	16%	0.0	0.0
Greening cropland to introduce habitats for predators and pollinators	1	0	1	0.5	1	1	0.7	0.8	73%	0.5	0.6
Conservation and restoration of peatlands	1	1	1	1	0	0.5	1.0	0.5	5%	0.1	0.0
Afforestation for water retention	0	0	0	0	0	0.5	0.0	0.2	4%	0.0	0.0
Transition to multifunctional forest management	2	1	1	2	0	0	1.3	0.7	10%	0.1	0.1
Urban intervention: Introducing nature-based solutions for water retention. (heat) stress reduction and water purification	2	1	1	2	2	0.5	1.3	1.5	75%	1.0	1.1