Estimating costs of nature management in the European Union

Exploration modelling for PBL's Nature Outlook

R.W. Verburg, W.H.G.J. Hennen, L.F. Puister, R. Michels & K. van Duijvendijk

WOt-technical report 97

WAGENINGEN UNIVERSITY & RESEARCH

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This document contributes to the body of knowledge which will be incorporated in more policy-oriented publications such as the National Nature Outlook and Environmental Balance reports, and thematic assessments.

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Abstract

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A cost model was developed for the Nature Outlook of PBL Netherlands Environmental Assessment Agency. This cost model estimates one-off and recurrent costs of natural vegetation based on Corine land cover types throughout Europe. Cost estimates were made for the base year 2000 and future scenarios, including a Trend scenario based on current EU policies and normative perspectives, including Strengthening Cultural Identity (SCI), Allowing Nature to Find its Way (NFW), Going with the Economic Flow (GEF) and Working with Nature (WWN). These scenarios all have a time horizon of 2050. To estimate various costs a comprehensive data analysis was carried out and a cost model was developed based on the IKN model for Dutch Nature Policy. The model estimates costs of recurrent management in the base year on € 5.6 billion per year in the EU-28. Costs of recurrent management within the Natura 2000 network is estimated on € 3.5 billion per year. Recurrent management costs in 2050 in the Trend scenario were estimated on € 5.2 billion per year. One-off costs of land purchase are estimated at € 450 per hectare per year and construction costs € 1028 per hectare per year. One-off costs of the perspectives are 5.09 (SCI), 6.56 (NFW), 6.20 (GEF) and 9.79 billion euro per year (WWN).

Keywords: Cost model, IKN model, Nature management, Nature policy, Outlook, Land purchase, Recurrent costs

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Preface

Between 2014-2017 we have developed a new cost model for the PBL's Nature Outlook. Through recurrent discussions with Jaap Wiertz, Henk van Zeijts, Anne Gerdien Prins and Arjen van Hinsberg (all PBL Netherlands Environmental Assessment Agency) we were challenged to improve the model and to provide relevant results for the Nature Outlook team. We thank Jaap Wiertz, Henk van Zeijts, Anne Gerdien Prins, Arjen van Hinsberg, Onno Knol, Sandy van Tol, Marjon Hendriks (all PBL) and Irene Bouwma and Rogier Pouwels (Wageningen Environmental Research and Statutory Research Tasks Unit for Nature & the Environment) for their feedback during the project work.

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Summary

PBL Netherlands Environmental Assessment Agency has developed four 'perspectives' (normative scenarios) on nature in Europe in its Nature Outlook study to capture the differing views people have on nature (Van Zeijts *et al.*, 2017). Moreover, a Trend scenario has been developed that includes current EU nature policies, among other policies. This report provides the results of indicative calculations with respect to the costs associated with nature management and one-off costs, such as conversion of land to new nature areas, for the current situation, under the Trend scenario and under the four perspectives. The four perspectives are the following: Strengthening Cultural Identity (SCI), Allowing Nature to Find its Way (NFW), Going with the Economic Flow (GEF) and Working with Nature (WWN). These scenarios have all a time horizon of 2050.

To carry out such cost estimates, various steps are taken which are described in this report. Data from various sources were collected, analysed and aggregated to create normalized costs. A cost model was developed, based on previous experiences of a cost model developed for the Dutch case of nature management. The presented cost model covers nature management in EU-28 and includes two types of costs. The first type is the cost of recurrent management, which includes nitrogen removal measures and conservation management to maintain vegetation in desired developmental stages. The model also includes one-off costs that are associated with investment costs of land purchase and land conversion. The latter type includes measures to convert agricultural land and natural vegetation to other types of natural vegetation. The one-off costs are annualized to provide yearly costs.

The model estimates costs of recurrent management in the base year (2000) on € 5.6 billion per year in the EU-28 for all nature areas (both inside and outside Natura 2000). Costs of recurrent management within the Natura 2000 network is estimated on € 3.5 billion per year and corresponds to ca. € 40 to € 60 per hectare per year for all recurrent management activities. Large variation in recurrent costs is found among the different land cover types. Highest values are observed for sparsely vegetated areas, moors and heaths, where costs are between € 300 and € 380 per hectare per year. Low costs occur for sclerophyllous vegetation and salt marshes where costs are less than € 5 per hectare per year.

A large share of recurrent management costs in the base year can be attributed to conservation management while a relative small portion is attributed to nitrogen management. In vegetation types where conservation management occurs – natural grasslands, moors and heaths, beaches and dunes, sparsely vegetated areas, inland marshes and peat bogs –, the costs of conservation management ranged between 30% (sparsely vegetated areas) and 96% (peat bogs) of total recurrent costs. When keeping these vegetation types in the current (desired) stage, relatively high costs are made. In other vegetation types, expenditures are mainly due to nitrogen emissions and exceedance, and thus to measures to remove nitrogen from vegetation.

Recurrent management costs in 2050 under the Trend scenario are substantially larger than in the base year. These higher costs can be fully attributed to the larger area of natural vegetation cover by 2050. Due to predicted lower nitrogen emissions from industry and traffic in 2050, nitrogen exceedance of critical loads for vegetation are expected to be much lower than in the base year. As a consequence, almost all recurrent management costs are costs for conservation management, rather than for nitrogen removal.

One-off costs are non-recurrent investments into land purchase or land depreciation, and construction costs, e.g. land conversion, habitat restoration or infrastructure. These costs were estimated for various scenarios: Strengthening Cultural Identity (SCI), Allowing Nature to Find its Way (NFW), Going with the Economic Flow (GEF) and Working with Nature (WWN). Average costs of land purchase are estimated at € 450 per hectare per year and construction costs € 1028 per hectare per year. One-off costs are lowest under the Trend scenario, but are still 3.34 billion euro per year as agricultural land

become abandoned and converted in to forest (i.e., land depreciation costs). One-off costs of the perspectives are 5.09 (SCI), 6.56 (NFW), 6.20 (GEF) and 9.79 billion euro per year (WWN). They are highest under the WWN scenario because part of the agricultural land is dedicated for the delivering of several ecosystem services. Splitting up the total into land purchase and construction costs shows that under the Trend scenario land purchase costs and land depreciation were lowest (2.76 billion euro per year), while in GEF the construction costs were the lowest (0.56 billion euro per year) compared to the other scenarios. The calculated one-off costs are much larger than found in literature. However, those literature sources did not take all aspects of one-off measures into account and even neglect the most costly aspects, such as measures for land conversion.

Although investment costs of some scenarios are relatively high, investments could still be worthwhile as economic and societal benefits of those scenarios could be large as well. Including the benefits of the different scenarios will provide a more balanced outcome of a quantitative economic analysis, and are therefore essential for balanced policy decisions. Benefits for biodiversity and ecosystem services can be found in Prins *et al.* (2017).

1 Introduction

Background
Throughout Europe, nature is highly diverse in form, function and biodiversity levels and is well perceived by its citizens (Van Zeijts *et al.*, 2017), but perspectives on nature also vary widely among groups of people . From a policy perspective, the EU Biodiversity Strategy to 2020 (EC, 2011) and the Natura 2000 network has gained most attention. Although progress has been made in creating this network to 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 (Prins *et al.*, 2017). The Nature Outlook (Van Zeijts *et al.*, 2017) aims to widen the scope of possible nature policy strategies to address issues on how people value nature and how these values can be guided to protect nature. This work has led to the development of narrative scenarios or perspectives on possible trajectories of nature development up to 2050. These are *Strengthening Cultural Identity*, *Allowing Nature to Find its Way*, *Going with the Economic Flow* and *Working with Nature*. In addition a Trend scenario was developed to compare these normative scenarios.

To make the storylines of the perspectives more clear and defined, the state of nature across the EU has been elaborated, in each of the perspectives. Impacts on land use, biodiversity and ecosystem services were assessed, using GIS and modelling tools (Prins *et al.*, 2017). In terms of effectiveness and efficiency, economic analysis can provide useful information on costs and possible costs reduction that can be highly valuable to decision making.

The information on costs can be used in different ways. First, assessments of cost effectiveness, i.e., assessment of the lowest cost to realize biodiversity policy targets can be made. Secondly, cost estimations can be used to develop scenarios and third cost calculations and estimations up to 2050 can show that some spatial scenarios might be less costly than others. In the latter case, scenarios could be developed given a fixed amount of budget. To answer such questions, accurate cost figures on the various aspects concerning the nature areas in Europe is needed. However, in the literature and (publicly) available datasets no overarching studies and datasets are available on cost estimates of nature in general and the Natura 2000 network in the EU Member States in particular. Instead, several studies only focus on partial costs, while others provide cost estimates for only a few vegetation types that constitute the Natura 2000 network. Available data suggest that a coarse classification of vegetation types can be used to differentiate costs..

In this study, we make use of different data sources, that are compared and combined to deliver reliable cost estimates of different aspects. Data sources are various Dutch studies, management reports of Natura 2000 Habitats' of DG Environment and a study of Gantioler *et al.* (2010). Additional data were collected from Eurostat and FADN (farm based statistics). These data include, amongst others, land (rental) prices, labour prices and GDP corrections.

Objective of the study
The objectives of this study are threefold:

- A stock-taking of data on various costs required to deliver normalized costs on recurrent and one-off costs related to nature management.
- Development of a model to simulate potential costs in the EU context, based on the (experiences with) the Dutch IKN nature management cost model.
- Delivering cost estimates of nature management for the base year (2000 in the Nature Outlook project) and cost estimates of nature management and development for 2050 under the different scenarios developed in the Nature Outlook project of PBL Netherlands Environmental Assessment Agency .

Organisation of the report

This report is organised in the following way: in Chapter 2 a theoretical background is provided regarding the different concepts used to develop the cost model as well as the various aspects included in recurrent management and one-off costs. In Chapter 3 a description is provided of all data sources used in this project as well as the compilation and aggregation of data to provide normalized costs of the different aspects. Chapter 4 describes the cost model, the model components and the databases. Chapter 5 provides the results of the cost calculations. Recurrent costs of the base year are presented as well as the recurrent and one-off costs under the Trend scenario. For the other scenarios only the one-off costs are provided. In Chapter 6, a discussion with respect to the most relevant results is provided followed by a conclusion on the main findings.

2 Theoretical background

2.1 Introduction

Reviewing international (scientific) literature reveals that no modelling framework on cost estimates of nature in general or the Natura 2000 network in particular exists. To date, only the reviews made by Gantioler *et al.* (2010) and Gantioler *et al.* (2014), which are mostly based on surveys, provide some insights in the specification of different cost elements. We used the framework of Gantioler *et al.* (2010) for the development of the cost model, while developing some aspects further to meet the specific aims of the present study.

The modelling framework presented in this study focusses only on terrestrial ecosystems. Cost estimates of marine ecosystems are not included. The framework is developed in such way it could use modelling output of the Bioscore model (Hendriks *et al*., 2016), which uses land cover types (CLC-3 types from Corine) rather than the Habitat types classification of Natura 2000. We used the area boundaries of Natura 2000 sites from GIS layers to restrict the estimated costs to the Natura 2000 area.

The proposed modelling framework largely builds upon the methodology developed for the Dutch nature cost model IKN (Schouten *et al.*, 2012). In addition, various costs are included that are found in European literature. Moreover, welfare effects of member states, reflected by differences in costs of production factors such as labour and capital, are taken into account.

The methodology is based on the use and implementation of normalized prices of activities. Using this approach, we assume that a particular activity has one standard price, within a certain (spatial) context. Nonetheless, previous studies (Balmford *et al.*, 2003; Bruner *et al.*, 2004; Vreugdenhil, 2003) have found that standard price variations can be explained by sizes of protected areas, the population density of a particular country or nearby conservation sites and the income level of countries. However, correlating costs with size of conservation site area is difficult, as no data in the literature is available for such analysis. Therefore, we assumed costs to be generic, irrespective of site area. With regard to income level, we assumed that the standard price level is dependent on the level of wages in a particular country. To implement this, we use the standard price level multiplied by a specific 'welfare index' calculated for the different EU member states.

2.2 Structure of the cost components

The modelling framework comprised a division between one-off and recurrent costs. One-off costs are subdivided into costs of land purchase and construction costs (including restoration costs). Land purchase includes the economic costs of land conversion from agricultural use to natural vegetation and only applies to future scenarios. Hence land purchase are calculated between the current situation and a future scenario. Recurrent costs include nitrogen management and conservation management. Agri-environmental management are also recurrent costs (see Figure 2.1), but not included in the cost model, because only price levels of subsidies by country are known. These subsidies could not be attributed to specific management types.

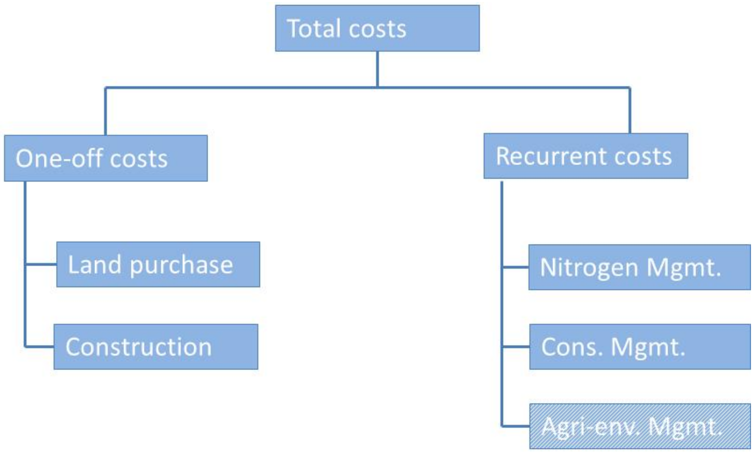

Figure 2.1 *The division of the different cost components applied in the modelling framework.*

The study of Gantioler *et al.* (2010) takes costs for personnel, monitoring, research, and surveillance into account. In other words, the costs of administration and apparatus. Such issues are not dealt with in the Dutch version of the modelling framework (Schouten *et al.*, 2012). To align current modelling results with previous Dutch results, we did not take into account such administrative costs. Cost estimations therefore include only those costs directly related to acquisition of new nature areas and management/conservation of nature areas.

2.3 Recurrent costs

2.3.1 Introduction

Recurrent management are activities related to nature management that have to be carried out on a yearly basis, - or calculated on a yearly basis when frequencies are between 1-5 years and at (potentially) an infinite time scale. These activities relate to mitigating adverse effects of environmental pressures to natural vegetation types and biodiversity. Pressures affecting habitat quality include desiccation, eutrophication, acidification, fragmentation, and climate change. These pressures can lead to degraded ecosystems and a decrease in habitat quality of species. Habitat fragmentation causes pressure on plant and animal populations such as reproductive isolation and inbreeding depression (Fahrig, 2003; Tilman *et al.*, 1994). As a result, populations may run an increasing risk of local extinction. To reduce effects, nature areas can be enlarged by (re)connecting nature fragments in landscapes through land purchase and land restoration.

The pressures indicated here may occur on different spatial scales. For example, desiccation and acidification occur very locally, while eutrophication due to (atmospheric) nitrogen deposition occurs on a larger scale. Desiccation and acidification (e.g. Bobbink *et al.*, 1998) of vegetation are well known pressures on vegetation structure and biodiversity. Desiccation is usually a local phenomenon and caused by (ground) water withdrawal near agricultural areas. Acidification by sulphur emissions has been an European wide pressure on the state of nature areas. Application of lime to increase pH and base saturation seems to be an adequate measure to restore vegetation from acidification (e.g., Roelofs *et al.*, 1996). We assume this to be part of the one-off costs.

Eutrophication by nitrogen has various sources, such as point pollution by agriculture (mainly nitrogen leaching) and atmospheric nitrogen deposition from industry, traffic and agriculture (NO_x, including NH_3). These deposition sources put considerable environmental pressure on plant biodiversity, species composition and results in biomass accumulation in vegetation. Effects of nitrogen deposition on vegetation structure and biodiversity are well known and studied in much detail in the 1980's and 1990's (e.g. Bakker and Berendse, 1999; Bobbink and Roelofs, 1995; Nordin *et al.*, 2005), and also studied in modelling frameworks (e.g., Van Dobben *et al.*, 2006). Critical nitrogen loads of vegetation are used to determine the impacts of nitrogen deposition. These critical loads are vegetation specific (e.g., Bobbink and Hettelingh, 2010; Bobbink, 2004).

2.3.2 Management of nitrogen exceedance

Exceedance levels of critical nitrogen loads of vegetation are used to determine the need and type of recurrent nature management. If the level of atmospheric nitrogen deposition exceeds the vegetation specific critical nitrogen load, it is assumed that recurrent management should take place to remove accumulated biomass to assure high plant diversity. In any vegetation nitrogen is stored above and belowground. In grassland vegetation removal of aboveground biomass results in the removal of a fraction of nitrogen. Therefore, measures like grazing or mowing results in a yearly efflux of nitrogen from the system. Belowground nitrogen however, is not removed and nitrogen can accumulate in the soil compartment.

The amount of nitrogen removed from aboveground vegetation is described by Bobbink and Hetelingh (2010) and can be defined as:

$$\mathrm{N}_{remove} = 11.152 * \mathrm{AGB}_{act} + 0.88651 \quad (2.1)$$

Where,
N_{remove} = amount of nitrogen removed from above ground biomass (in kg N/ha/yr)
AGB_{act} = Actual amount of aboveground biomass (in ton/ha/yr)

To calculate nitrogen removal from vegetation an estimation of the yearly amount of aboveground vegetation is needed. Grassland productivity is determined by various factors, such as temperature, altitude, rainfall, soil type and nutrients (e.g., Hector *et al.*, 1999; Lane *et al.*, 2000; Munson and Lauenroth, 2014). Depending on local site conditions, aboveground European grassland productivity ranges between 2 and 13 ton dry matter per hectare per year (Table 2.1). Assuming the average aboveground biomass values will fall within this large range, more precise calculations are needed that take into account local determinants of biomass production. These calculations are determined by the various input data, such as altitude, rainfall, soil type and nutrient availability. For the calculations, we used a nested approach, of temperature, soil moisture content and soil type. The latter on as indicator of soil fertility.

Table 2.1
Potential levels of aboveground biomass of different vegetation. Based on: Alday et al. (2015), Cerrillo and Oyonarte (2006), Leeuw et al. (1990), Truus (2010), Willems et al. (1993)

Grassland type	Potential AGB (ton/ha/yr)
Dry grassland	2.5
Moist grassland	5.7
Wet Grassland	4.5
Pastures	10
Bogs	2
Reed and swamps	13
Salt marshes	2.9
Heathland moor (only herb layer)	5.2

GIS data of the European Environmental Agency on biophysical constraints (soil, moisture, temperature) are used as input to the cost modelling. These input data with various parameters and specific values, will determine the different scalar functions that are developed for the cost model. These scalar functions are needed to estimate aboveground biomass of vegetation. Such values are needed to calculate amounts of nitrogen efflux by the yearly removal of aboveground biomass. Three scalar functions (steps) are defined. The first step encompasses the division of vegetation from high altitudes and longitudes and lowland vegetation. High altitude/longitude vegetation has relatively low aboveground biomass due to a short growing season. For this, the temperature sum (T_{sum}) is used for both altitude and longitude. Aboveground biomass (AGB) of boreal and high altitude vegetation is determined by:

If $T_{sum} < 2500,\ AGB = 0.75$ (2.2)

Where T_{sum} = Sum of temperature (in °C, 0-6000).

The limit of 2500 was set by visual inspection of the distribution maps of vegetation in Europe. At this limit, highlands in Scotland, lowlands in Iceland, mid and north Scandinavia and mountain ranges in the Alps and Pyrenees, for example, are considered montane/boreal vegetation (Figure 2.2). This threshold limit is to some extent arbitrary and only affects the amount of accumulated aboveground biomass calculations and therefore the amount of nitrogen in aboveground vegetation that can be removed annually.

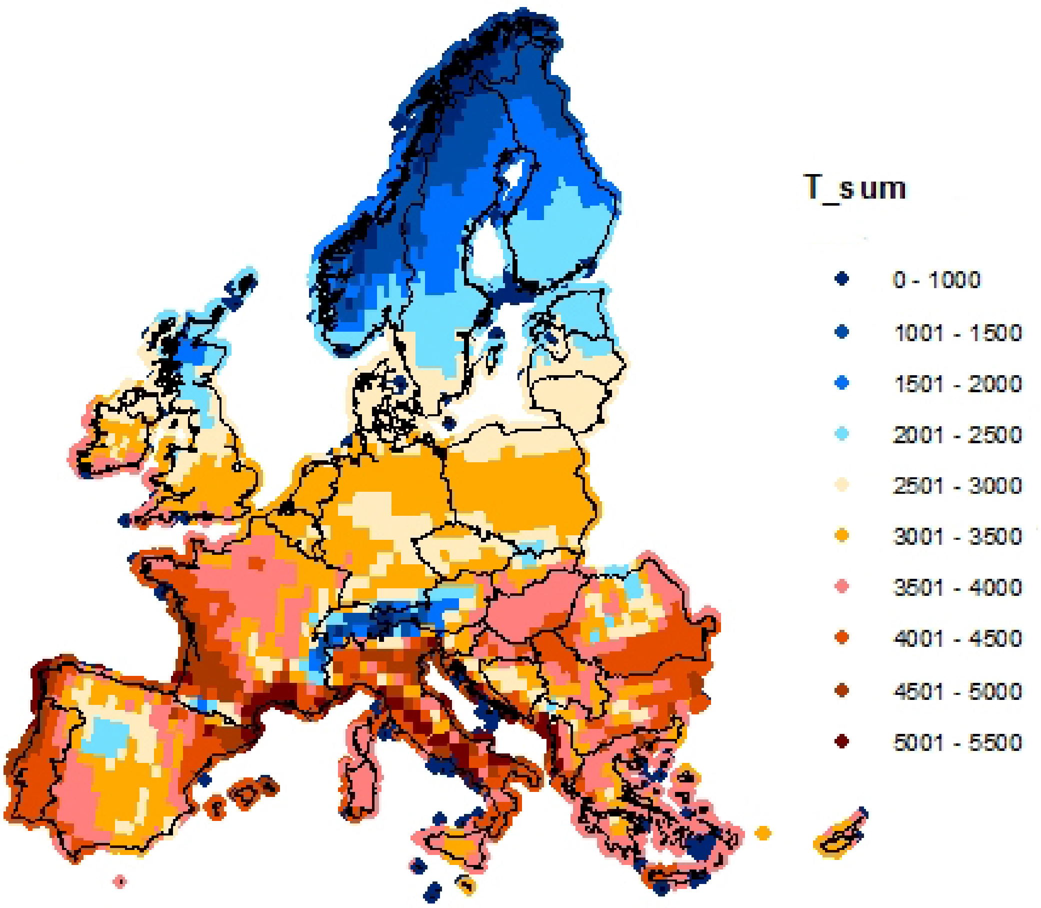

Figure 2.2 *The spatial distribution of T_{sum} values. T_{sum} <2500 is considered montane/boreal vegetation (blue colours) and T_{sum} > 2500 lowland/temperate vegetation (orange and red colours).*

The second step includes the effect of moisture content of the soil on aboveground biomass. The soil moisture index, ranging from 0 to 1.5 was used. The relation between AGB and the index was scaled in such a way that the AGB of natural moist grasslands (6 ton/ha/yr) was assumed at a moisture index value of 1. This resulted in the following scalar function:

$$AGB = (5.9868 \text{ x Moisture Index}) + 0.0395 \quad (2.3)$$

Where moisture index = annual moisture index of soil (0-1).

The spatial distribution of the soil moisture index is depicted in Figure 2.3.

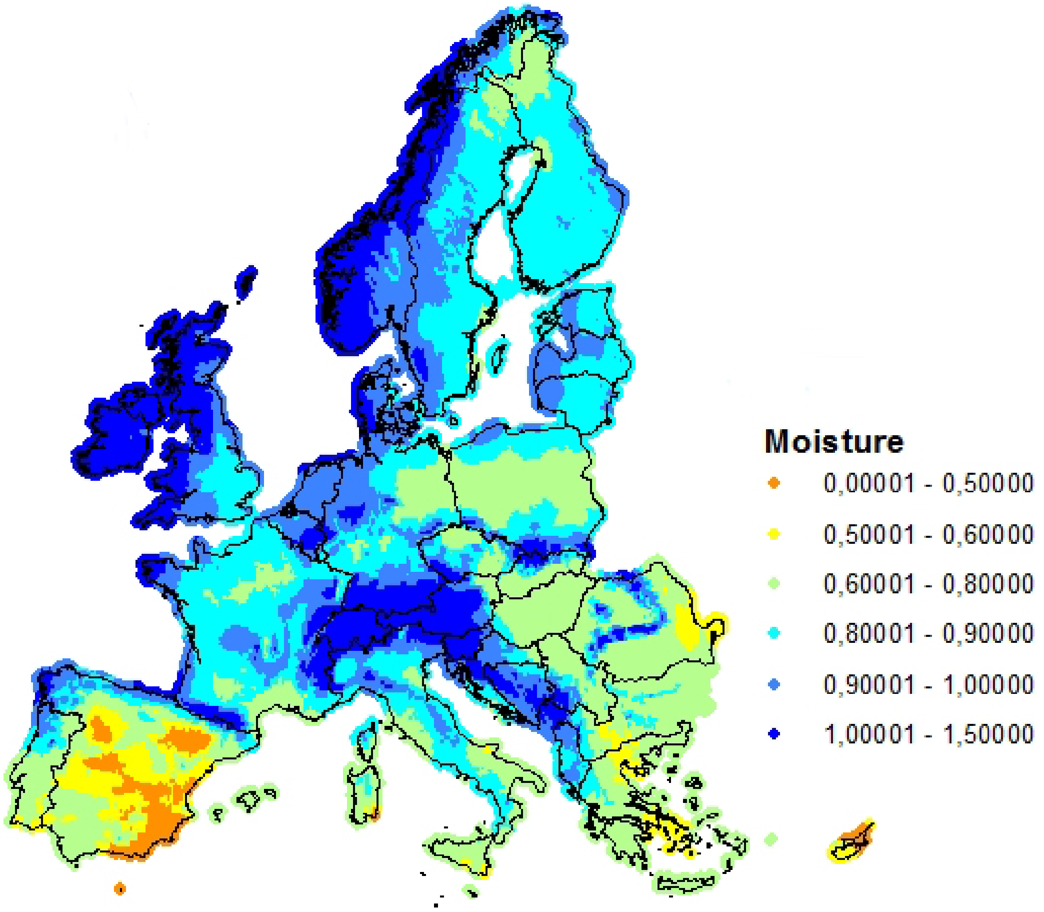

Figure 2.3 *The spatial distribution of soil moisture content.*

The third step included the effect of soil fertility on AGB. Clay content of soil was used as a proxy for nutrient availability in natural growing conditions. The clay content is used as a factor to be multiplied with AGB. At high levels of clay (> 40%) this factor will lead to a value of 1.3 (AGB = 7.8 ton/ha/yr). The function of the scalar function is:

$$AGB_{act} = ((0.02 \text{ x Clay content}) + 0.5) \text{ x AGB} \quad (2.4)$$

Where AGB_{act} = the actual aboveground biomass, Clay content (in %, 0-40)

The spatial distribution of soil moisture is depicted in Figure 2.4.

In cases where nitrogen removal from grazing or mowing is not sufficient to meet the critical exceedance levels, more drastic measures have to be taken. Typically, in heathland vegetation sod cutting and removal of the top soil layer is used as an effective measure to remove nitrogen (e.g., Britton and Fisher, 2007; Power *et al.*, 2001; Terry *et al.*, 2004). In aquatic environments, like water bodies, dredging is applied to remove large quantities of accumulated nitrogen. These types of measurements are very expensive, but are carried out at low frequencies ranging from once in 20 to one in 30 years. When applying these measures, the nitrogen will almost completely be removed from ecosystems leading to an effectiveness of 95-99% nitrogen removal. As a down site, these measures cannot be carried out frequently, since seed banks in vegetation are destroyed, leading to poor rehabilitation conditions.

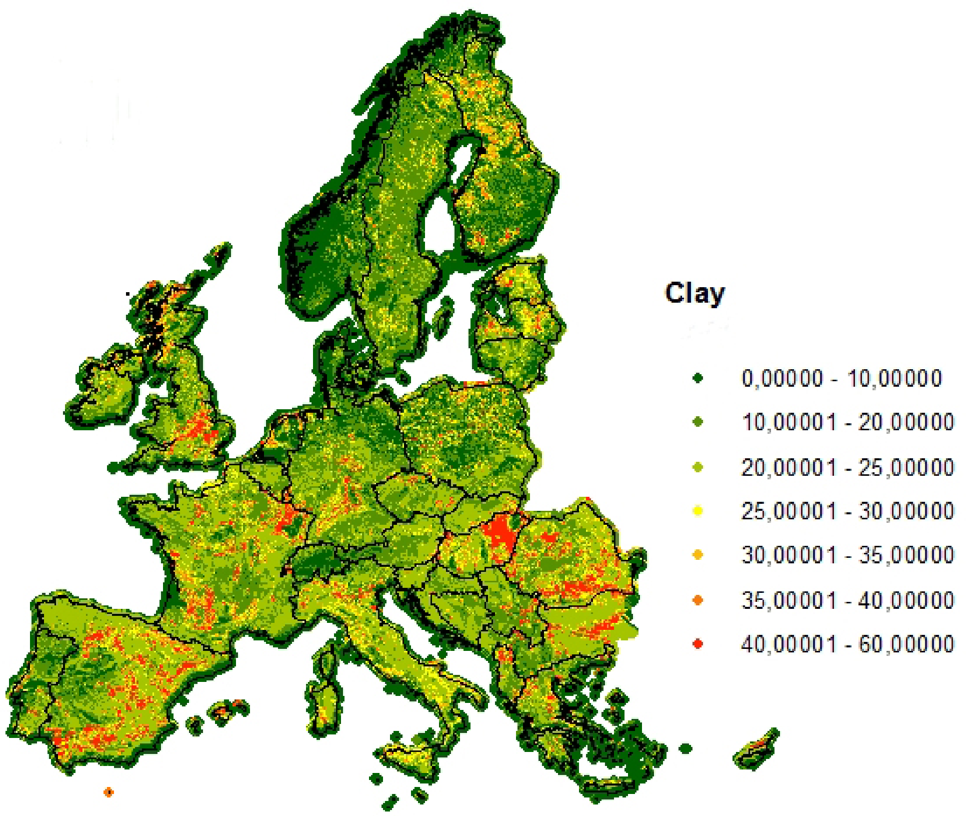

Figure 2.4 *The spatial distribution of the clay fraction.*

2.3.3 Conservation management

In addition to the recurrent nitrogen management, costs for conservation management were included. This type of management refers to the conservation of specific vegetation to inhibit further natural succession, a so-called plagio-climax stage. For example, many grassland and heather vegetation in western Europe is defined as plagio-climax vegetation, caused by former agricultural usage. If such vegetation is allowed to develop further, these types will change in various forms of forest vegetation. Maintaining such vegetation in the desired (plagio-climax) stage requires recurrent management, which we refer to as conservation management. Such management is to a large extent independent of environmental pressures, such as nitrogen deposition. To define the areas where such management would be required, the natural distribution maps of vegetation types in Europe were compared with the actual distribution of vegetation types. If the current distribution of a particular vegetation type, like heather, does not overlap with the natural distribution, conservation management is applied. Such management includes mainly mowing and grazing (Wamelink *et al.*, 2007).

2.3.4 Agri-environmental management

The third management type includes agri-environmental management schemes. In this case, nature management is deployed on agricultural land. For this, the present budgets of agri-environmental schemes can be used (as defined in the Common Agricultural Policy), which cannot further broken down in specific activities or biodiversity indicators due to incomplete information.

2.4 Effectiveness of recurrent management

The model calculates the costs of recurrent management when the level of atmospheric nitrogen deposition exceeds the level of critical nitrogen loads of vegetation or costs when conservation management is needed. These costs, however, do not provide information on the effectiveness of the proposed measures. Adjacent models used in the Nature Outlook, such as Bioscore, evaluate biodiversity impacts and biodiversity patterns in different scenarios. Effectiveness of costs and the associated measures can only be evaluated taking aspects of biodiversity (number of species, species diversity, etc.) into account.

As an indicator of effectiveness, nitrogen exceedance levels are used in relation to the atmospheric nitrogen emissions in a linear way and depicted as a relative value for species richness:

$$Exceedance = \left(\frac{N_{dep} - N_{crit}}{N_{crit}}\right) * 100 \qquad (2.5)$$

Where,
N_{dep} = atmospheric nitrogen emissions (in kg N/ha/yr)
N_{crit} = critical nitrogen load of vegetation types (in kg N/ha/yr)

2.5 One-off costs

One-off costs are defined as costs associated with measures that are applied only once. Such costs can be applied to future scenarios, but not for the base year. These measures are associated with the need to enlarge nature areas or developing other types of nature . The land conversion between the base year and 2050, usually from agricultural land to natural vegetation, is calculated for each scenario. The resulting land conversion matrix, i.e., the state of land cover (CLC classes) in the current situation compared to the land cover in the future situation, is used as input to calculate one-off costs. In one-off costs the purchase of land for nature purposes and the transformation of land to natural vegetation are taken into account.

2.5.1 Land purchase

Although land conversion into natural vegetation in the Dyna-CLUE model does mostly occur due to abandonment of agricultural land, opportunity costs should be calculated. Land that is no longer used for agricultural practices include costs of missed opportunities and is referred to as depreciation costs.. The calculated opportunity costs do not involve costs for specific actors (individual farmer, governments, etc.), but can be seen as costs for society. If current land use comprises natural vegetation and the land use scenario determines conversion to other natural vegetation, no costs for land purchase are made.

The costs for land purchase are converted into annualized costs, using the full period of a scenario. Assuming the base year at 2000 and the future scenarios time horizon for 2050, the time interval enumerating one-off costs is 50 years. In addition, annualizing one-off costs should include a discount rate. Setting a particular discount rate should envisage the long term governmental investments and opportunity costs. In the Netherlands, a discount rate of 2.5% is used for long term governmental projects (Romijn and Renes, 2013), such as investments in nature.

2.5.2 Conversion costs

Various types of measures can be taken when land uses are converted from one type to another. Abandonment of agricultural land may lead to natural vegetation without interventions. In this particular case no conversion costs are made. Conversion measures taken could include modest restoration measures, such as removal of woody components, a period of intensive mowing to remove surplus of nitrogen, or more expensive measures such as soil removal, digging, tree planting and sowing. Costs of such measurements based on international data and literature are scarce.

An analysis of various data sources was carried out to derive a generic set of measures that were linked to specific land conversion types. Costs of such conversions are assumed one-off costs and the costs are annualized using the same procedure described for land purchase costs.

3 Input data and parameterisation

3.1 Introduction

In this chapter data collection and parameterisation of the different variables used in the cost model are described. The structure of the data collection is in line with the description in Chapter 2. Cost calculations are carried out at the level of vegetation types. The Habitat directive of the Natura 2000 network in Europe is developed around so called habitat types, while various national governments use specific classifications. For example, within the Dutch nature policy, nature types are used (see also Schouten *et al.,* 2012).Therefore, the consistency between these different systematics are analysed to derive meaningful values. In the Nature Outlook project, as well as the costs model, Corine land cover maps are used as primary input (Prins *et al.*, 2017; Hendriks *et al.*, 2016). The Corine maps are available at the EU level at a grid size of 1 km^2 and 25 km^2. To be able to construct a database on the various costs elements, specific information of vegetation types, for example habitat types, should be converted into Corine land cover types. Available data from literature search suggested that a coarse classification of vegetation types could be made. In this case a cross-analysis between the habitat types, the Dutch nature type classification and the Corine land cover classes was made.

3.2 Land use and vegetation types

The Corine land cover classes are developed at three aggregated levels (see Annex 2). The highest aggregation level includes only five land cover types, the intermediate level fifteen classes and the lowest level (CLC level 3), 44 classes. The typology include both artificial and natural classes. However, the typology does not include (much) ecological information and data on vegetation types. Hence, several conversion steps had to be included to ensure enough information of specific vegetation types was included/covered.

For this, a classification of habitat types was made (see Annex 1). These habitat types correspond to the descriptions within the Habitat Directive of Natura 2000 of the European Commission. Habitat types were then reclassified and aggregated to vegetation classes. These classes are partly based on vegetation structure, but also on locality. The classification is partly in line with the 'EU Handbooks of Natura 2000 habitats' Technical Reports. The ca. 200 habitat types resulted in nine coarsely defined types (see Annex 1). Based on these habitat descriptions, the nine aggregated classes were defined as: Bogs, Dunes, Forests, Grasslands, Marine ecosystems, Rock surfaces, Scrubs, Salt marshes and Water courses and ponds.

In addition, many cost estimates (both recurrent and one off costs) are based on Dutch norm values (DLG, 2009) and the Dutch nature cost database, IKN (Schouten *et al.*, 2012). In this database, ca. 18 nature types are included. A cross link between the nine habitat classes, the Dutch nature types and the CLC level 3 type of the Corine land cover map was made. This resulted in 19 land cover types with predominately natural vegetation, for which nature management costs could be developed. These 19 CLC classes are narrowed down to so-called 'management types'. A management type can be defined as a set of vegetation types with a common type of recurrent nature management (like, grazing, mowing, etc.). The management types comprise grasslands, moorlands, wetland and swamps, forests, salt marches, water courses and sand dunes, see Table 3.1. Management types are the anchor points to calculate recurrent costs. Both CLC 3 and management classes are included in the costs database.

Table 3.1

CLC 3 Corine land cover classes and corresponding management types for a CLC 3 type.

CLC code	CLC name	Management type
231	Pastures	Grasslands
243	Land principally occupied by agriculture, with significant areas of natural vegetation	Grasslands
321	Natural grasslands	Grasslands
323	Sclerophyllous vegetation	Shrubland
324	Transitional woodland-shrub	Shrubland
333	Sparsely vegetated areas	Grasslands
322	Moors and heathland	Moor- and heathland
412	Peat bogs	Peatland bogs
411	Inland marshes	Wetlands, swamps
244	Agro-forestry areas	Forest
311	Broad-leaved forest	Forest
312	Coniferous forest	Forest
313	Mixed forest	Forest
421	Salt marshes	Salt marches
422	Salines	Salt marches
512	Water bodies	Water courses
522	Estuaries	Water courses
511	Water courses	Water courses
331	Beaches, dunes, sands	Dunes
211	Non-irrigated arable land	
212	Permanently irrigated land	
213	Rice fields	
221	Vineyards	
222	Fruit trees and berry plantations	
223	Olive groves	
241	Annual crops associated with permanent crops	
112	Discontinuous urban fabric	
242	Complex cultivation patterns	
121	Industrial or commercial units	
332	Bare rocks	
334	Burnt areas	
335	Glaciers and perpetual snow	
423	Intertidal flats	
122	Road and rail networks and associated land	
521	Coastal lagoons	
123	Port areas	
124	Airports	
131	Mineral extraction sites	
132	Dump sites	
133	Construction sites	
111	Continuous urban fabric	
141	Green urban areas	
142	Sport and leisure facilities	
523	Sea and ocean	

3.3 Critical loads of nitrogen deposition

To estimate the levels of management related to nitrogen deposition, specific levels of critical nitrogen loads (N_{crit}) are needed. However, no data are available at CLC 3 level regarding critical loads. Several studies (Bal *et al.*, 2007; Bobbink and Roelofs, 1995; Bobbink, 2004; de Haan *et al.*, 2008; Van Dobben *et al.*, 2012) provide an overview of critical loads of vegetation types. A summary is given in De Haan *et al.* (2008) and by Van Dobben *et al.* (2012) for vegetation and habitat types in the Netherlands. Many of those types are found within a single CLC 3 class. Hence an aggregation step was applied to derive single critical nitrogen loads values for each relevant CLC 3 class. Annex 3 provides the aggregation of habitat and vegetation types , described by Van Dobben *et al.* (2012) and CLC 3 Corine land cover types. Based on these aggregations, the critical nitrogen loads of CLC 3 classes are listed in Table 3.2.

Table 3.2
Estimates of critical nitrogen loads of CLC 3 classes in mol N/ha/yr and kg N/ha/yr, based on Van Dobben et al. (2012).

CLC code	Label	N (mol N / ha / yr)	N (kg N / ha / yr)
244	Agro-forestry areas	1429	20.006
311	Broad-leaved forest	1693	23.702
312	Coniferous forest	1000	14.000
313	Mixed forest	1429	20.006
243	Land principally occupied by agriculture, with significant areas of natural vegetation	1316	18.424
231	Pastures	-	-
321	Natural grasslands	1316	18.424
331	Beaches, sand, dunes	1071	15
322	Moors and heathland	1024	14.336
412	Peat bogs	786	11.004
422	Salines	1586	22.204
421	Salt marshes	1586	22.204
324	Transitional woodland-shrub	1393	19.502
333	Sparsely vegetated areas	1071	14.994
323	Sclerophyllous vegetation	1024	14.336
522	Estuaries	2400	33.6
512	Water bodies	1502	21.028
411	Inland marshes	1695	23.730

3.4 Recurrent costs

3.4.1 Recurrent nitrogen management

An assessment on various data sources (see Annex 4) was carried out to estimate recurrent nitrogen management costs. First, cost estimates were examined from the management handbooks published by DG-Environment. Second, cost estimates made by Gantioler *et al.* (2010) were further broken down. Third, estimates based on De Jong *et al.* (2007) on habitat types were analysed and fourth estimates of Dutch management, 'Index N&L' were studied. The full list of these estimates are depicted in Annex 4.

The various handbooks of Natura 2000 habitat management provide cost estimates of recurrent management within various habitat types. These handbooks are presented according to main vegetation types, like grasslands, salt marshes, dunes, etc., and we assumed the published management options to be examples of recurrent management costs of all habitat types within a broader defined vegetation type. Table Annex 4-1 provides the various activities described in these management reports as well as the costs associated with these activities. De Jong *et al.* (2007)

estimated management and restoration costs of Dutch Natura 2000 habitat types. Also costs of restoration are provided in this study. These data are summarized in Annex 4.

Gantioler *et al.* (2010) provides data on the recurrent costs associated with Natura 2000 in various EU member states (Annex 4). Estimates are derived from surveys rather than a literature and data review. These estimates are separated into management planning and habitat management and monitoring costs. The data in Annex 4 show large differences among the member states. Several factors might explain these differences. First, management costs are different among different vegetation types. For example, (semi) natural grasslands are more expensive to manage than forests or dunes. These differences cannot be analysed with data provided in Annex 4, since these costs are calculated for the whole Natura 2000 network. Secondly, labour prices differ and countries with high GDP might have higher costs, and thirdly the recurrent costs might be dependent on the area size in such a way that management of large areas is cheaper than management of small areas.

The Wageningen Economic Research (formerly LEI) cost database of Dutch nature, IKN, provides standardized cost data of recurrent management of nature types (not habitat types). These data are based on normalized costs of 'Index N&L' of February 2009 (version 0.3), while these normalized data are based on various defined management activities described in the 'Standardized costs of direct nature related activities' (Anonymous, 2009; 'Herberekening nav. Commissie Verheijen'). The values of these standardized costs are listed in the tables of Annex 5.

The collected data from different and independent sources provide various cost estimates. The different tables show, that for similar habitat types management costs can differ considerably. From these tables, it is not clear what might cause this large variation. This variation complicates a reliable cost estimation. One could argue that to estimate reliable costs, consistent management activities should be defined and linked to specific vegetation types. This also means that various vegetation types with similar types of management activities will have similar recurrent management costs.

To define recurrent management costs based on specific management activities new data were collected. For this, we mainly used Anonymous (2009). In this report, consistent activities are collected by DLG for nature management in the Netherlands. These are summarized in Annex 4.

From Annex 4 it becomes clear that the various coarsely defined vegetation types include similar types of activities. Activities on grasslands include mowing and grazing, in forest coppicing, in heathlands sod cutting, etc. Based on Annex 5 and the defined management types (Table 3.1), we derived nine activities in nine management types (Table 3.3).

Table 3.3
Recurrent costs (in €/ha) for activities in different management types. Each management type is linked to CLC 3 Corine land cover types. Costs based on the tables in Annex 4 and 'Index N&L' on standardized norm costs, year 2009.

Vegetation type	Ditch mowing	Mowing Dry soil	Mowing Wet soil	Grazing	Sod cutting	Coppice	Liming	Dredging
Forest						497.43	335	
Grasslands		586.29	942.94	194.40				
Moor and heathland	115.77	447.1	1999.64	104.56	3992.48			
Salt marches		655.72	655.72	150.12				
Shrub land		447.10	447.10	104.56				
Water bodies								30000
Wetlands, swamps	115.77		1261	104.56				
Peatland bogs			1999.64		3992.48			
Dunes		586.29						

In Table 3.3 a distinction is made between mowing and grazing on dry and on wet soils. The difference in costs is caused by differences in equipment and labour force (see Annex 5). To extrapolate cost measures to various member states, GDP (ppp) corrections are made. To do this, both differences in labour costs, machinery and equipment were taken into account. These values were derived from Eurostat data and transformed in such way that for the Netherlands an index value of 1 was used. Multiplying the country specific index value with the Dutch costs provides GDP corrected cost value for each member state.

3.4.2 Conservation management

In addition to recurrent management to manage detrimental effects of nitrogen exceedance levels, some vegetation needs to be managed to conserve the present state. Due to human interference, vegetation types can be found in Europe that are strongly associated with past agricultural practices. For example, grasslands and heathlands can be found in Northwestern Europe that are associated with former agricultural land use. These vegetation types are in a so-called plagio-climax state. During succession of natural vegetation, biomass and vegetation structure will build up. Under favourable abiotic conditions, such as water or nutrient levels, sparse and open (grassland or heath) vegetation will ultimately develop into shrub and forest vegetation. In contrast, at particular local climate conditions, such as altitude and longitude these vegetation remain in a climax stage due to limiting factors (e.g., temperature, soil moisture content, length of growing season).

If a particular plagio-climax vegetation is the aim of a nature policy and critical nitrogen loads do not exceed nitrogen deposition, conservation management is applied. To determine the need for conservation management spatial information is used to determine the natural distribution of vegetation. Based on Bohn *et al.* (2003) a map was constructed on the natural spatial distribution of European vegetation and biomes. The different maps in Bohn *et al.* (2003) were used for this purpose, and a conversion was made from the original description of vegetation types to CLC 3 land use cover types. Table 3.4 provides the conversion of the vegetation types described by Bohn *et al.* (2003) to CLC 3 land cover types.

Table 3.4
The conversion of natural vegetation types (from Bohn et al., 2003) to CLC 3 land cover types.

Natural vegetation type	CLC 3 code	CLC 3 name
Subnival-nival vegetation of high mountains in the boreal and nemoral zone	-	-
Arctic and mountain tundra and Alpine vegetation	333	Sparsely vegetated areas
Atlantic dwarf heath and shrubland	322	Moors and heathland
Forest steppes or dry grasslands alternating forests and shrubs	321	Natural grasslands
(Herb-) Grass steppes	321	Natural grasslands
Vegetation of coastal sandy dunes and sea shores, often in combination with halophytic vegetation, partly with vegetation of rocky sea shores	331	Beaches, dunes, sands
Tall reed and tall sedge swamps	411	Inland marshes
Peat bogs and moorland (e.g., Palsamoore, Aapamoore, Deckmoore, Hochmoore, Waldmoore, Gebirgshochmoore)	412	Peat bogs

The corresponding spatial distribution of natural vegetation, with the exception of closed climax vegetation such as forests, is depicted in Figure 3.1. This map will thus provide spatial information to be applied to conservation management.

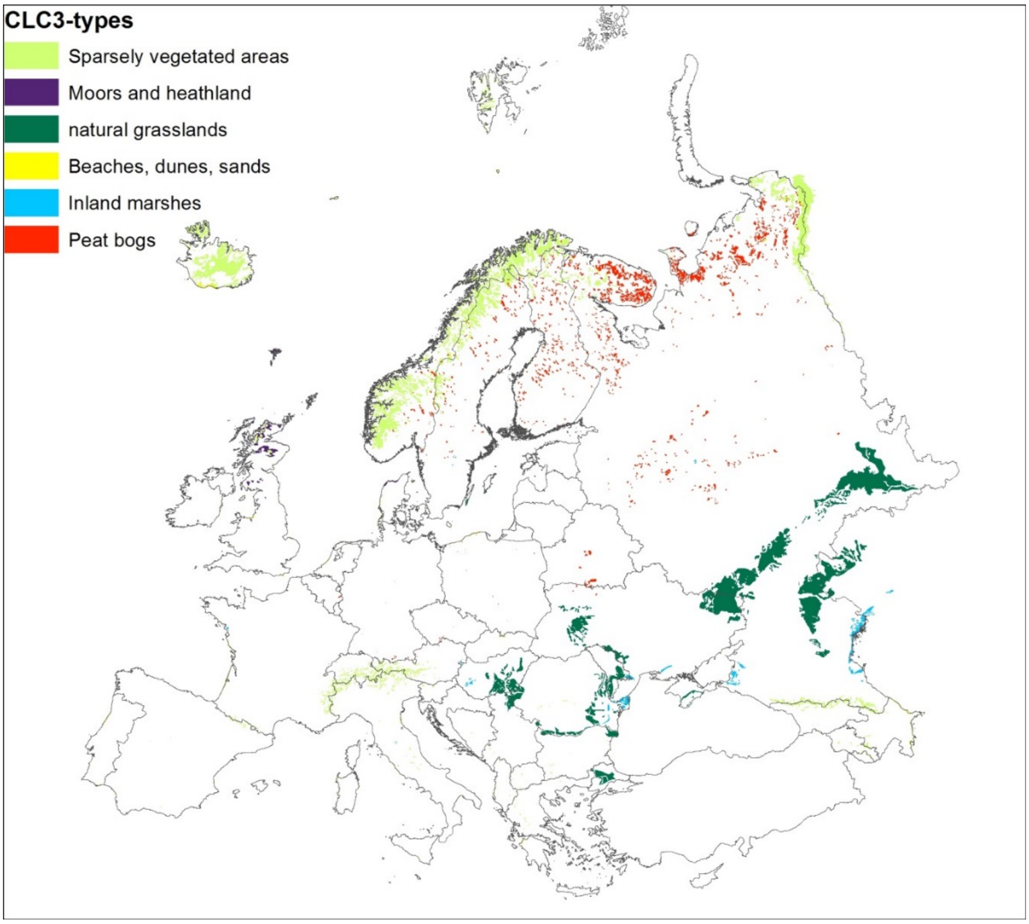

Figure 3.1 *The natural distribution of sparse and open natural vegetation in Europe, based on Bohn et al. (2003) and converted into Corine CLC 3 land cover types.*

3.4.3 Agri-environmental payments

To estimate costs of agri-environmental schemes public expenditures were retrieved from ENRD (2015). The data were published separately for each Member State and at EU27-level (Table 3.5). This table presents EAFRD (European Agricultural Fund for Rural Development) and Total Public expenditures on agri-environmental measure, both realised and programmed expenditures. These expenditures are not used in the costs model, since these data are based on subsidies rather than on costs of measurements. For all recurrent management on agricultural land, only the measurement costs of mowing and grazing are used, as defined in Table 3.3.

Table 3.5
Expenditures on agri-environmental measures 2007-2013 (realised and programmed) in 100,000 € (rounded to the nearest integer)

	Realised 2007-2013		Programmed 2007-2013	
Country	EAFRD	Total Public	EAFRD	Total Public
Austria	1,766	3,418	1,825	3,534
Belgium	149	320	163	356
Bulgaria	154	188	228	279
Cyprus	35	61	38	65
Czech	786	967	874	1,092
Germany	2,267	3,771	2,603	4,210
Denmark	152	275	164	295
Estonia	140	176	168	210
Spain	1,216	1,949	1,574	2,466
Finland	664	2,331	685	2,408
France	1,754	2,830	1,843	2,874
Greece	675	855	913	1,194

	Realised 2007-2013		Programmed 2007-2013	
Country	EAFRD	Total Public	EAFRD	Total Public
Hungary	775	991	873	1,137
Ireland	1,116	1,919	1,058	1,892
Italy	1,667	3,170	1,985	3,773
Lithuania	190	238	246	307
Luxembourg	23	93	26	107
Latvia	140	174	159	202
Malta	4	5	7	9
Netherlands	143	277	126	244
Poland	1,401	1,750	1,853	2,314
Portugal	470	540	536	618
Romania	935	1,131	1,088	1,270
Sweden	890	1,900	913	1,984
Slovakia	262	332	307	390
Slovenia	188	235	217	272
United Kingdom	2,058	3,258	2,448	4,026
EU27	20,031	33,167	22,933	37,542

Based on the information in Table 3.5 and Annex 9, the expenditures on agri-environmental measures per hectare were calculated. Both the expenditures per hectare under agri-environmental support and per hectare utilised agricultural area are presented in Table 3.6.

Table 3.6

Expenditures under agri-environmental support and UAA (Utilized Agricultural Area) in €/ha.

	Agri-environmental support		UAA 2007	
Country	EAFRD	Total Public	EAFRD	Total Public
Austria	810	1,567	554	1,072
Belgium	751	1,610	109	233
Bulgaria	397	484	51	62
Cyprus	1,482	2,558	244	421
Czech	735	905	223	275
Germany	450	748	134	223
Denmark	947	1,711	57	103
Estonia	235	294	155	194
Spain	239	383	49	78
Finland	305	1,069	290	1,017
France	292	472	64	103
Greece	1,350	1,711	166	210
Hungary	672	859	183	234
Ireland	442	760	270	464
Italy	708	1,345	131	249
Lithuania	757	946	72	90
Luxembourg	198	792	179	716
Latvia	596	744	79	99
Malta	2,329	2,912	461	576
Netherlands	627	1,215	75	145
Poland	684	855	91	113
Portugal	493	566	135	156
Romania	508	615	68	82
Sweden	467	996	286	610
Slovakia	734	930	135	172
Slovenia	865	1,082	385	482
United Kingdom	388	613	128	202
EU27	**466**	**772**	**116**	**192**

3.5 One-off costs

Within the one-off costs, we distinguish two components: land purchase or depreciation and construction and/or restoration of nature sites (including infrastructure) (see also Gantioler *et al.,* 2010). Land conversion to natural vegetation mostly occur from agricultural land uses. Hence agricultural land prices are used to determine (opportunity) costs of land purchase.

3.5.1 Land purchase

Gantioler *et al*. (2010) provide data on land purchase, but these values seems to be rather low. Moreover, for some countries no data are given. Eurostat provides data on agricultural land prices for Austria, Belgium, Bulgaria Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Northern Ireland (UK), Poland, Romania, Scotland, Slovakia, Spain, Sweden, United Kingdom, Wales, while data of Estonia, Cyprus, Portugal and Slovenia are missing. Moreover, for some countries values on the overall agricultural land price is given, while for others only those of arable fields, meadows, (non)-irrigated land or rental prices are provided. In Table 3.7 the agricultural land prices are shown derived from the Eurostat database. From Table 3.7 it becomes clear that 1) agricultural land prices are not available for all EU member states and 2) a number of member states show a discontinuity in the time series, so that the latest data (2009) are missing.

In the following steps the missing data are extrapolated from various regressions.

Step 1. Updating land prices for missing 2009 data
Belgium, Germany, Greece, Ireland, Italy, N. Ireland, Romania, UK and Wales do not have the latest 2009 data for land prices. Drivers of changes in land prices are diverse. Agricultural output, land scarcity and land use policies determine prices and general ‘rules’ cannot easily be subtracted. For example, in some countries the land prices tend to follow the total agricultural added value, but not in others. To extrapolate future prices of the incomplete lists (up to 2009) the price developments in the past as well as the average land use prices, as a determinant of the current price changes, should be taken into account. As a first step the dataset was split up into several regions, to compare countries with similar prices and/or agricultural output.

The selection of West European countries leads to the following list: Denmark, Finland, France, Germany, Ireland, Northern Ireland, Luxemburg, the Netherlands, Scotland, Sweden, United Kingdom (as a whole), Wales and Belgium. For this countries (in)complete temporal series are available. For each country the yearly price changes (in %) are calculated, as well as the average price change for all countries. For the missing values (for example in Belgium from 2007 to 2009) the estimates are calculated by the running average between 2000-2006 (i.e., the historical price change) and the average price change for the particular year for all countries. This estimated price change is then multiplied with the last known land price to arrive at a new land price. In other words, the new price is a function of the historical trend within the country as well as the average current change in all West Europe countries. The corresponding estimates are depicted in Figure 3.2.

Table 3.7

Agricultural land prices. Source: Eurostat database. 1= data (partly) from Ciaian et al. (2010).

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Austria										
Belgium	21069.00	20372.00	16795.00	20273.00	23155.00	22053.00	27190.00			
Bulgaria										
Czech Rep.	1555.86	1402.87	1527.92	1522.36	1561.29	1621.08	1625.33	1867.32	2375.41	2249.71
Cyprus										
Denmark	10330.30	12211.32	12919.72	14668.87	15994.84	18787.41	22790.95	27111.91	31652.36	25919.26
Estonia										
Finland	3932.91	4039.03	4246.00	4700.00	5197.00	5377.00	5979.00	6250.00	7000.00	6885.00
France				4350.00	4460.00	4700.00	4730.00	4900.00	5160.00	5130.00
Germany	9081.00	9427.00	9465.00	9184.00	9233.00	8692.00	8909.00			
Greece[1]	11620	11909	12937	12375	11120	12375	11250			
Hungary										
Ireland	12816.00	13897.00	13574.00	14397.00	16258.00	16230.00				
Italy[1]	13653.85	14266.35	15750	15800	15800	15800	15750			
Latvia			545.61	525.99	1001.20	2183.28	3786.27	3552.35	1939.66	1014.60
Lithuania	294.44	321.02	468.00	389.84	406.04	536.09	733.61	830.92	1075.07	971.39
Luxembourg				15195.00	15837.00	14874.00	17047.00	16920.00	17853.00	20000.00
Malta						129818.57	130000.00	130000.00	130000.00	130000.00
Netherlands	35713.00	37150.00	40150.00	34160.00	31432.00	30235.00	31276.00	34969.00	40916.00	47051.00
N. Ireland	15806.92	16017.82	19808.22	21604.36	23997.29	29009.94				
Poland										
Portugal										
Romania	351.37	307.64	278.22	237.01	283.88	878.79				
Scotland	5371.79	4126.26	7426.49							
Slovakia	895.29	877.62	888.46	911.56	945.73	980.60	1016.54	1120.65	1210.74	1256.39
Slovenia										
Spain	7292.16	7552.89	8026.21	8552.80	9024.43	9713.83	10402.00	11070.00	10974.00	10465.00
Sweden	1989.30	1988.09	2019.41	2126.21	2454.98	3350.50	3706.35	3956.71	4180.88	3747.96
UK	11619.74	11909.24	10955.27	10177.89	11127.81	12974.55	13382.13	16035.89	17772.64	
Wales	8172.54	8348.53	10366.08	9403.32	9534.97	8594.62				

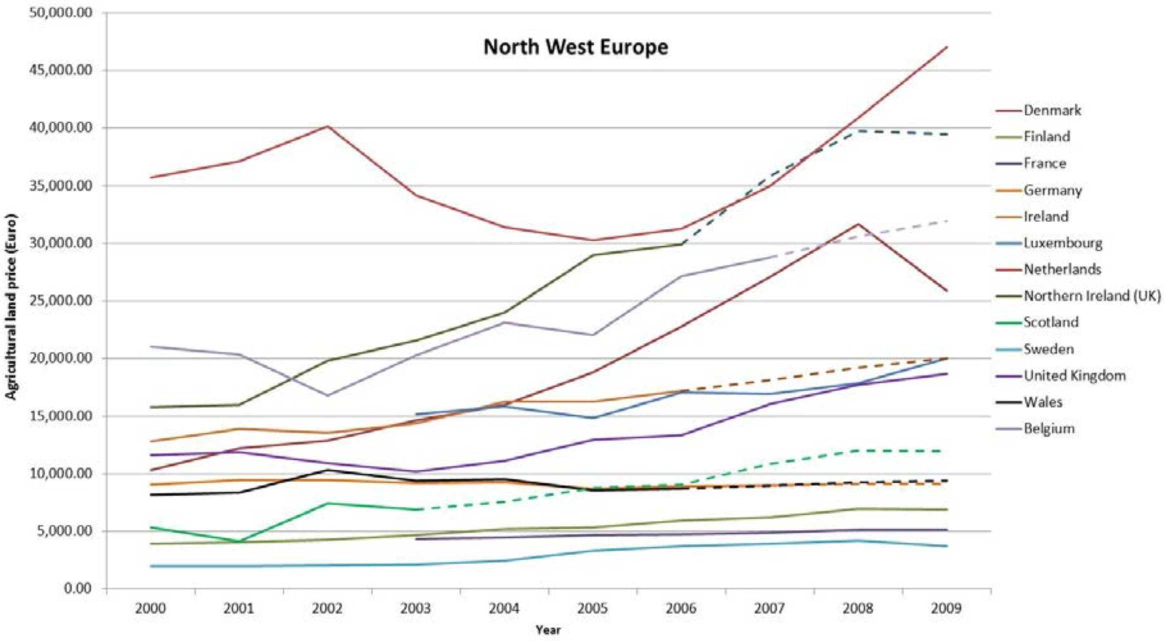

Figure 3.2 *Agricultural land prices in Northwestern European countries from 2000-2009. Dashed lines are estimates based on the calculation procedure described in step 1.*

Step 2. Estimates of agricultural land prices based on separate arable / meadow land prices
For a number of countries, i.e. Belgium, Bulgaria, Denmark, France, Luxembourg, Netherlands, Poland and Spain separate prices for arable and meadow land are available, while for Bulgaria and Poland the overall agricultural land price is not available. Based on arable and meadow land prices, overall agricultural land prices can be estimated. Prices for arable land seem to have more weight than meadow land to determine the overall price. Based on these data, we can assume arable land prices to be three times higher than that of meadow land. Using this assumption, a reliable estimate on overall land prices can be made (see Figure 3.3).

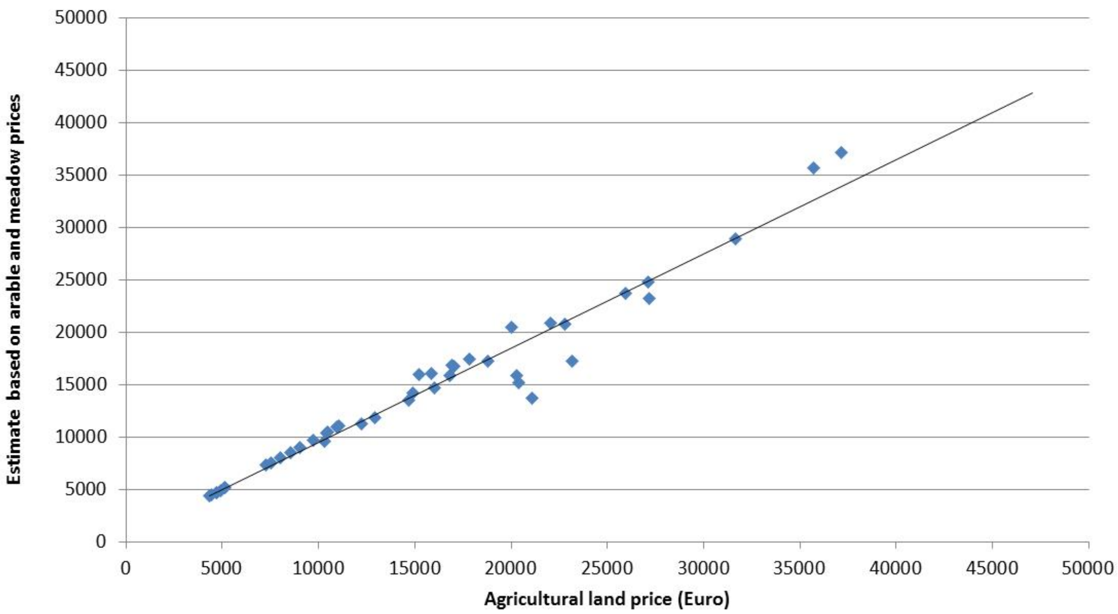

Figure 3.3 *Estimate of the overall agricultural land price based on separate arable and meadow land prices. Dots are Eurostat data.*

Step 3. Estimates of agricultural land prices based on separate arable / meadow land rental prices.
For Austria and Hungary only rental prices of arable and meadow land are available, while a subset of countries have both rental and purchase prices for arable and meadow land. For both types separate regressions were made (arable land: land price=53.25*(land rent)–1172.2, R^2=0.94; meadow land: land price=64.172*(land rent)-321.31, R^2=0.99). The estimated land prices of arable and meadow land were then translated into overall land prices, described in step 2.

Step 4. Estimates of agricultural land prices with additional data
In the previous three steps missing country data were obtained by combining different Eurostat datasets on various types of land prices. Using the three steps, prices of 26 countries out of the 30 countries/regions (including N. Ireland, Scotland and Wales) were obtained. Data of Cyprus, Estonia, Portugal and Slovenia are missing in Eurostat and need to be derived from other data. Regressions using agricultural added value and utilized agrarian area (UAA) from Eurostat did not lead to interpretable results.

Additional data were obtained from the CAPRI model, which is used in many scenario studies on European agriculture. In CAPRI shadow prices are used as marginal input costs. In other words, the price of adding one hectare of land to produce income. These prices are in €/ha and to some extent comparable (but not similar) to the Eurostat prices. The regression of known Eurostat land prices and CAPRI shadow prices led to a distinction of two country groups (see Figure 3.4). Country set 1 includes Bulgaria, Czech republic, Finland, France, Germany, Greece, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Spain and Sweden, while set 2 includes Austria, Belgium, Denmark, Ireland, Italy, Netherlands and the UK. Apparently, set 1 includes countries with relatively low land prices and set 2 with high prices. Dividing all countries into these two groups leads to two significant regression models. The missing land prices were derived by using this regression formulas.

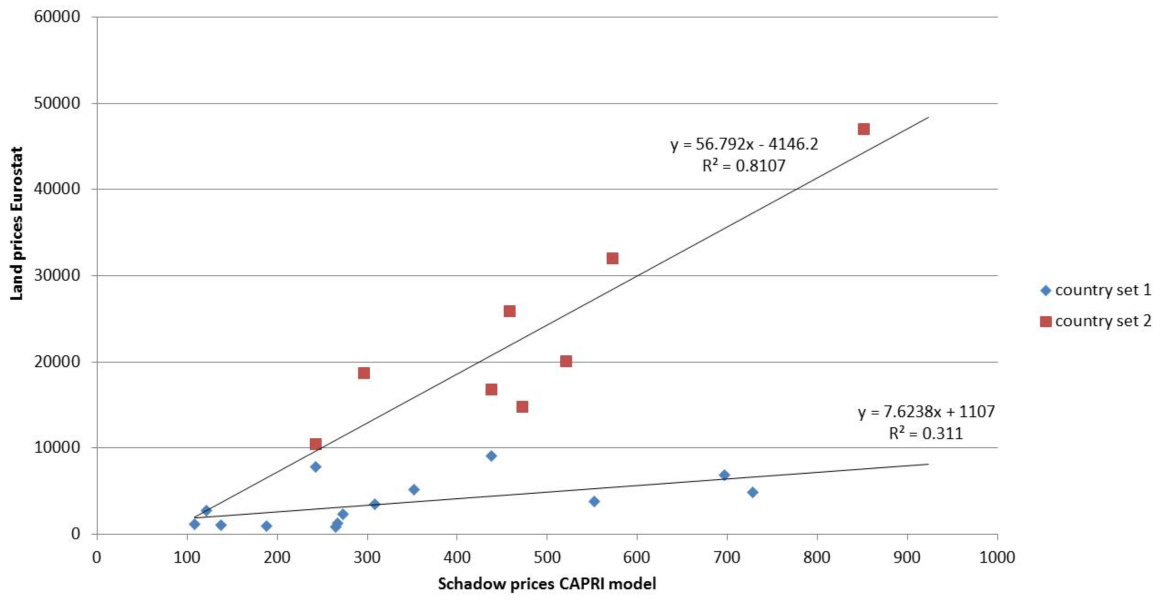

Figure 3.4 *Relation between CAPRI shadow prices and Eurostat land prices of EU countries.*

3.5.2 Final land price dataset

The four steps combined leads to the land prices for 2009, as depicted in Table 3.8.

Table 3.8

Estimated agricultural land prices in Euro/ha for 2009 and annualized land price (calculated over 50 years using a discount rate of 2,5%)

Country	Land price 2009 (€/ha)	Annualized price (€/ha/yr)
Austria	14,763.70[3]	705.37
Belgium	31,983.95[1]	1,528.12
Bulgaria	1,138.92[2]	54.42
Cyprus	4,034.84[4]	192.78
Czech Republic	2,249.71	107.49
Denmark	25,919.26	1,238.36
Estonia	2,644.34[4]	126.34
Finland	6,885.00	328.95
France	5,130.00	245.10
Germany	9,091.82[1]	434.39
Greece	11,207.59[1] / 4,854.5[a]	535.47 / 231.94
Hungary	3,413.55[3]	163.09
Ireland	20,021.66[1]	956.59
Italy	16,796.84[1]	802.51
Latvia	1,014.60	48.48
Lithuania	971.39	46.41
Luxembourg	20,000.00	955.55
Malta	130,000.00	6,211.09
Netherlands	47,051.00	2,247.99
Northern Ireland (UK)	39,494.87[1]	1,886.97
Poland	844.92[3]	40.37
Portugal	3,005.78[4]	143.61
Romania	2,764.18[1]	132.07
Scotland	11,974.21[1]	572.10
Slovakia	1,256.39	60.03
Slovenia	5,616.63[4]	268.35
Spain	10,465.00 / 7,807[a]	499.99 / 373.00
Sweden	3,747.96	179.07
United Kingdom	18,690.98[1]	893.01
Wales	9,409.90[1]	449.58

Based on Eurostat data and estimates according to the different steps:
[1]= estimate following description in step 1,
[2] = estimate as described in step 2,
[3]= estimate described in step 3,
[4]= estimate described in step 4.
[a]= land price of non-irrigated land.
Annualized costs were calculated over 50 years using a discount rate of 2,5%

3.5.3 Land prices at NUTS 2 level

Land prices may differ considerably within countries, for example, in Spain or France. Eurostat FADN provides NUTS 2 level land rent values. Such rental prices at NUTS 2 are not provided for all countries in FADN. To estimate land prices at NUTS 2 the rental price at NUTS 2 was multiplied with the quotient of the land price at NUTS 1 (country level, see Table 3.8) and rent price at NUTS 1 (country level, FADN).

Table 3.9

Estimated agricultural land prices at NUTS 2 level in Euro/ha.

Country	Region	Land price (€/ha)
Belgium	(0341) Vlaanderen	38,862
	(0343) Wallonie	26,382
Bulgaria	(0831) Severozapaden	854
	(0832) Severen tsentralen	1219
	(0833) Severoiztochen	1776
	(0834) Yugozapaden	563
	(0835) Yuzhen tsentralen	903
	(0836) Yugoiztochen	821
Germany	(0010) Schleswig-Holstein	13,782
	(0020) Hamburg	26,617
	(0030) Niedersachsen	14,242
	(0050) Nordrhein-Westfalen	15,161
	(0060) Hessen	6513
	(0070) Rheinland-Pfalz	8608
	(0080) Baden-Württemberg	9100
	(0090) Bayern	9837
	(0100) Saarland	3419
	(0112) Brandenburg	4088
	(0113) Mecklenburg-Vorpommern	6428
	(0114) Sachsen	5782
	(0115) Sachsen-Anhalt	7961
	(0116) Thueringen	5986
Greece	(0450) Makedonia-Thraki	11,166
	(0460) Ipiros-Peloponissos-Nissi Ioniou	12,432
	(0470) Thessalia	17,414
	(0480) Sterea Ellas-Nissi Egaeou-Kriti	8102
Spain	(0500) Galicia	10,600
	(0505) Asturias	18,140
	(0510) Cantabria	4361.
	(0515) Pais Vasco	7632
	(0520) Navarra	16,034
	(0525) La Rioja	9737
	(0530) Aragón	6966
	(0535) Cataluna	19,940
	(0540) Baleares	3648
	(0545) Castilla-León	9758
	(0550) Madrid	611
	(0555) Castilla-La Mancha	10,506
	(0560) Comunidad Valenciana	20,819
	(0565) Murcia	25,050
	(0570) Extremadura	6676
	(0575) Andalucia	14,502
	(0580) Canarias	71,034
France	(0121) Île de France	5281
	(0131) Champagne-Ardenne	10,522
	(0132) Picardie	6314
	(0133) Haute-Normandie	6748
	(0134) Centre	3966
	(0135) Basse-Normandie	5687
	(0136) Bourgogne	5551
	(0141) Nord-Pas-de-Calais	6356

Country	Region	Land price (€/ha)
	(0151) Lorraine	3134
	(0152) Alsace	9821
	(0153) Franche-Comté	3512
	(0162) Pays de la Loire	4375
	(0163) Bretagne	4868
	(0164) Poitou-Charentes	4001
	(0182) Aquitaine	7292
	(0183) Midi-Pyrénées	3783
	(0184) Limousin	2676
	(0192) Rhônes-Alpes	4220
	(0193) Auvergne	3336
	(0201) Languedoc-Roussillon	4974
	(0203) Provence-Alpes-Côte dAzur	6009
	(0204) Corse	1869
Hungary	(0760) Közép-Magyarország	4908
	(0761) Közép-Dunántúl	3151
	(0762) Nyugat-Dunántúl	3197
	(0763) Dél-Dunántúl	4703
	(0764) Észak-Magyarország	2308
	(0765) Észak-Alföld	3050
	(0766) Dél-Alföld	3226
Italy	(0221) Aosta	5106
	(0222) Piemonte	13,026
	(0230) Lombardia	25,218
	(0241) Trentino	16,900
	(0242) Alto-Adige	56,088
	(0243) Veneto	29,290
	(0244) Friuli-Venezia	14,582
	(0250) Liguria	11,298
	(0260) Emilia-Romagna	36,537
	(0270) Toscana	13,543
	(0281) Marche	15,770
	(0282) Umbria	16,602
	(0291) Lazio	11,187
	(0292) Abruzzo	4086
	(0301) Molise	4723
	(0302) Campania	19,082
	(0303) Calabria	8489
	(0311) Puglia	14,103
	(0312) Basilicata	2471
	(0320) Sicilia	8992
	(0330) Sardegna	5973
Poland	(0785) Pomorze and Mazury	829
	(0790) Wielkopolska and Slask	959
	(0795) Mazowsze and Podlasie	818
	(0800) Malopolska and Pogórze	597
Portugal	(0615) Norte e Centro	5168
	(0630) Ribatejo e Oeste	18,540
	(0640) Alentejo e do Algarve	926
	(0650) Açores	5912
Romania	(0840) Nord-Est	3038
	(0841) Sud-Est	2524
	(0842) Sud-Muntenia	3049
	(0843) Sud-Vest-Oltenia	4045

Country	Region	Land price (€/ha)
	(0844) Vest	4197
	(0845) Nord-Vest	2339
	(0846) Centru	1981
	(0847) Bucuresti-Ilfov	2553
Finland	(0670) Etela-Suomi	8027
	(0680) Sisa-Suomi	5132
	(0690) Pohjanmaa	8365
	(0700) Pohjois-Suomi	3912
Sweden	(0710) Slattbygdslan	4872
	(0720) Skogs-och mellanbygdslan	2771
	(0730) Lan i norra	898
United Kingdom	(0411) England-North	17,657
	(0412) England-East	28,339
	(0413) England-West	23,816
	(0421) Wales	16,224
	(0431) Scotland	6577
	(0441) Northern Ireland	27,521

Data from FADN Eurostat for land rental prices. Purchase prices were obtained by multiplying rental prices at NUTS 2 with the quotient of purchase prices at NUTS 1 (see Table 3.8) and rental prices at NUTS 1 (FADN data). All purchase prices for 2009.

3.5.4 Estimate costs of construction and restoration

International data and literature on restoration costs within the EU context are scarce. The EU handbooks on the Management of Natura 2000 Habitats provide data, but values seem to be very context specific while a consistent overview is not provided (see also Annex 4). Within the Dutch IKN model on nature costs, construction costs are based on data provided by the previous Agency of Rural Areas (Dienst Landelijk Gebied, DLG) of the ministry of Economic Affairs. DLG has developed estimates of land conversion to nature areas. The report 'Eindrapport Berekening Normkosten Inrichting met de SSK' of DLG (DLG, 2009) provides standardized cost estimates of different nature management types. Moreover, costs are also provided for specific activities. These data are used, complemented with some data from the EU Handbooks, to construct norm values of activities. These activities will be linked to the specific CLC land cover types. In other words, transitions from various CLC 3 types to nature specific CLC 3 types will be linked to a set of activities. Based on these sets, construction and/or restoration costs can be determined.

For soil removal (type 1 activity) various costs are found in DLG (2009). This variation is determined by the amount of top soil to be removed. For example, to create water bodies on former grasslands, more soil has to be removed than the creation of heathland on former grasslands. The norm value for soil removal will therefore be scaled for different types of land conversion. This factor determines the amount of soil to be removed. The full price (42772 €/ha) is set for 1 m of top soil removal (10.000 m^3 soil). Multiplication factors for land conversions are depicted in Table 3.11.

Table 3.12 provides the link between construction and restoration activities and types of land use change. In this table a number of land conversions include more than one activity. In such cases, the costs of different activities associated with construction and restoration are added.

Table 3.10

Costs of activities associated with construction and/or restoration. Data from DLG (2009) and EU handbooks on Management of Natura 2000 Habitats. Values are investment costs for 2009 and are not annualized.

Type	Measures	€/ha	Remark
SUC	Natural succession	0	No additional activities implemented
Type 1	Soil removal	42772	Price from DLG, multiplied by additional factor
Type 2	water works	2707	Price from DLG
Type 3	clearing and pruning	3030	Price from EU handbook
Type 4	cut trees, trimming	2010	Price from EU handbook (average of 1320-2700€/ha)
Type 5	planting tree saplings	15773	Price from DLG
Type 6	Sowing	300	Price from EU handbook (average of 200-400€/ha)
Type 7	nutrient removal by intensive mowing	1700	Price = yearly mowing + for 5 years additional 340 €/ha (1700€), From EU handbook
Type 8	arable to grassland conversion	135	Price from EU handbook
Type 9	clearing overgrown land	1500	Price from EU handbook
Type 10	Sod cutting	3992.5	Price from DLG

Table 3.11

Multiplication factor for soil removal (activity type 1) as defined in table 3.10, when linked to a CLC 3 land cover type.

CLC 3	Factor
Water courses	1
Water bodies	1.5
Inland marshes	0.6
Peat bogs	0.8
Moors and heath lands	0.6
Grasslands (all types)	0.3

Table 3.12

Matrix of land conversions and associated activities. Activities (T1-T10) are described in Table 3.10. Codes in column headings refer to CLC 3 land cover types (see Annex 2). Columns are CLC 3 types after land coversion (T_1), rows CLC 3 types before land conversion (T_0).

	T_1																				
T_0	1.4.1	2.4.3	2.4.4	3.1.1	3.1.2	3.1.3	3.2.1	3.2.2	3.2.3	3.2.4	3.3.1	3.3.3	4.1.1	4.1.2	4.2.1	4.2.2	4.2.3	5.1.1	5.1.2	5.2.1	5.2.2
2.1.1	0.5*T5+T6	T8	T5	0.8*T5	0.8*T5	0.8*T5	0.5*T7	0.6*T1+T2	SUC	SUC	SUC	SUC	0.6*T1	0.8*T1	0.6*T1	0.6*T1	SUC	T1+T2	1.5*T1+T2	SUC	SUC
2.1.2		T8		0.8*T5	0.8*T5	0.8*T5	0.5*T7	0.6*T1+T2	SUC	SUC		SUC			0.6*T1			T1+T2	1.5*T1+T2		SUC
2.1.3		T8		0.8*T5	0.8*T5	0.8*T5	0.5*T7		SUC	SUC									1.5*T1+T2		SUC
2.2.1	1/4*T3+T6	T3		0.25*T5	0.25*T5	0.25*T5	T4+T9	0.6*T1+T2	SUC	SUC	SUC	SUC	0.6*T1		0.6*T1			T1+T2	1.5*T1+T2	SUC	
2.2.2	1/4*T3+T6	SUC		0.25*T5	0.25*T5	0.25*T5	T4+T9	0.6*T1+T2	SUC	SUC	SUC	SUC						T1+T2	1.5*T1+T2		
2.2.3	1/4*T3+T6	SUC		0.25*T5	0.25*T5	0.25*T5	T4+T9	0.6*T1+T2	SUC	SUC	SUC	SUC							1.5*T1+T2		
2.3.1	0.5*T5+T6	SUC	T5	0.8*T5	0.8*T5	0.8*T5	0.25*T7	0.6*T1+T2	SUC	SUC	SUC	SUC	0.6*T1	0.8*T1	0.6*T1		SUC	T1+T2	1.5*T1+T2	SUC	SUC
2.4.1		SUC		0.8*T5	0.8*T5	0.8*T5	T7	0.6*T1+T2	SUC	SUC	SUC	SUC							1.5*T1+T2		
2.4.2	0.5*T5+T6	SUC	T5	0.8*T5	0.8*T5	0.8*T5	T7	0.6*T1+T2	SUC	SUC	SUC	SUC	0.6*T1	0.8*T1	0.6*T1		SUC	T1+T2	1.5*T1+T2	SUC	SUC
2.4.3	0.5*T5+T6		T5	0.8*T5	0.8*T5	0.8*T5	SUC	0.6*T1+T2	SUC	SUC	SUC	SUC	0.6*T1	0.8*T1	0.6*T1	0.6*T1	SUC	T1+T2	1.5*T1+T2	SUC	SUC
2.4.4		SUC		SUC	SUC	SUC	T3	0.6*T1+T2	T4	0.25*T4		T4							1.5*T1+T2		
3.1.1	T3	0.5*(T3+T4)	1/3*T3+1/3*T5				T4+T9	0.6*T1+T2	T4	0.25*T4			0.6*T1					T1+T2	1.5*T1+T2		
3.1.2	T3	0.5*(T3+T4)					T4+T9		T4	0.25*T4				0.8*T1				T1+T2	1.5*T1+T2		
3.1.3	T3	0.5*(T3+T4)	1/3*T3+ 1/3*T5				T4+T9		T4	0.25*T4				0.8*T1					1.5*T1+T2		
3.2.1	1/3*T5	0.3*T9	T5	SUC	SUC	SUC							0.6*T1					T1+T2	1.5*T1+T2		
3.2.2				SUC	SUC	SUC															
3.2.3		0.5*T9	T5	SUC	SUC	SUC	T4+T9														
3.2.4	T4	0.5*T9	0.5*T5	SUC	SUC	SUC	T4+T9						0.6*T1	0.8*T1				T1+T2	1.5*T1+T2		
3.3.1				SUC	SUC	SUC							0.6*T1					T1+T2			
4.1.1				SUC	SUC	SUC	SUC			SUC								T1+T2	1.5*T1+T2		
4.1.2				SUC	SUC	SUC		0.6*T1+T2		SUC									1.5*T1+T2		
4.2.3	SUC																				
5.1.1				T1+T5		T1+T5															
5.1.2	SUC			1.5*T1+T5	1.5*T1+T5	1.5*T1+T5															

3.5.5 Land abandonment

The restoration activities defined in Table 3.12 assume uniform construction costs for the different types of land conversions. In addition, land conversion could also takes place in a passive manner by land abandonment. Such land abandonment is not restricted to particular types of land conversions per se, but related to low economic development in rural areas across Europe. The CLUE model assumes such land abandonment in many areas, indicating a spatially explicit component in the costs of land conversion. When land abandonment takes place, no construction costs are assumed. Because land abandonment is spatially explicit, all types of transitions were split into abandoned and actively transformed, based on the Dyna-CLUE output. Land abandonment data are grid based (size resolution of 25 km^2). The original land conversion calculations included a spatial resolution of 1 km^2, the 25 km^2 grid cell sizes include 25 grid transitions. Because the tabular land abandonment data included only land abandonment in a 25 km^2 resolution, we assumed in such case all land transitions within a 25 km^2 resolution are caused by land abandonment.

3.6 Scenarios

One-off costs are applicable to the various future scenarios developed in the Nature Outlook project (Van Zeijts *et al.*, 2017). These include five scenarios, for which four are normative and referred to as perspectives. Only the state of land uses by 2050 are elaborated on in the four perspectives. A trend scenario was developed to include socio-economic development up to 2050. In Dyna-CLUE yearly maps were developed, but the cost model is only applied to the 2050 map year.

3.6.1 Trend scenario

The Trend scenario (Trend) does not include new policies and can be seen as a business-as-usual-scenario. The Trend scenario is based on the A2 marker scenario developed in the EU Volante project, which was extended to 2050 (Pedroli *et al.*, 2015). The following changes of drivers are assumed: -1% population growth between 2005-2050, economic growth of 1.4% per year, no further trade liberalisation, no stringent climate change policies and + 2°C in 2050, no change in the Common Agricultural Policy and constant budgets, no restrictions on urban expansion, implementation of current environmental and nature policies. Regarding land-use change, consumption of woody biomass for energy production is projected to increase from 435 to 859 million m^3 in 2030, leading to an increase in forested areas. Productivity in agriculture is assumed to increase, while agricultural area is expected to be stable. In addition, abandonment of marginal land, for example in mountainous areas, is expected, while the agricultural production in accessible areas with suitable conditions is likely to increase.

Overall, the land-use changes resulting from the Trend scenario show three remarkable developments, see Prins *et al.* (2017) for a full overview. First, urbanization is expected to continue, due to increase in population and welfare, resulting in an increase of urban areas by 19% from 2010 to 2050. The regions that are highly urbanized today become even more urbanized for housing and commercial purposes. These regions can in particular be found in north-western Europe and stretches approximately from North West England to Northern Italy. Second, the total surface under agriculture is projected to remain almost stable, although developments vary across regions. For example, more abandonment is taking place in mountainous regions, while in other regions expansion is likely to occur. Thirdly, regrowth of forests in abandoned areas is expected to occur at a large scale, resulting in an 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%. Although dynamics in total agricultural area are limited, the management of agricultural areas is changing. An increased use of fertilizer has been projected in certain regions in Europe, particularly in eastern European countries. This results in higher N-application per hectare. It has been assumed that such a process of intensification goes along with the disappearance of green elements at places where current agricultural field size is small (i.e. smaller than 10 ha). Forest management practices have been kept constant towards 2050.

Emissions of S and N are both expected to decline (Prins *et al.*, 2017). Progressing implementation of air quality legislation together with the structural changes in the energy system will lead to a decline of SO_2 emissions, resulting in acidification of nature areas, in the EU towards 2030. After 2030, stabilization occurs since no further reduction policies are assumed. In 2030 total SO_2 emissions will be almost 70% below the 2005 level. Most of these reductions result from changes in the power sector. Also NO_x emissions, implementation of current legislation will lead to a reduction of about 60%. These changes emerge from measures in the power sector and implementation of emission standards for road vehicles. With respect to NH_3 only slight changes in total emissions in the EU-28 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 impact of emission legislation for road transport.

The Trend scenario includes 97 types of nature related transitions. All these transitions lead to a nature related CLC type in 2050. Based on the activities in Table 3.12, the conversion cost table for the Trend scenario can be found in Annex 11.

3.6.2 Strengthening Cultural Identity

In *Strengthening Cultural Identity (SCI),* 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 stonewalls, 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. The SCI scenario includes 108 unique type of nature related transitions and conversion costs can be found in Annex 11. A full description of the scenario can be found in Prins *et al.* (2017).

3.6.3 Allowing Nature to Find its Way

In *Allowing Nature to Find its Way (NFW),* 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 invests 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. The NFW scenario includes 214 unique type of nature related transitions. All these transitions lead to a nature related CLC type in 2050. Conversion costs can be found in Annex 11. A full description of the scenario can be found in Prins *et al.* (2017).

3.6.4 Going with the Economic Flow

In *Going with the Economic Flow (GEF),* 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. The GEF scenario includes 142 unique type of nature related transitions. All these transitions lead to a nature related CLC type in 2050. Conversion costs can be found in Annex 11. A full description of the scenario can be found in Prins *et al.* (2017).

3.6.5 Working with Nature

In *Working with Nature (WWN)*, 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. The WWN scenario includes 137 unique type of nature related transitions. All these transitions lead to a nature related CLC type in 2050. Conversion costs can be found in Annex 11. A full description of the scenario can be found in Prins *et al.* (2017).

4 Model description

4.1 Introduction

This chapter describes the cost database (Section 4.2), the structure of the cost model (Section 4.3) and the data handling. The cost model includes two separate R modules: one R module for calculations of recurrent management and one R module for one-off costs. The latter one is only applicable for the future scenarios, including the TREND scenario.

4.2 Cost database

The cost database `IKN-EU database.accb` includes 7 tables that constitute mostly static normalized cost data.
`CLC`: input table derived from the Costmap database of PBL that includes the codes and names of CLC land use types
Country_prices: includes the index values of countries to correct for GDP differences in the cost calulations.
`Recurrent management costs`: this table includes the costs of different measures sorted at 'nature type'. Different CLC coverages can have the same 'nature type' (i.e., forest, grasslands, shrubland) and for each 'nature type' different measures with associated costs are provided.
`Payments agri-environmental schemes`: includes yearly agri-environmental payments in EU-28. These data are described in Chapter 3, but not used in the cost model.
`Landprices_NUTS1`: includes the annualized land purchase prices at NUTS1 (country level) of EU-28
`Landprices_NUTS2`: includes the annualized land purchase prices at NUTS2 (region level) of 14 EU countries
`Transition_measures`: This table provides the costs of different conversion measures, data are depicted in Table 3.11

These tables are stored in one access database to secure the data. The database itself cannot be used in the R modules that constitute the cost model. The R modules can only use separate tables, stored as .DBF or .CSV file extensions. All tables in the cost database are exported to .csv files or .dbf files for further use in the cost model.

4.3 Input databases

For the input of scenarios and for the base year input data from PBL are used. Most data is provided in a database. The costmaps.accb database is used for recurrent management calculations. This cost - maps database includes several tables but only a few are used for the cost model. These are:
`Seq5km_totaal_xy`: this table includes x, y coordinated of the gridcodes
`Costmaps`: this table includes the columns Map, gridcodes and mapvalue
`Mapoverzicht`: which includes the names and types of different parameters and for each parameter the specific id, called MAP. This MAP is an unique number and the Mapvalue in table Costmaps corresponds to the value of the parameter with unique ID number (depicted in MAP).

To derive relevant data for the current year and the TREND, queries that include the above three tables are made. The queries are exported to .csv files for further processing in the R modules.

The various transitions of land use were provided by PBL in different tables. For each scenario land use transition data was used as input. These tables were stored in one database for data management These files were used in the on-off cost module for further processing.

4.4 Recurrent management module

The data handling and calculation of recurrent management is depicted in Figure 4.1. The following sections provide detailed information on the handling and calculation steps.

4.4.1 Scenario input data

The input data of PBL is a large access database, costmaps. This database include various tables, for which the costmaps table includes all relevant information. This table has the following header information:

`Map_id Grid Code     Map Value`

`Map_id` refers to specific column information. Each parameter (e.g., CLC types, environmental parameters such as N deposition, T sum, moisture, clay) has an unique value for `Map_id`.

`Grid Code` refers to the unique x, y coordinate. The x, y coordinates are stored in the Access table `SEQ5km_totaal_xy`.

`Map Value` refers to the value of each unique `Map_id` (i.e., the value of the specific parameter).

The file structure of this table therefore holds many measurements for each gridcel (x, y coordinate) and is the result of a stacking procedure of various GIS map layers.

The description of each `Map_id` is described in the Access table `mapoverzicht`.

The `Costmaps` table is not suited for analysis within the R module, the table only includes 4 columns. A suitable input table should include various columns for each gridcel. Therefore, for each x, y coordinate various columns should be made in which each column includes the values of a single parameter. By using specific queries, combining the table information in the Costmaps database an input file is produced. For each input scenario (i.e., Base year and TREND) a separate file is made. These files include the following columns:

`Grid_code     x      y      [CLC]  Ndep   Moisture      Tsum   Clay   N2k_share`

To calculate recurrent management input include the grid code, x and y grid coordinate, a number of CLC columns, indicated by [...],environmental variables Nitrogen deposition (N_{dep}), Soil moisture index (Moisture), Temperature sum (T_{sum}), Soil clay fraction (Clay) and the grid area within Natura 2000 (N2k share) for each 5 x 5 km grid cell. This input is different for each scenario (Base, TREND). Moreover, each grid cell is assigned to the different member states of the EU, using a GIS layer with country boundaries.

4.4.2 Costs input data

Cost data are included in the IKN Access costs database: `IKN-EU database.accdb`. This database contains several tables, for which `Critical N levels`, `Recurrent management costs` and `Country index values` are used for the calculations of recurrent management costs.

The table Critical N levels includes the critical deposition levels of each CLC land use type (see Annex 2). The table Country index values includes the price index values of countries to specify for GDP differences in cost estimates.

The table Recurrent management costs includes specific data on the various cost estimates to be applied to different nature types (Table 3.3). Each CLC type (nature based) is linked to these different nature types. For each calculation on recurrent management costs the specific costs from Table 3.3 are used. Some management types requires low frequencies to be applied (i.e., dredging, sod cutting, removal top layer). These low frequencies (e.g., 1 per 20 or 30 years) are specified in the R module.

4.4.3 Module

The R module Recurrent management is the central part of the calculations. This module includes three main program compartments. In the first compartment data handling is carried out. The different input files are included and aligned for further processing. The second part of this compartment includes the calculation of potential aboveground biomass (AGB) of herbaceous vegetation, based on the equations 2.2-2.4 depicted in Section 2.3. To calculate AGB environmental parameters, such as T_{sum}, moisture index and clay fraction were used.

In the second compartment the costs and exceedance levels are calculated on the grid cel level for different nature types. A nature type can include more than one CLC land cover type. Each calculation is set up as a loop. First costs of conservation management are calculated using CLC cover types depicted in Table 3.4 and Figure 3.1. If the current vegetation cover is equal to the biogeographical vegetation cover type, no conservation management is carried out. After this step, recurrent management costs for nitrogen exceedance is calculated. This step includes the equation:

$$N_{dep} \geq N_{crit} \quad (4.1)$$

If the nitrogen deposition level at the grid level is higher than the critical nitrogen load of vegetation, nitrogen management is included. By calculation of the aboveground biomass production in the first model compartment, the potential nitrogen removal from vegetation is calculated, using equation 2.1 depicted in Section 2.3. Depending on the vegetation type and environmental parameters (i.e., moisture index) different types of management are applied: mowing or grazing. After calculation of nitrogen removal from vegetation, the nitrogen exceedance level is calculated.

For some vegetation types, such as moors and heaths, peat bogs, swamps and water bodies an additional equation is included in which:

$$N_{dep} \geq 1.2N_{crit} \quad (4.2)$$

If the nitrogen deposition level exceeds 1.2 x critical nitrogen level additional measurements are taken, such as soil removal, sod cutting or dredging. These measures have a low frequency (1/20 or 1/30 years). It is assumed that these measures remove all nitrogen, including soil nitrogen, from ecosystems. After applying these measurements nitrogen deposition does no longer exceed critical nitrogen loads.

Each loop was run for three nitrogen ‘scenarios’. In the first run N_{crit}=100%, the second run (N_{crit}*0.9)=90% and third run (N_{crit}*1.1)=110%. These runs are used as a type of sensitivity analysis. We expected strong cost effects in grid cells where critical nitrogen loads are near nitrogen deposition levels. Because the critical nitrogen loads are estimations as well as collections of various vegetation types in a (single) CLC land cover type, a sensitivity analysis provides a better insight in cost estimates.

The CLC loops including ‘nitrogen scenarios’ are carried out for each grid separately. In the third model component a second data handling is carried out. Here the various parameter values for each grid are combined to deliver output on country level. In a second step the country specific index values are applied to the costs calculations and in a third step separate costs for Natura 2000 areas are calculated. All output is written as .csv files for further processing.

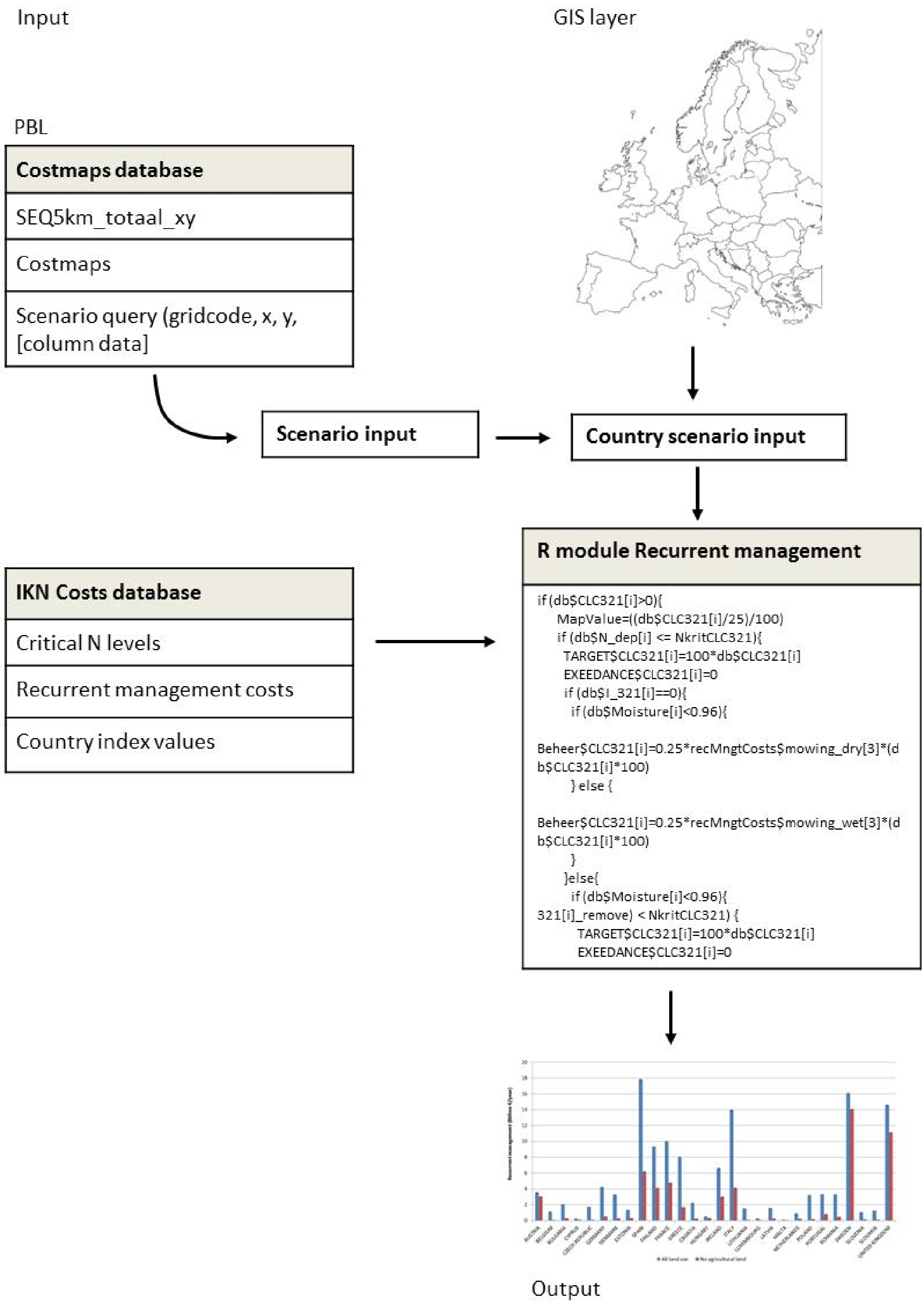

Figure 4.1 *Model structure of recurrent nature management costs. The structure includes data input from two separate databases. Each input scenario is run separately.*

4.5 One-off cost module

The data handling and calculation of the one-off costs is depicted in Figure 4.2. The following sections provide detailed information on the handling and calculation steps.

4.5.1 Scenario input data

Two input files are delivered by PBL. The first input file is the access database `Costmaps.accdb`. This database is also used for calculations on recurrent management costs. Only the table `SEQ5km_totaal_xy` is used, which includes the specific x, y coordinates of each grid cell (unique grid code). The second database includes the scenario land conversions (transitions), stored in the access database `Transition.accdb`. This database includes 5 scenario tables: `TREND_aandeel_km5`, `SCI_aandeel_km5`, `NFW_aandeel_km5`, `GEF_aandeel_km5` and `WWN_aandeel_km5`. Each of the scenario files (scenario_aandeel_km5) have the following data structure:

`OBJECTID    Value  Count  Transition`

OBJECTID refers to a unique access row number is not further used.

Value refers to the grid code, a unique number including x and y coordinates listed in the `SEQ5km_totaal_xy` table.

Count refers to the number of transitions in a 25km^2 grid. Each count therefore represents a land conversion with a 1km^2 spatial scale.

Transition refers to a unique transition number. These numbers are included in the Tables 3.13-3.16 in Chapter 3. Each transition number therefore represents an unique transition from CLC_{t0} to CLC_{t1} (see Annex 11).

Using an Access query the grid code, x and y coordinates in table `SEQ5km_totaal_xy` are connected to the different scenario_aandeel_KM5 tables for further processing.

The access database `IKN-EU database.accdb` includes various tables related to the calculation of one-off costs. For land purchase calculations at NUTS1 level (country level)are available in the table `Landprices_NUTS1.csv`. Data at the NUTS2 regional level are stored in the table `Landprices_NUTS2.csv`. Both tables include annualized land prices (2.5% inflation rate, 50 year period) of land price data described in Chapter 3. At NUTS1 level land prices at country level are provided and at NUTS2 regional land prices.

Because each scenario file has unique numbers for transition, separate transition files had to be made. This process could not be automated and was made by hand, resulting in five `Transition_scenario.csv` files. In each scenario a transition number refers to a specific land conversion (from CLC at t_0 to CLC at t_1), unique for each scenario. However, each specific land conversion, CLC at t_0 to CLC at t_1, is linked to different activities (see Table 3.12 for an overview). By joining the scenario specific transition number with the generic conversion measures, each scenario displays the same type measure for an equal type of conversion. The conversion measures denoted in Table 3.12 are joined with the full cost table of measures, displayed in Table 3.11. This leads to full costs per transition number in each scenario file. To annualize full conversion costs the values were recalculated using a 2.5% inflation rate over a 50 year period. The tables `Conversion costs` therefore include the following columns:

`Transition   Annual costs`

Transition refers to the unique transition number for each scenario, provided by PBL.

Annual costs refers to the annualized land conversion costs, based on the different types of measurements depicted in Table 3.11 and Table 3.12.

4.5.2 Costs input data and preparation

Costs of land purchase are provided at the NUTS1 and NUTS2 level. However, NUTS2 level land prices are not available for all countries. The selection of countries with only NUTS1 level data was selected by hand and included in IF statements in the R script. Exclusion of the IF statements results in NUTS2 level land price calculations. If countries have NUTS2 level land prices (Belgium, Bulgaria, Germany, Greece, Spain, France, Finland, Hungary, Italy, Poland Portugal, Romania, Sweden and UK) than only these data are used.

Cost calculations of land purchase (at NUTS1 and NUTS2 level) are calculated by using the selected transition codes in the input tables `scenario_aandeel_km5` and the scenario specific `Transition_scenario.csv` file. In this latter file only transitions are included that constitute a transition to natural vegetation at t_1 (CLC codes 141, 243, 244, 311, 312, 313, 321, 322, 324, 331, 333, 411, 412, 421, 422, 423, 511, 512, 521, 522). However, not all land transitions lead to costs of land purchase. No costs of land purchase are assumed when at t=0 the CLC coverage is one of these above (a 'nature to nature' land conversion), except the transitions from CLC 243 and 244 to natural vegetation in t=1 (a transition from agricultural land use to natural vegetation cover) and transitions of other land uses to CLC 243 or 244. These exceptions have two reasons: first, transitions from one nature type to another does not involve land purchase and, secondly, because the codes 243 and 244 are defined primarily as agricultural use. These exceptions are covered by different transition numbers in each scenario. These exceptions are manually implemented in the R code in an IF statement. If such an exception occurs, than land purchase costs are assumed to be zero.

The NUTS2 region codes and land prices, derived from the FADN database, did not align with the GIS Corine Land Cover maps used for all other calculations. For calculations at the NUTS2 regional level two separate csv files were designed: `FADNcodesRaster.csv` and `FADNcorrectieTabel.csv`. These files correct for spatial misalignments and provide the relevant grid codes to the different FADN region codes.

While the land purchase cost data include country level differences in GDP, the conversion cost table uses generic costs. To correct for GDP differences using index values, the input table `Country_prices.csv` was used.

4.5.3 Module

The one-off cost module, programmed in R (Figure 4.2) includes four compartments. In the first compartment all input data is defined and aligned so that further calculations can be made. The different `scenario_aandeel_km5` input files are connected with a large input file (`XYcountry.csv`) that includes all `x` and `y` coordinates and grid codes. With this connection each transition code in `scenario_aandeel_km5` is connected to a unique `x`, `y` coordinate.

For land purchase calculations at NUTS1 level (country level) and NUTS2 regional level the data files `Landprices_NUTS1.csv` and `Landprices_NUTS2.csv` are used. The NUTS2 data are spatially aligned using the `FADNcodesRaster.csv` and `FADNcorrectieTabel.csv` files.

Cost calculations of land purchase (at NUTS1 and NUTS2 level) are calculated by the selected transition codes in the input tables `scenario_aandeel_km5` and the scenario specific `Transition_scenario.csv` file. The input tables `scenario_aandeel_km5` also include the column `count`, which denotes the number of transitions in the specific `x`, `y` (grid code) coordinate. The `x`, `y` coordinates are at a spatial resolution of 25 km^2, while the transitions are calculated at a 1km^2 spatial resolution. In theory, a specific transition can have a maximum value of 5 in the column *count*. By multiplying count*100 with land purchase costs (costs per hectares of land) the total costs for land purchase are calculated. Using the IF statement to discard transitions without land purchase costs calculations are only made for selected transition codes. This procedure is carried out for each scenario separately. By summing all cost data of grid codes per country or region (NUTS2), the land purchase costs are calculated at country (NUTS1) or regional (NUTS2) level.

The calculation of construction costs uses the input file Transition_scenario.csv and LNDAB_XXX.csv. The latter file includes the grid specific land abandonment and is developed by PBL. The transition input file includes the unique transition number, the number of transitions per grid and the annualized construction costs. By multiplying these costs with count*100 the total construction costs per grid is calculated. After merging all grid values for each country to derive country specific construction costs, the costs are multiplied by the index value in the input file country_prices.csv. This input file includes index values to correct for GDP differences in the EU member states.

All output is written in three separate files: NUTS1.csv, NUTS2country.csv and Transaction_table_indexed.csv. The first output file includes land purchase cost output data at the country level, the second file regional calculated land purchase costs combined at the country level and the third file the indexed construction costs data at the country level. In Excel these files are combined for further processing.

The model structure of the One-off cost module is depicted in Figure 4.2.

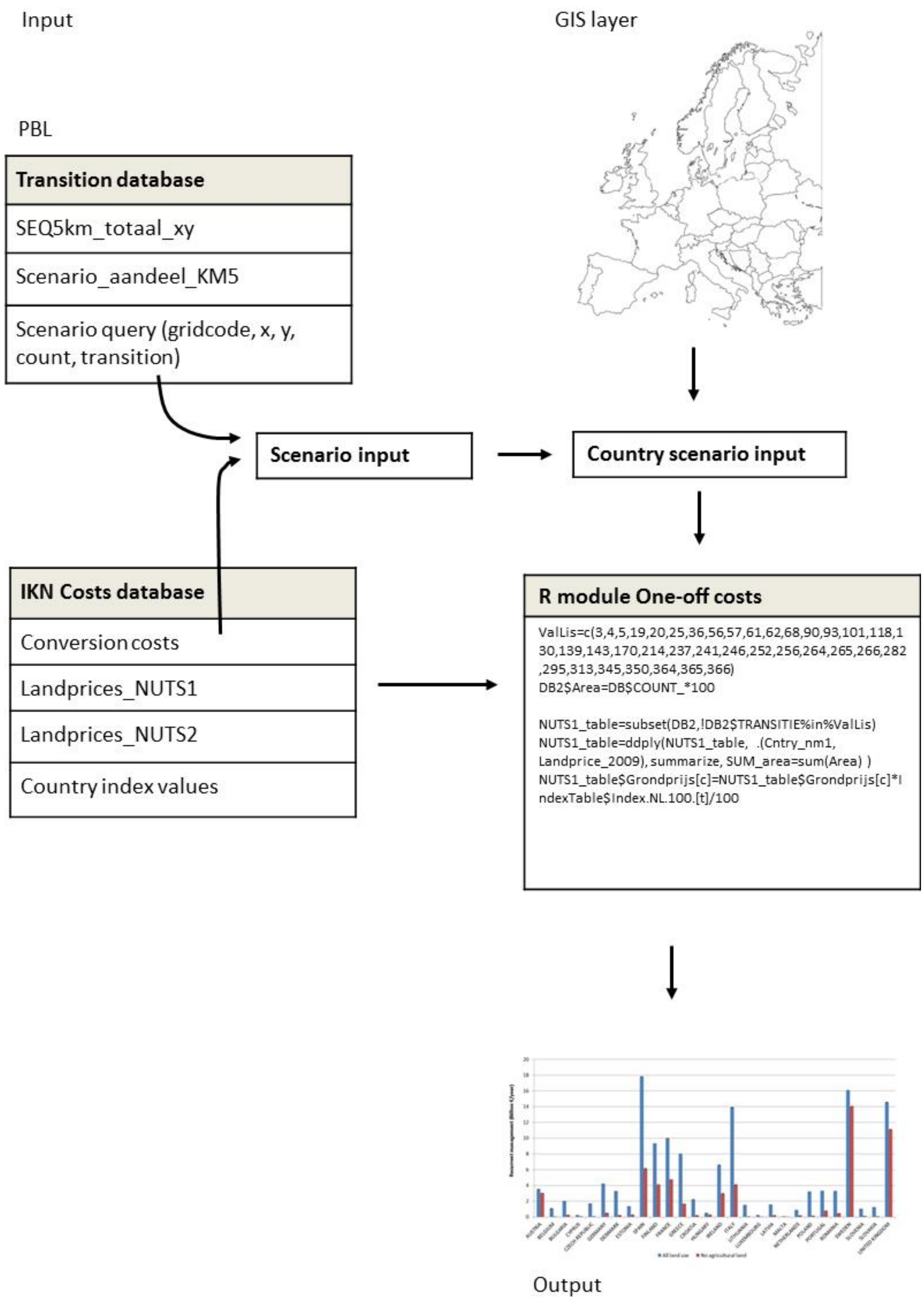

Figure 4.2 *Model structure of one-off costs. The structure includes data input from two separate databases. Each input scenario is run separately.*

5 Results

5.1 Base year

5.1.1 Nitrogen exceedance levels

The exceedance of critical nitrogen loads of vegetation types (CLC types) indicates the need for recurrent nature management. If atmospheric nitrogen deposition is higher than the critical nitrogen load of vegetation, biomass removal by management will lead to lower exceedance levels. The spatial distribution of atmospheric nitrogen deposition is depicted in Figure 5.1. It shows that in West and Central Europe (UK, Netherlands, Denmark, France, Germany Czech Republic, Poland and Northern Italy deposition is higher than the critical nitrogen levels of vegetation.

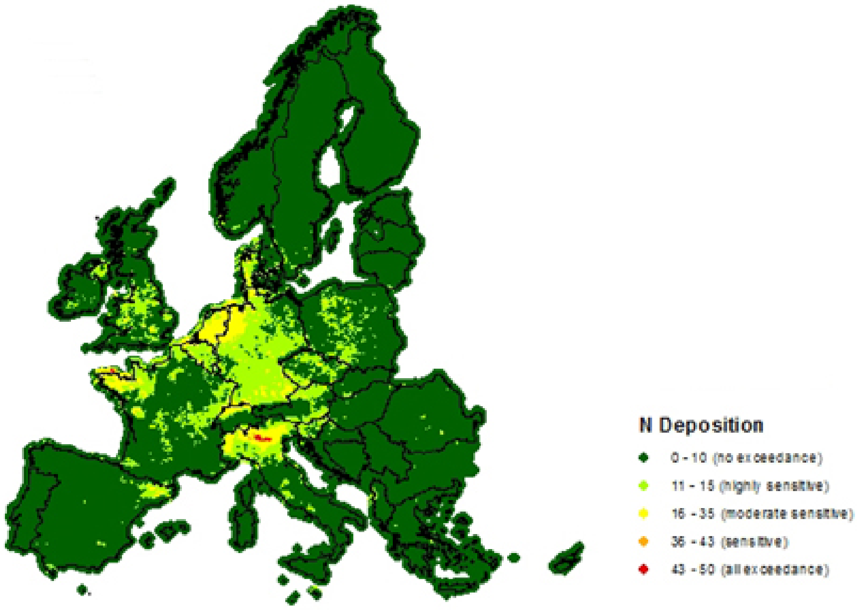

Figure 5.1 *Atmospheric nitrogen deposition in base year. Dark green indicates deposition does not exceed critical deposition levels and red deposition exceeds critical deposition of the most vulnerable vegetation types. Yellow coding indicates intermediate exceedance levels.*

Without recurrent management, nitrogen exceedance levels are found in ten EU countries (Figure 5.2, orange bars). The highest exceedance levels are found in the Netherlands, Germany, Belgium, France, Italy and Denmark. In Bulgaria, Cyprus, Estonia, Finland, Croatia, Lithuania, Latvia, Malta, Portugal and Slovakia critical nitrogen levels are not exceeded. The exceedance levels are found in respectively peat bogs, coniferous forests, moors and heathland and 'land principally occupied by agriculture, with significant areas of natural vegetation' (referred as agricultural land) (Figure 5.3, orange bars).

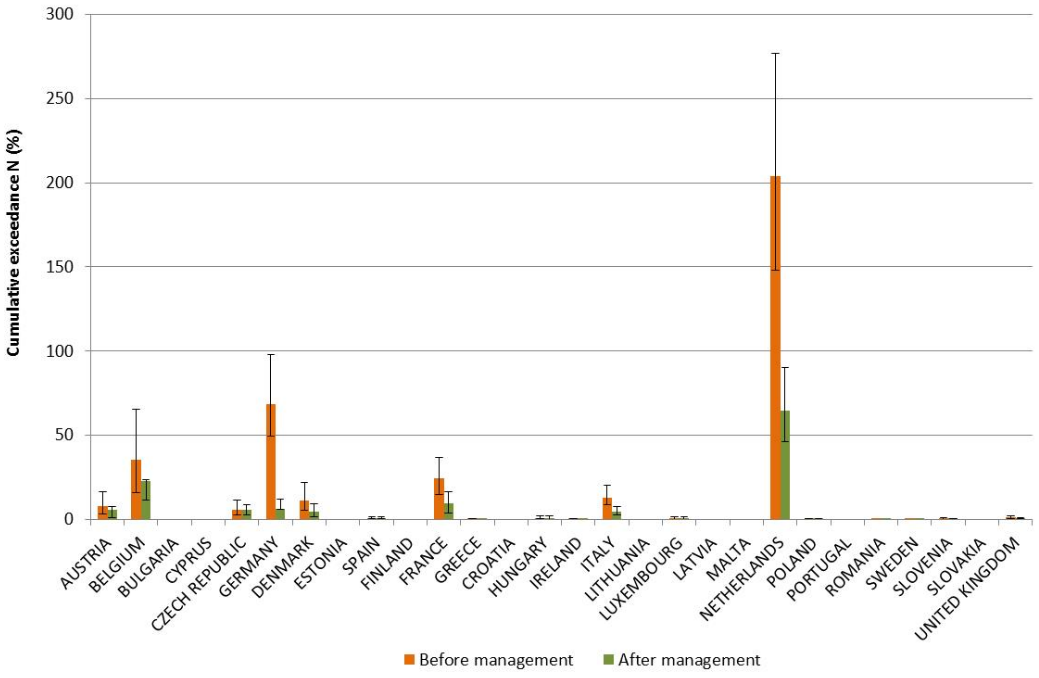

Figure 5.2 *Cumulative exceedance levels of nitrogen deposition in 28 EU countries in the base year. Orange: levels without recurrent management, green: levels with recurrent management.*

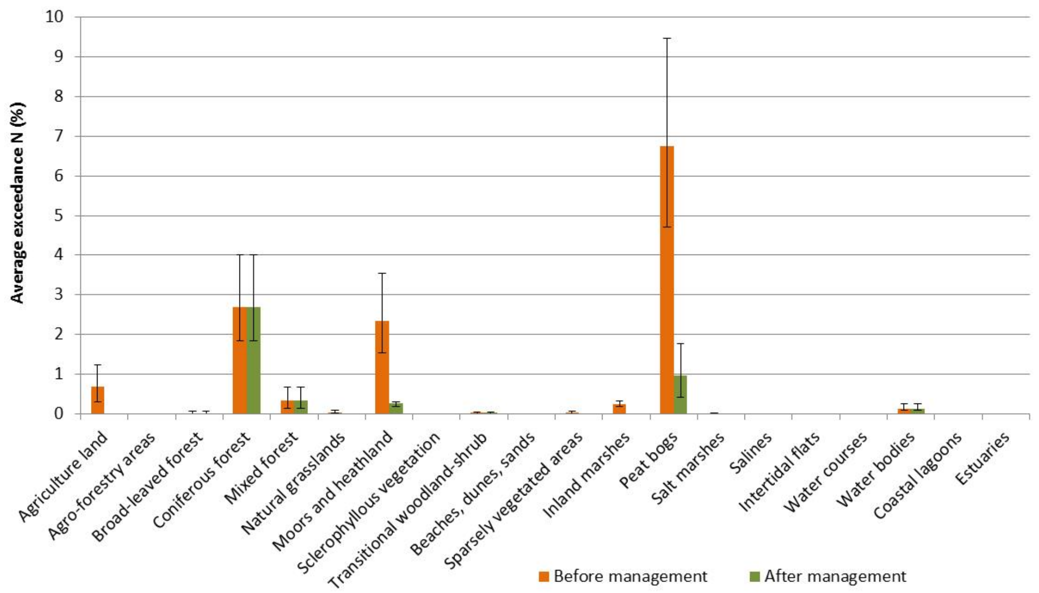

Figure 5.3 *Average exceedance levels of nitrogen deposition in CLC land use types in the base year. Orange: levels without recurrent management, green: levels with recurrent management.*

Recurrent management reduces the exceedance levels, but cannot prevent that critical loads remain exceeded after nature management. In Germany, France, Netherlands, Italy and Romania recurrent management could reduce exceedance levels by more than 60% (Figure 5.2, green bars). In other countries reduction of nitrogen exceedance levels was much lower.

In the various vegetation types exceedance reduction ranges between 100% and 85%. In some vegetation types no reduction could be made, such as in all forest types and marine, coastal and aquatic vegetation types. In these vegetation types no nitrogen removal management took place and as a result, no reduction of nitrogen exceedance can be realized.

5.1.2 Costs of recurrent management

The yearly costs of recurrent management in the EU-28 is estimated on 13 billion Euro per year (13.243.651.904 €/year). The highest costs are found in respectively Spain, Sweden, United Kingdom, Italy and France (Figure 5.4). These high costs, however, are strongly determined by the costs involved in the land use type 'land principally occupied by agriculture, with significant areas of natural vegetation'. This land use type includes various agri-environmental schemes. When the costs of this land use type are omitted, the total costs of recurrent management is found at 5.6 billion Euro per year (5.564.617.950 €/year). Taking these costs into account, largest costs are found in Sweden and United Kingdom (Figure 5.4).

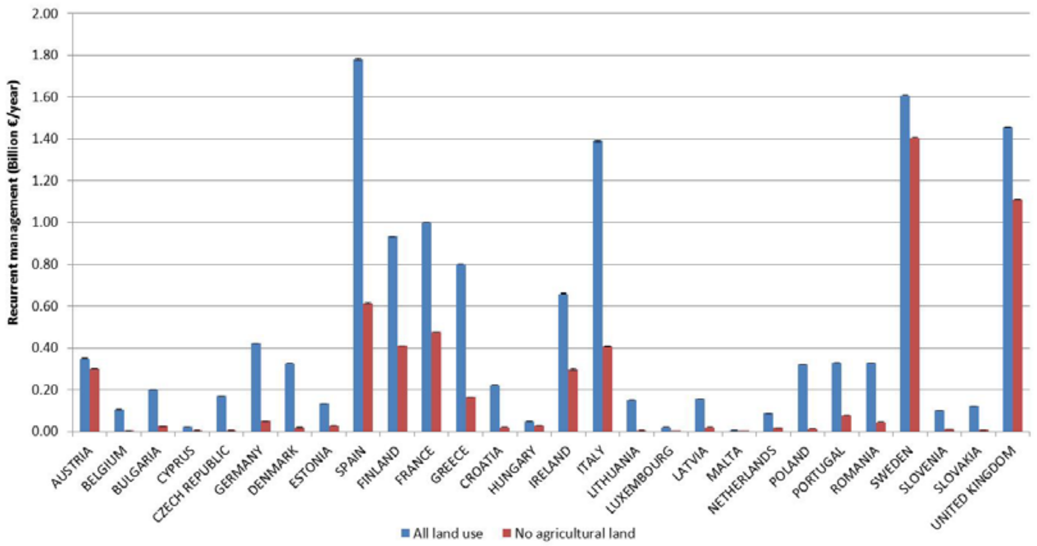

Figure 5.4 *Costs of recurrent management in 28 EU countries in the base year (in billion €/year). Blue: All land uses, Red: no agricultural land uses.*

Most recurrent management costs are made in only four CLC land use types. In respectively moors and heathland, natural grasslands, peat bogs and sparsely vegetated areas the largest amount of costs are made (Figure 5.5). The cost differences between runs in which nitrogen exceedance levels were set at 90% or 110% are relatively low.

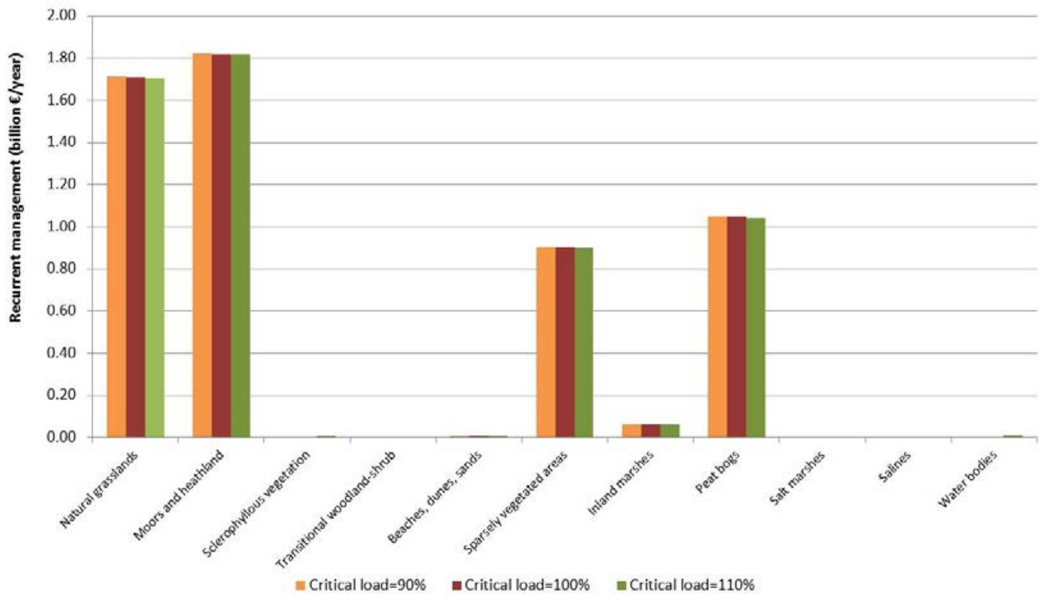

Figure 5.5 *Costs of recurrent management in CLC land use types in the base year (in billion €/year) at various levels of nitrogen exceedance. Red: values at critical nitrogen load of 100%, Orange: values at critical nitrogen load of 90%, Green: values at critical nitrogen load of 110%.*

The recurrent management costs depend on both the areas of land uses and the specific costs made per unit area (hectares). Relatively high costs are found in respectively Austria, Ireland, Sweden, Denmark and Finland for all land use types (Figure 5.6). Excluding agricultural land uses shows that recurrent management is highest in Sweden, Ireland, Finland and Austria. The average recurrent management costs are found between 58.68 €/ha/year for all land uses and 41.79 €/ha/year for natural vegetation coverages only.

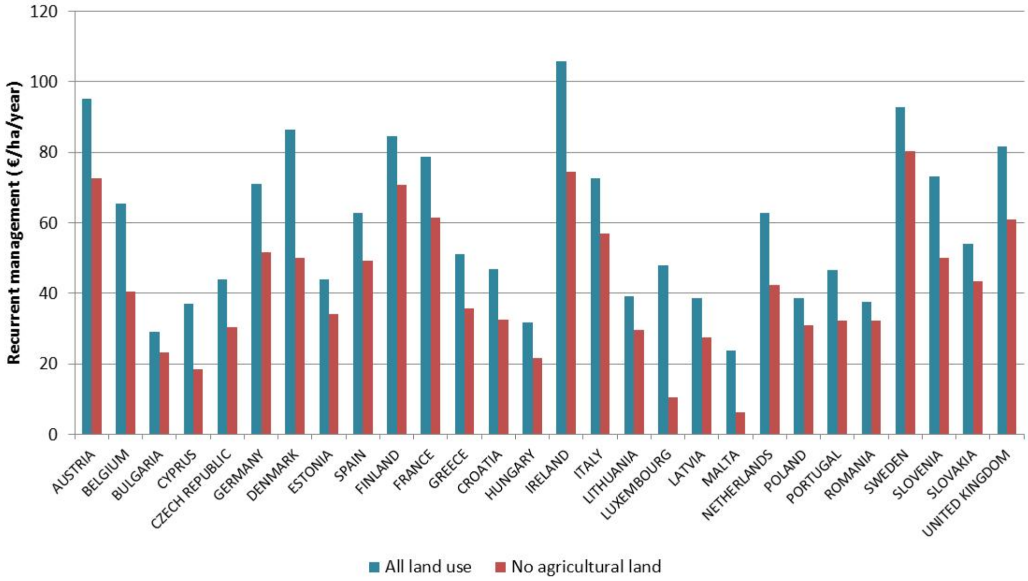

Figure 5.6 *Costs of recurrent management in 28 EU countries in the base year (in €/ha/year). Blue: All land uses, Orange: no agricultural land uses.*

As introduced in Chapter 2, recurrent management includes two types of management. First, nitrogen management, which refers to biomass removal to reduce nitrogen level exceedance and second conservation management which refers to management imposed to prohibit further vegetation succession, such as encroachment of grasslands and heathlands. The calculated recurrent management costs can largely be attributed to the latter conservation management. In natural grasslands, moors and heathland and peat bogs and inland marches the largest (or full) part of recurrent management costs are conservation costs (Figure 5.7). In sparsely vegetated areas recurrent management can mostly be attributed to nitrogen removal management.

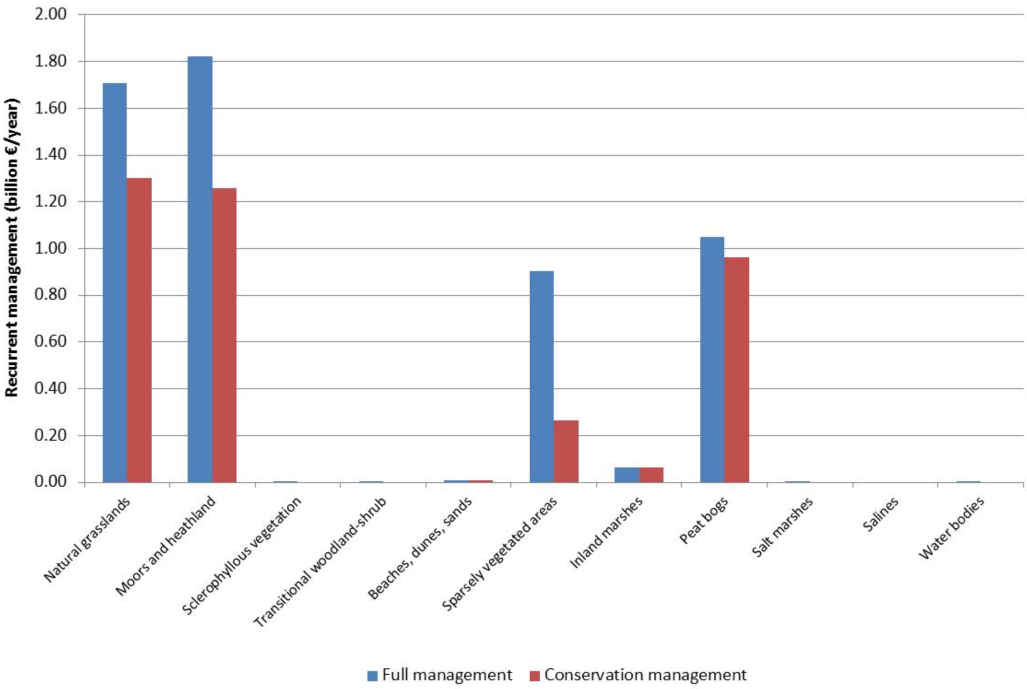

Figure 5.7 *Costs of full and conservation management of CLC land use types in the base year (in million €/year). Blue: Full management, Red: Conservation management only.*

The recurrent management costs in Natura 2000 areas are calculated at 3.5 billion Euro per year (3.465.798.472 €/year). The highest costs are found in Sweden, Italy and United Kingdom (Figure 5.8). The difference in costs between all nature areas and Natura 2000 areas are smallest in Hungary (57% of costs), Bulgaria and the Netherlands (40% of costs) and Croatia, Slovakia, Slovenia and Sweden (ca. 30% of costs). The highest differences are found in Denmark, Lithuania and Belgium (ca 12.5% of costs).

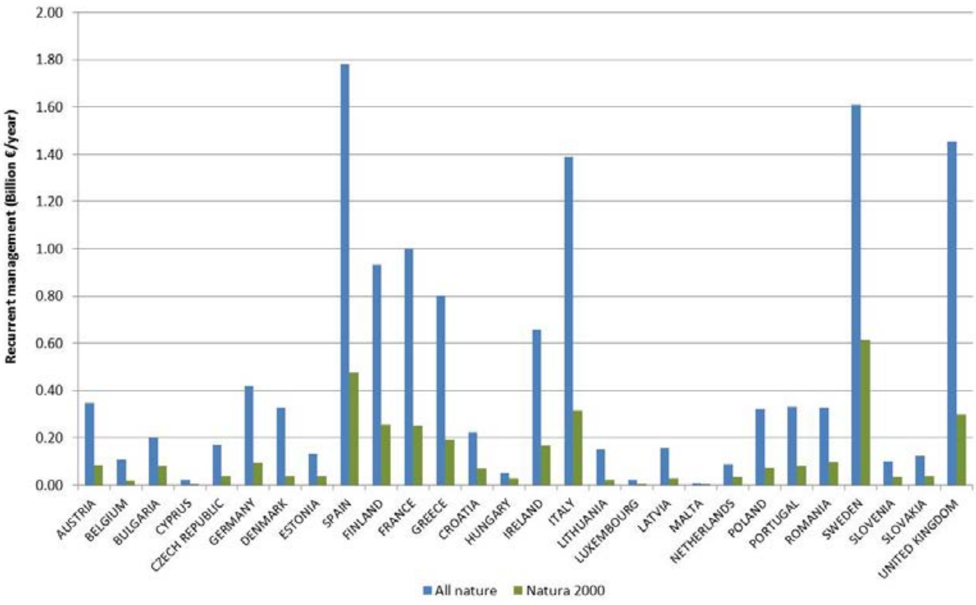

Figure 5.8 *Costs of recurrent management in 28 EU countries in the base year (in billion €/year). Blue: All nature areas, Green: Only Natura 2000 areas.*

5.2 Trend scenario

5.2.1 Nitrogen exceedance levels

Due to lower atmospheric nitrogen deposition (Figure 5.9), the levels of nitrogen exceedance are lower than found in the base year. Before recurrent management, only in Belgium, Germany, Denmark, France, Italy and the Netherlands cumulative exceedance levels were higher than 1% (Figure 5.10). After recurrent management highest levels were found in respectively the Netherlands (34%), Belgium (6%), Germany (4%), France (3.7%) and Italy (2.7%).

Nitrogen exceedance levels in different vegetation types in the Trend scenario were ca. 50% lower than in the base year (Figure 5.11). The patterns in exceedance levels are similar to the base year. Highest exceedance levels are found in peat bogs. After recurrent management only a fraction of peat bogs experienced exceedance levels of nitrogen deposition.

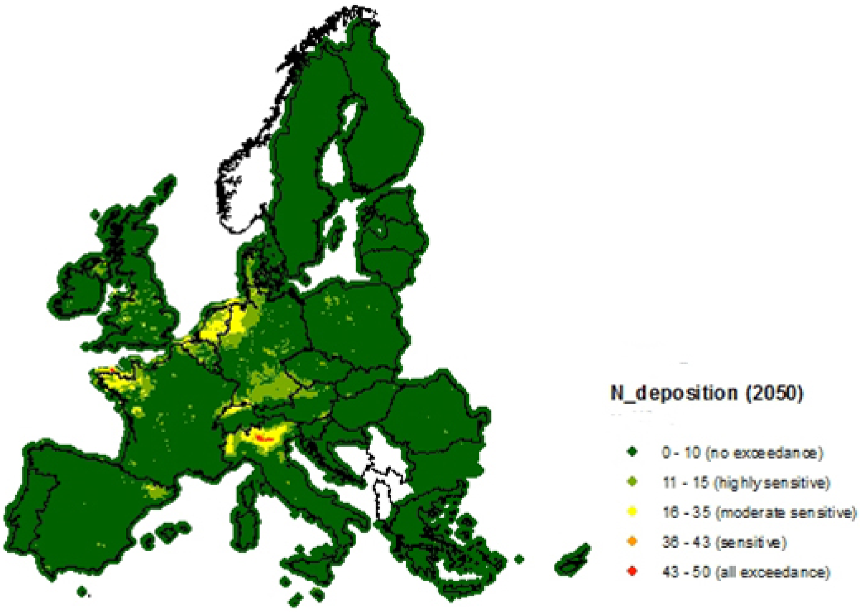

Figure 5.9 *Atmospheric nitrogen deposition in 2050 (Trend). Dark green indicates deposition does not exceed critical deposition levels and red deposition exceeds critical deposition of the most vulnerable vegetation types. Yellow coding indicates intermediate exceedance levels.*

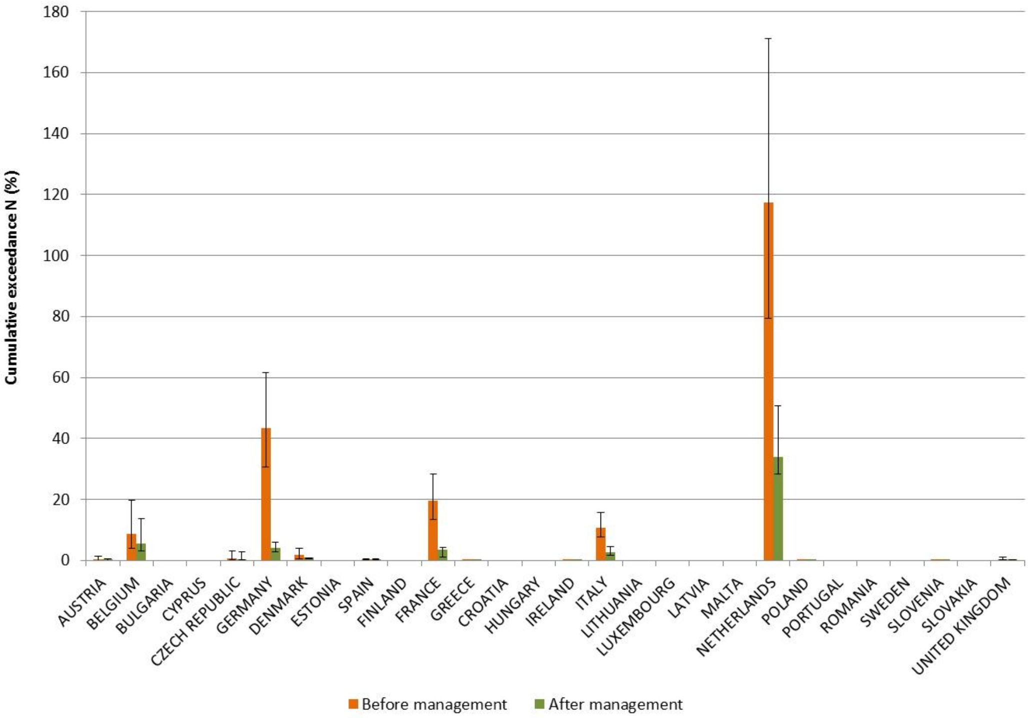

Figure 5.10 *Cumulative exceedance levels of nitrogen deposition in 28 EU countries in the Trend scenario. Orange: levels without recurrent management, green: levels with recurrent management.*

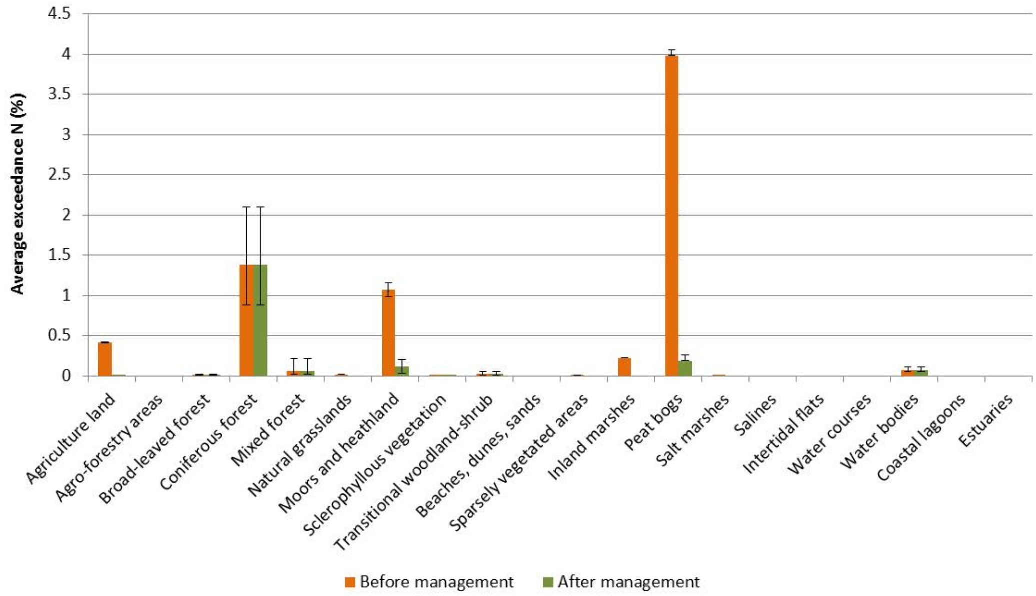

Figure 5.11 *Average exceedance levels of nitrogen deposition in CLC land use types in the Trend scenario. Orange: levels without recurrent management, green: levels with recurrent management.*

5.2.2 Costs of recurrent management

In the Trend scenario, the yearly costs of recurrent management in the EU-28 is estimated on 15.8 billion Euro per year (15.843.064.231 €/year). Highest costs are found in respectively Spain, Italy, Sweden, United Kingdom and France (Figure 5.12). Omitting costs associated with land use type "land principally occupied by agriculture, with significant areas of natural vegetation" results in yearly costs of 5.2 billion Euro per year (5.170.417.874 €/year).

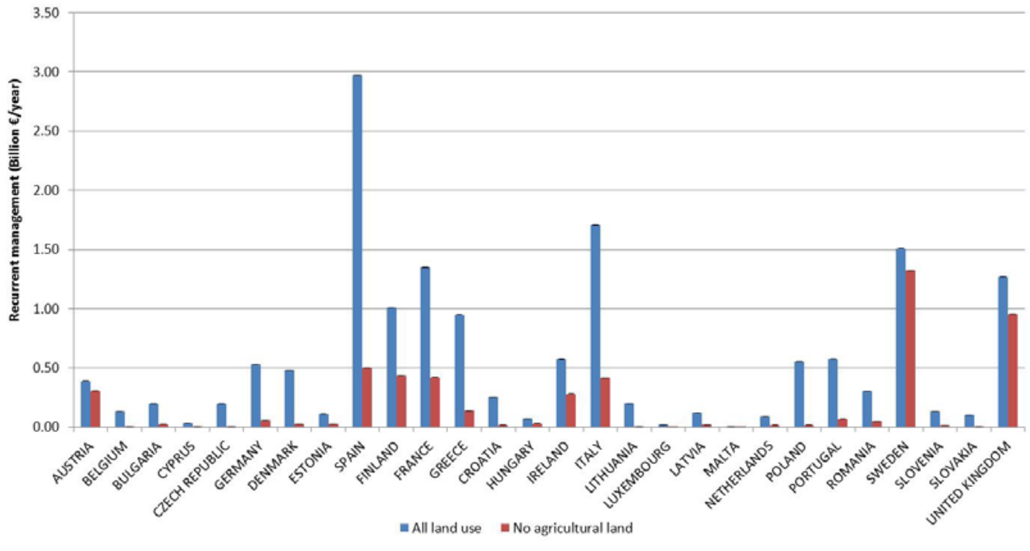

Figure 5.12 *Costs of recurrent management in 28 EU countries in the Trend scenario (in billion €/year). Blue: All land uses, Red: no agricultural land uses.*

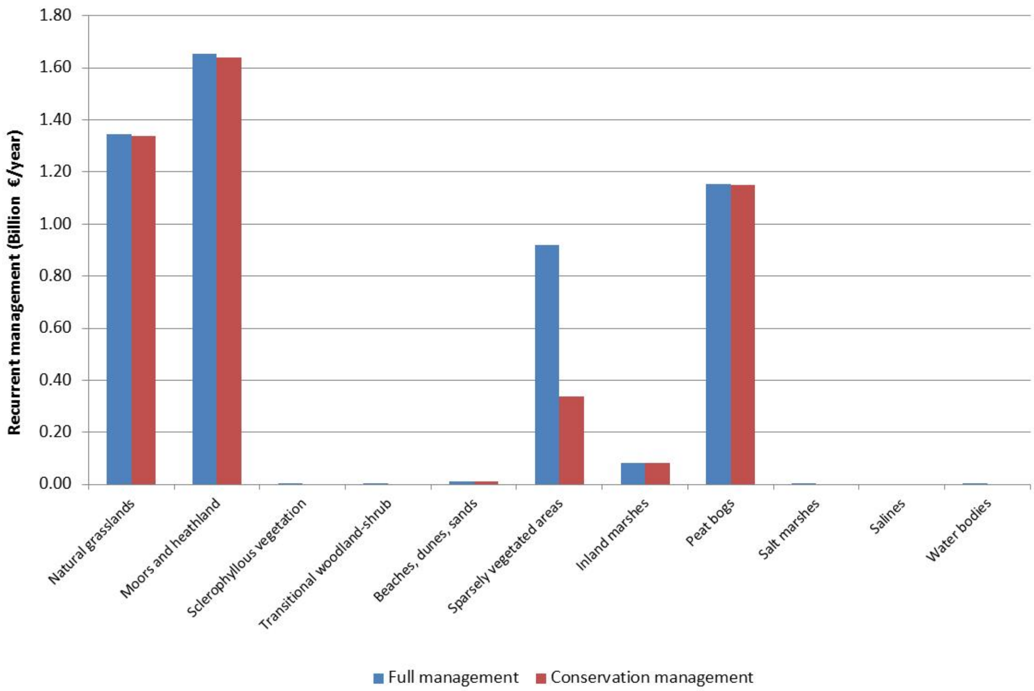

Figure 5.13 *Costs of full and conservation management of CLC land use types in the Trend scenario (in billion €/year). Blue: Full management, Red: Conservation management only.*

Almost all costs are related to conservation management (Figure 5.13). In sparsely vegetated areas a considerable part of the recurrent management costs are related to nitrogen management. In all other land use types almost no costs for nitrogen management are taken.

5.2.3 One-off costs

One-off costs include costs for land purchase and costs for construction work. These costs are annualized to yearly costs. Land purchase is only included when land for other purposes than nature is converted to CLC land use types associated to natural vegetation. Land conversion from one type of nature to another type does not include costs of land purchase. Land cover types CLC 243 (land principally occupied by agriculture, with significant areas of natural vegetation) and CLC 244 (Agroforestry) are not considered nature areas as such and therefore costs of land purchase are not included.

Figure 5.14 depicts the annualized one-off costs of land purchase and construction in the Trend scenario in the different EU states. For EU-27 (excl. Croatia due to lack of data) the total annualized costs are estimated on 3.3 billion Euro per year (3,335,165,238 €/year). Land purchase is estimated om 2,8 billion Euro per year (2,756,903,299 €/year) and construction costs on 578 million Euro per year (578,261,939 €/year).

The highest one-off costs are found in Italy. Costs of land purchase in Italy are 1.5 times higher than costs of land purchase in the second highest country, Spain. In 12 countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Irish Republic, Netherlands, Romania, Spain and United Kingdom costs of land purchase are higher than 50 thousand Euro per year.

Highest construction costs, associated with management changes in land cover and vegetation type, are found in respectively Spain, Finland, France and Greece. In all other countries construction costs are lower than 45 thousand Euro per year.

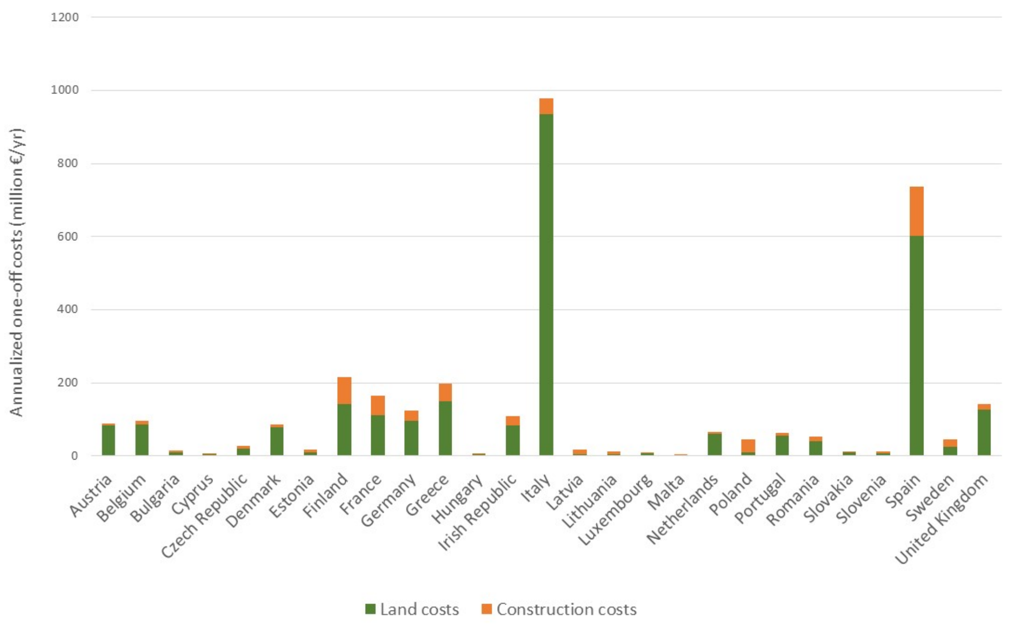

Figure 5.14 *Annualized one off costs in the Trend scenario for land purchase (green bars) and construction costs (orange bars) in 27 EU states (in million €/year).*

5.3 Comparison base year and Trend

In 2050, under the Trend scenario recurrent management cost are higher than in the base year. These higher costs are predominately associated with the large increase in the CLC land cover type 'Land principally occupied by agriculture, with significant areas of natural vegetation' (Table 5.1). Large cost increments are found in Spain and to a lesser extent in France, Italy, Poland and Portugal (Figure 5.15). For the cost calculations these agricultural land use type is taken into account for biodiversity conservation. Excluding this land cover type from the analysis shows that the recurrent management cost in the Trend scenario becomes lower than in the base year (Table 5.1).

Table 5.1
Recurrent management costs in the base year (2000) and the Trend scenario (2050) in billion €/year for all land uses and excluding the CLC 3 land cover type 'Land principally occupied by agriculture, with significant areas of natural vegetation'.

	All land uses	Excl. agricultural land use
Base year (2000)	13.24	5.56
Trend scenario (2050)	15.84	5.17

Because the large changes in agricultural land (CLC type 243) strongly determine the cost pattern differences between the base year and the Trend scenario, which is mainly due to the increased CLC 243 areas in 21 of the EU states, slight changes in costs in other land cover types are hardly traceable. Therefore the agricultural land cover type is omitted from the cost comparison.

Figure 5.16 depicts the cost differences between 2050 under the Trend scenario and base year in the 28 EU states for different land cover types. In Sweden, United Kingdom, Spain and France the largest cost differences are found. Lower Trend costs are found in Spain, France, Greece and the UK for natural grasslands, and in the UK and Sweden for moors and heaths. Higher Trend costs are found in Finland and Sweden for peat bogs. In France, Italy and Austria some small cost increments in the Trend scenario are found for sparsely vegetated areas.

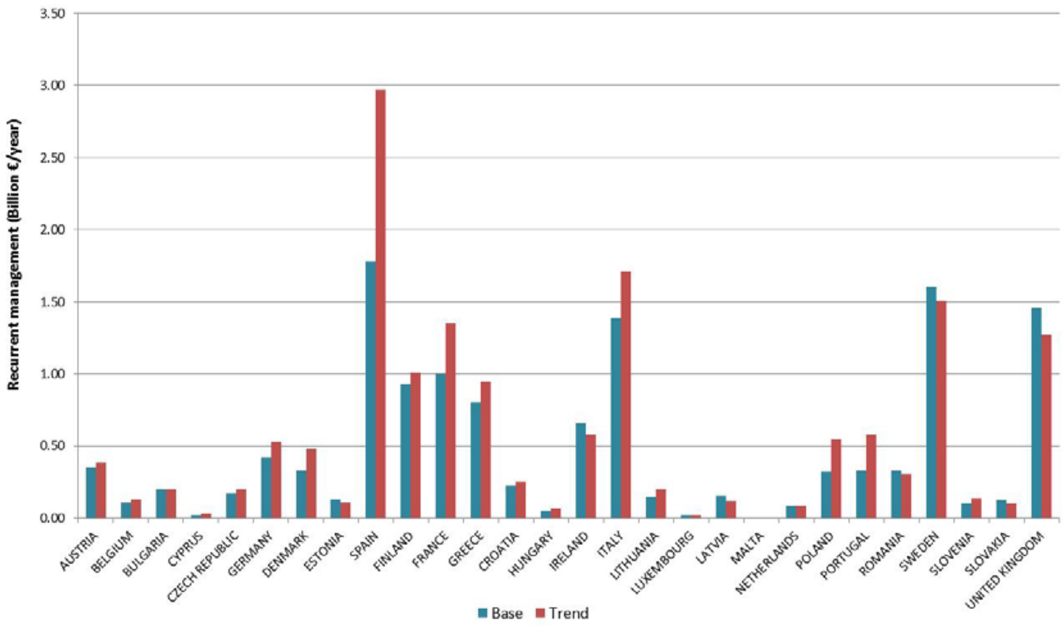

Figure 5.15 *Recurrent management costs in the base year (blue bars) and the Trend scenario (red bars, in billion €/year).*

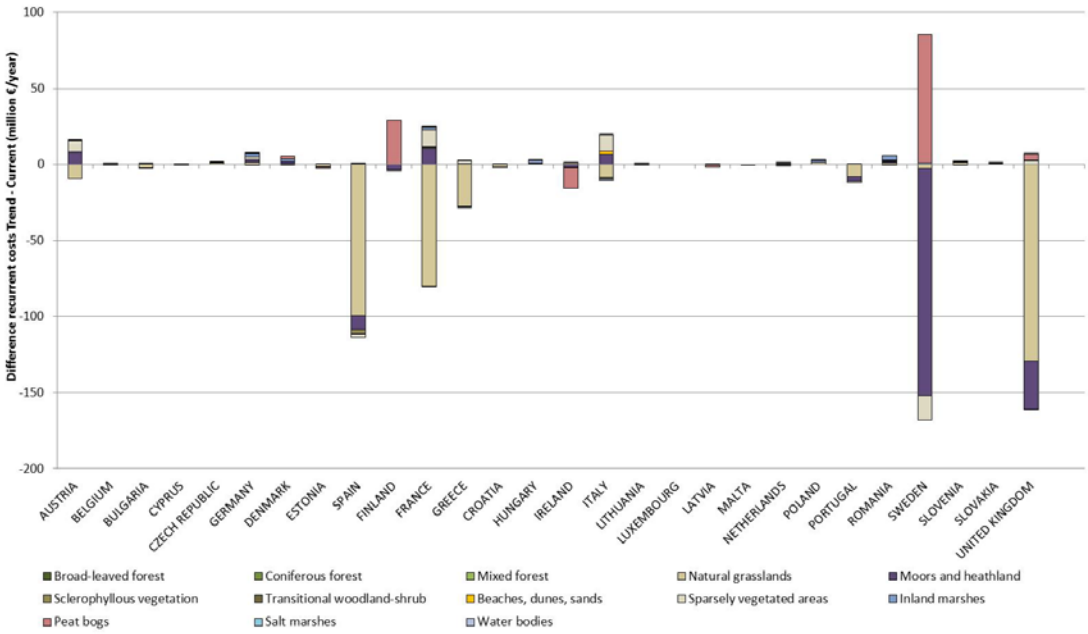

Figure 5.16 *Differences in recurrent management costs between 2000 and 2050 under the Trend scenario for different land cover types, in million €/year. Positive values indicate higher costs in 2050 than in 2000, negative values lower costs in 2050 than in 2000.*

Cost differences between the Trend scenario and the base year can therefore be attributed to area changes, since atmospheric nitrogen deposition in the Trend is lower than in the base year. Hence lower costs for nitrogen removal per area base in the Trend scenario are taken. Figure 5.17 depicts the area shifts between the Trend and base year. High land mobility (dynamics) is found in Spain, France, Greece and Sweden. A reduction in mainly transitional woodland-shrub land cover, sclerophyllous vegetation, natural grassland (Spain) and moors and heaths (Sweden) are found in the Trend scenario. Increase in cover of agricultural land (CLC 343), and various forest types (reforestation) are found, while pastures areas increased in Germany, France and Poland.

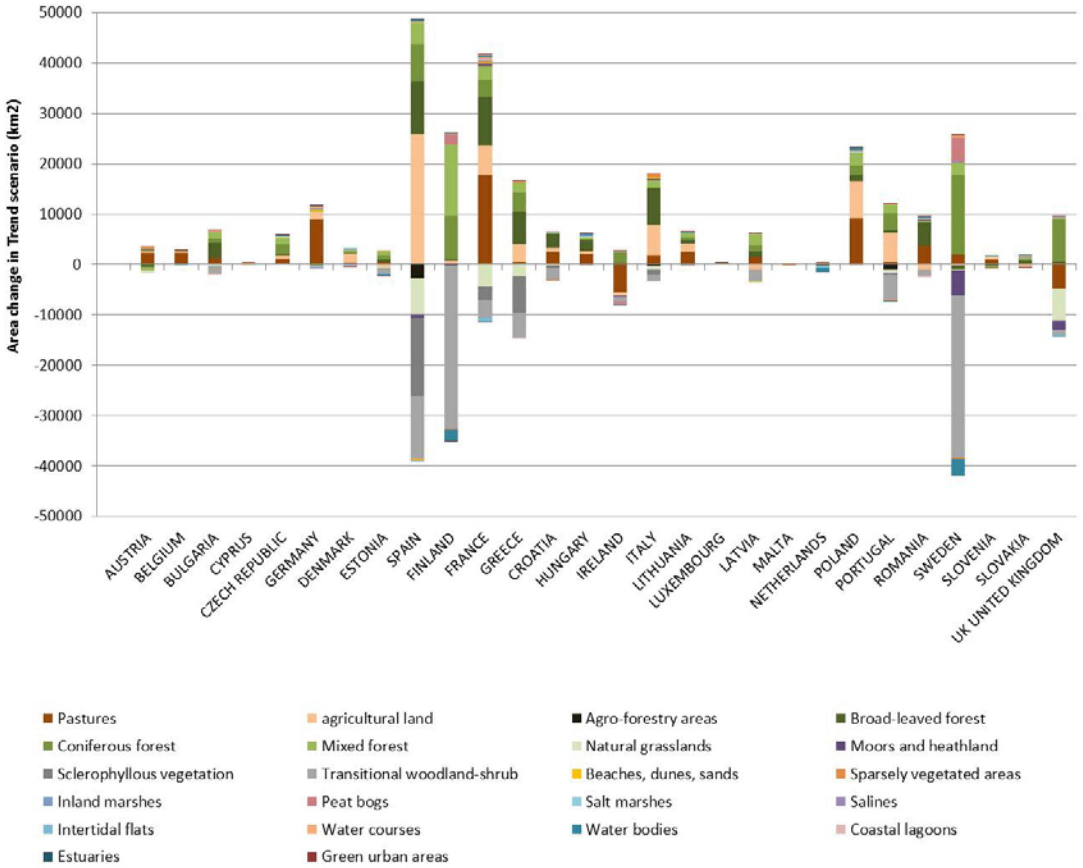

Figure 5.17 *Area differences between the Trend scenario and base year for different land cover types, in km². Positive values indicate an area increase in the Trend scenario, negative values an area decrease in the Trend scenario.*

5.4 One-off costs of perspectives

In all perspectives (SCI, Strengthening Cultural Identity, NFW, Allowing Nature to find its Way, GEF, Going with the Economic Flow, WWN, Working with Nature) costs of land purchase are higher than in the Trend scenario (Table 5.2). Also construction costs are higher, but not for NFW. Total annualized one-off costs are lowest in Trend, followed by SCI. Highest total annualized costs are found in WWN (Table 5.2).

Table 5.2

Total annualized one-off costs for land purchase and construction in the different scenarios (in billion €/year). Trend= Trend scenario, SCI = Strengthening Cultural Identity, NFW= Allowing Nature to find its Way, GEF = Going with the Economic Flow, WWN = Working with Nature.

Scenario	Land costs	Construction costs	Total
Trend	2.76	0.58	3.34
SCI	3.52	1.57	5.09
NFW	3.86	2.7	6.56
GEF	5.64	0.56	6.2
WWN	7.57	2.22	9.79

Figures 5.18 and 5.19 depict respectively the annualized one-off costs of land purchase/depreciation and construction for the different scenarios in 27 EU states. In all scenarios land depreciation costs are highest in Italy, followed by Spain. With regard to construction costs, differences among countries and scenarios are less clear. Under NFW costs are highest in Finland, Sweden and France, while in WWF highest costs are found in Spain, France Italy and Germany. For SCI highest construction costs are found in the UK, Italy, France Germany and Spain. Under GEF no large differences in construction costs among countries are found. Therefore, largest by-country differences in construction costs are found in respectively NFW, WWN and SCI.

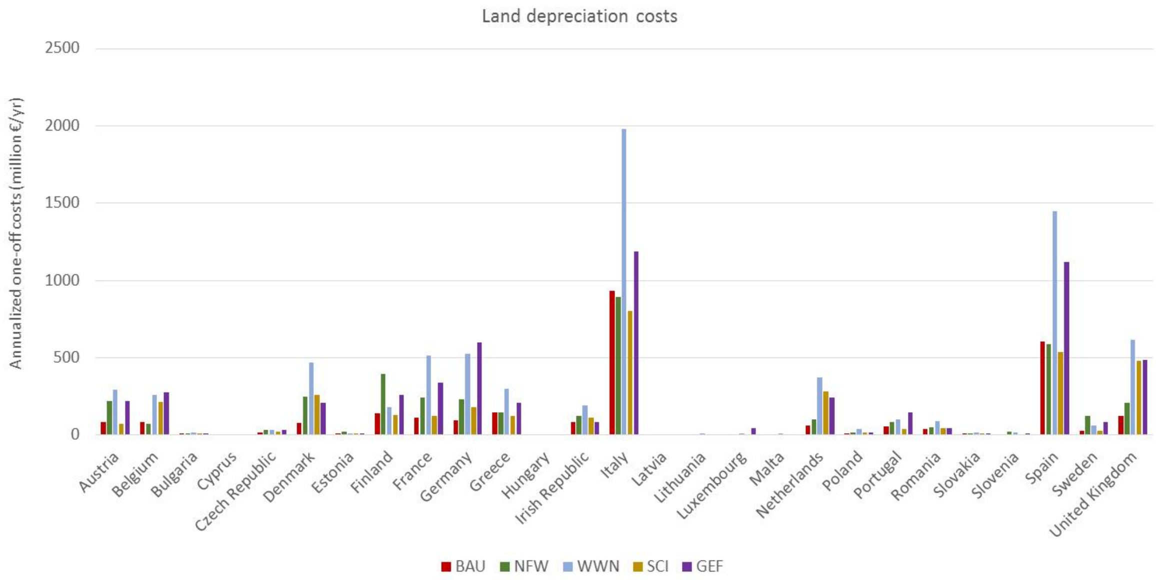

Figure 5.18 *Annualized one-off costs of land purchase (in million €/year) in the different scenarios (Trend = Trend scenario, SCI= Strengthening Cultural Identity, NFW= Allowing Nature to find its Way, GEF= Going with the Economic Flow, WWN= Working with Nature).*

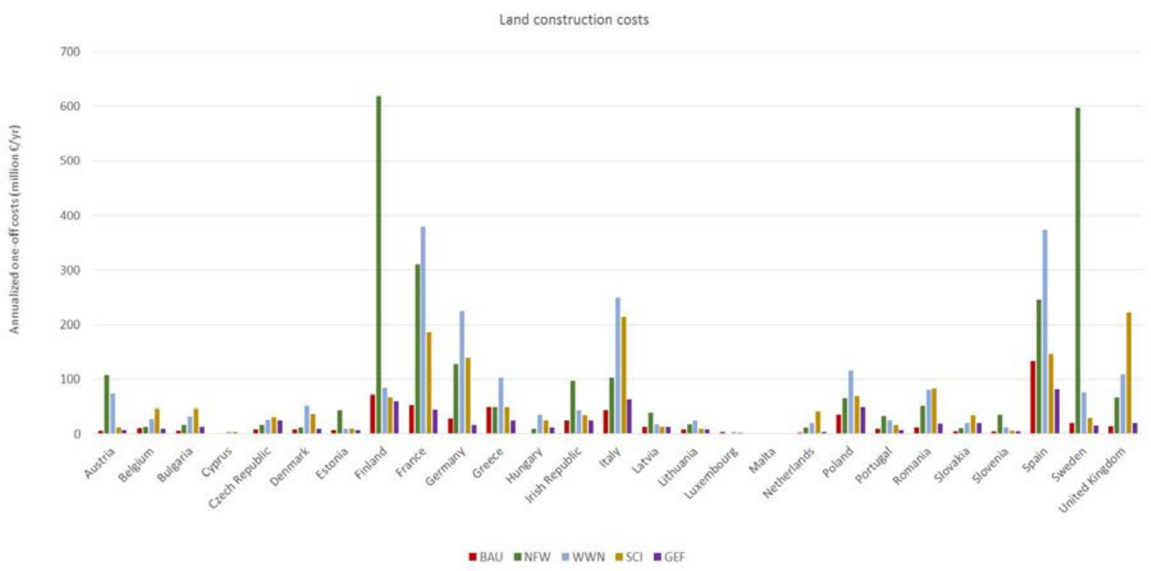

Figure 5.19 *Annualized one-off costs of construction (in million €/year) in the different scenarios (Trend = Trend scenario, SCI= Strengthening Cultural Identity, NFW= Allowing Nature to find its Way, GEF= Going with the Economic Flow, WWN= Working with Nature).*

6 Discussion

6.1 Recurrent costs

Costs of nature management can be divided into different categories such as production costs, implementation costs and decision making costs (Wätzold *et al.*, 2010). Recurrent management costs can be considered production costs, since Wätzold *et al.* (2010) define such as “the costs of the actual conservation measures that are carried out including foregone economic benefits due to restriction on economic activities”. Examples of production costs are costs for setting up and maintaining fences and foregone profits of farmers due to restrictions on farming for reasons of conservation. Nonetheless, the calculated recurrent costs in this report do not cover all types of production costs activities. Nitrogen management and conservation management (grazing, mowing, sod cutting and measures such as costs of fencing, drinking water for herds, etc.) are included, but important measures to counteract pressures of biodiversity decline, such as desiccation and acidification are not taken into account. The model estimates costs of recurrent management in the base year between 5.6 and 13.2 billion Euro per year in 28 EU member states. This large range in cost estimates is due to the selection of land cover types. If the land cover type ‘land principally occupied by agriculture with significant natural vegetation’ is included, the highest value of 13 billion Euros is found, due to the large area covered by this land type. Since this land type is primarily agriculture, omitting it from the calculations result in recurrent management costs in the lower range of 5.6 billion Euro per year.

Not all costs can be attributed to the management of Natura 2000 since the cost estimates include all nature area. Costs of recurrent management in Natura 2000 areas are estimated on 3.47 billion Euro per year for EU-28 by the cost model. In literature there are hardly any data sources to compare with and to validate this estimate. Gantioler *et al.* (2010, 2014) used surveys and interviews to estimate recurrent management costs. Recurrent management costs in Natura 2000 for EU27 (excl. Croatia) was estimated on 3.43 billion Euro per year. These costs include both management planning and habitat management and monitoring. Since the cost model only includes management, the costs of habitat management and monitoring of Gantioler *et al.* (2010, 2014) should be compared. These costs are estimated on ca. 2.7 billion Euro per year. This category includes more than only management of habitats, but costs of these sub categories are not further broken down. Comparing our model results with Gantioler *et al.* indicates a 28% higher estimate of recurrent management costs by the cost model.

The size of areas may strongly determine unit costs of nature management (e.g. Balmford *et al.*, 2003; Vreugdenhil, 2003; Bruner *et al.*, 2004). Large areas are relatively less costly to manage than small areas. The cost model did not include size effects of nature areas. Calculations are made at grid scale level and are independent of the land cover type in adjacent grids. Since area may strongly determine full cost estimates (e.g. Balmford *et al.*, 2003; Vreugdenhil, 2003; Bruner *et al.*, 2004), accurate size estimations of nature areas highly important. However, in literature there is still no consensus on the area estimates of the (full) Natura 2000 network. While in Gantioler *et al.* (2010) the area of the network in EU 25 (excl. Croatia, Romania and Finland) was estimated at 804,984 km^2, the Eurobarometer of the European Commission (February 2016) estimates total terrestrial Natura 2000 area for EU 28 at 787,606 km^2 and a total Natura 2000 area (including marine protected areas) of 1,147,956 km^2. The Corine land cover maps derived from EEA data sources and used in our study, shows 820,750 km^2 of Natura 2000 terrestrial area. It is clear that different size estimates result in different total costs for recurrent management.

The calculated recurrent management costs on area basis are on average between 40 and 60 € per hectare per year. Among the various land cover types large cost differences are found. Highest values are found for sparsely vegetated areas and moors and heaths where per area management costs are between 300 and 380 € per hectare per year. Low costs are found for sclerophyllous vegetation and salt marches where costs are less than 5 € per hectare per year. These large range in values are, to some extent, comparable to calculations on the Dutch nature policy (e.g. Leneman *et al.*, 2013;

Schouten *et al.*, 2012) and estimations of Rusu (2013) in the case of Romania on recurrent management costs. In the Dutch cost model, recurrent management only includes regular mowing and grazing. In the EU context of the model presented here, also measures such as sod cutting and dredging are taken into account, which are relatively costly measures. The Dutch cost model includes such measures as sod cutting and dredging, but referred to as 'additional nitrogen management'.

A large fraction of recurrent management costs only contributes to conservation management, while it was expected nitrogen management would include a much larger fraction of the costs. In those vegetation types in which conservation management was applied (natural grasslands, moors and heaths, beaches and dunes, sparsely vegetated areas, inland marshes and peat bogs) the fraction of conservation management to full recurrent management ranged between 29% (sparsely vegetated areas) and 96% (peat bogs). This indicates that costs could substantially be reduced when natural succession of vegetation is allowed to take place. While keeping these vegetation types in the current (desired) stage, relatively high costs have to be made. In other vegetation types costs are mainly taken for nitrogen emissions and exceedance, although the management costs in these vegetation types are relatively low.

Recurrent management costs in the Trend scenario showed to be substantially larger than in the base year. However, these higher costs can be attributed fully to the larger area of natural vegetation in the Trend scenario. Due to predicted lower nitrogen emissions from industry and traffic, nitrogen exceedance of vegetation showed to be much lower than in the base year. As a consequence almost all recurrent management costs are executed for conservation management, rather than for nitrogen removal.

Calculations of nitrogen exceedance levels after management are used as proxy to estimate the efficiency of measures. Since exceedance levels correlate with species richness of vegetation, these nitrogen exceedance levels indicate to what extent policy targets, regarding species diversity and richness, can be met. However, species richness does not always decrease linearly with increasing nitrogen levels. In herbaceous vegetation species richness strongly decline with small levels of nitrogen exceedance (e.g. Bobbink, 2004; Bobbink and Hettelingh, 2010). Therefore the exceedance levels used as proxy in the cost model underestimate impacts on species richness for herbaceous vegetation types. Recurrent management decreased nitrogen exceedance levels in different vegetation types considerably. A comparison of exceedance levels before and after management showed a strong decline of areas in an 'unfavourable condition' (i.e., areas in which the nitrogen levels exceed the threshold to maintain full species richness). Only in the Netherlands, Belgium and to a much lesser extent in France, Germany and Italy some areas of natural vegetation have such high nitrogen levels that after management critical nitrogen deposition levels are still exceeded. This is mainly caused by high exceedance levels in coniferous forests and peat bogs. Because recurrent management only includes removing nitrogen by mowing, grazing and sod cutting of herbaceous vegetation, recurrent management did not affect exceedance levels in coniferous forests. In peat bogs nitrogen exceedance levels are strongly reduced by recurrent management, but due to the high critical nitrogen load, management could not remove all nitrogen deposition.

6.2 One-off costs

One-off costs are non-recurrent investments into land purchase, land conversion, habitat restoration and infrastructure. A transition from agricultural land use to natural vegetation cover due to agricultural land abandonment indicates a passive conversion without costs. But land abandonment still includes costs of land depreciation due to a change in function; i.e., from agricultural land cover to nature. Therefore all land conversion (except nature-to-nature conversions) includes land purchase costs

The construction costs included measures to actively change vegetation cover type. In such construction also restoration measures are taken into account. For all these measures a 'low cost trajectory' is assumed: if natural succession can lead to a particular vegetation cover, than no measures are assumed. This is the case in land cover changes from for example grasslands to shrub coverage.

To complete the Natura 2000 network, Gantioler *et al.* (2010) estimated an average annualized one-off cost of ca 20 €/ha/year. These costs include development of management plans, land purchase and infrastructure. This value is more than 70 fold lower than the estimates of the cost model. On average the assessment on land purchase costs (see Chapter 3), based on Eurostat and FADN data, indicated 450 € per hectare per year while data used in the cost model indicate average construction costs of 1028 € per hectare per year. Gantioler *et al.* (2010) argued that in many member states "land purchase is only contemplated in rare circumstances, and that forming management agreements with private landowners is the norm". This would imply no opportunity costs, but compensation payments for decrease of agricultural yields. Surprisingly, such opportunity costs are not considered by Gantioler *et al.* Furthermore, the infrastructure costs of Gantioler *et al.* (2010) include activities and aspects such as investment costs of equipment, signage, trails and observation platforms. Although some references towards restoration costs are made, it is unclear to what extent the provided infrastructure costs include restoration and land conversion activities. Therefore it is difficult to compare and validate the one-off costs estimated for the Trend and other scenarios. Construction costs, however, are in line with previous calculations of the cost model for Dutch nature policy. Annualized construction costs differ considerably between types of land conversion and ranges between 0 and 556 € per hectare per year (see also the Tables 3.13-3.17). Highest costs are found for conversions from agriculture to forest types.

Natural land cover is larger under the four policy scenarios (SCI, NFW, GEF, WWN) than under the Trend scenario. In Trend ca. 7.5 million ha of agricultural land is transformed to nature in some kind, compared to the base year. In the policy scenarios land transformation ranges from 8.4 million hectares in SCI to 16.3 million hectares in WWN. These larger areas strongly affect the one-off costs. In all policy scenarios, including GEF, land purchase/depreciation costs are higher than in the Trend scenario. But this does not entirely hold for construction costs. In GEF construction costs are somewhat lower than in the Trend scenario.

The remaining policy scenarios have higher construction costs. Largest one-off costs, both for land purchase and construction, are found in the WWN (Working with Nature) scenario. This scenario emphasises the use of ecosystem services and natural capital for societies and includes services like water retention, carbon sequestration, etc. Design of such a scenario may thus imply high investment costs, for example conversions of land to water bodies. Such conversions are relatively costly due to measures such as soil digging. The objective of this scenario is to make better use of ecosystem services. Hence, including benefits of scenarios may show a more favourable balance between investment costs and future benefits. However, benefit calculations were not a part of the cost model.

6.3 Methodological issues

Sensitivity analyses are important tests of any model. Such tests provide insights into the effects of parameter value changes on the outcome of model calculations. In data intensive models, such as the cost model, accurate parameter estimations are crucial. Depending on the structure of the model and the role parameter values play in the outcome, small changes in parameter values may have strong effects on model calculations. The cost model is strongly data driven. Normalized costs of recurrent management, one-off costs, nitrogen deposition and critical nitrogen loads of vegetation interact in such manner a large range of model output is possible. The current model includes one sensitivity analysis on nitrogen deposition. Because exceedance of critical nitrogen loads of vegetation types determine recurrent management, a sensitivity analysis was performed on varying levels of nitrogen deposition. By using + 10% and – 10% of the specific critical nitrogen loads of vegetation types and indication of the range of cost estimates could be made. The results, however, showed a much smaller range of cost effects than expected. This was mainly due to the large share of conservation management in recurrent management. In most nature areas, critical nitrogen levels did not exceed due to atmospheric nitrogen deposition, but the areas are managed to keep vegetation in the desired state, i.e., conservation management.

In the model standardized costs are used of various measures. In both recurrent management as one-off costs, such standardized costs are developed from various data sources. However, uncertainty of these values and ranges in values are largely unknown. Without doubt, inaccurate estimations will have profound effects on cost calculations. Therefore, sensitivity analyses on the standardized costs should be made, but this requires some large changes in the current model structure and model code which will take considerable time to implement. Nonetheless, it is recommended to apply such sensitivity analyses in a follow-up study.

6.4 Conclusion

The estimated recurrent and one-off costs of the cost model are in line with previous calculations of the cost model applied to the Dutch nature policy context. Nonetheless, estimations of both types of costs are much larger than previously found in international literature on maintaining the Natura 2000 network. Explanations for the cost differences are found in the measurements taken into account. In the scenario analyses one-off costs are much higher than recurrent management costs to maintain habitat quality. In the Trend scenario recurrent management costs are in the order of 50 €/ha/year while one-off costs can be as large as 1500 €/ha/year. Construction costs are much lower than costs of land purchase although our calculations of the latter type are much higher than previously described in literature. Construction costs can further be reduced by using natural succession as a mechanism of land conversion. To implement such, the many types of land use conversions with high construction costs in the scenarios should be avoided. Although investment costs are relatively high, benefits of the different scenarios can be large as well. Therefore including the benefits of the different scenarios will provide a much more balanced outcome of the quantitative analysis.

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Justification

This project was supervised by Henk van Zeijts and Anne Gerdien Prins (PBL contact persons) and Irene Bouwma (WOT N&M contact person). The work plan, and project decisions were carefully adjusted in consultant with the contact persons. The authors thank all mentioned researchers for their contributions.

Annex 1 Habitat types in the Natura 2000 network

Table A1

Classification of habitat types along vegetation types

HABITATCODE	HABITAT DESCRIPTION
	Bogs
7110	Active raised bogs
7120	Degraded raised bogs still capable of natural regeneration
7130	Blanket bogs (* if active bog)
7140	Transition mires and quaking bogs
7150	Depressions on peat substrates of the Rhynchosporion
7210	Calcareous fens with Cladium mariscus and species of the Caricion davallianae
7230	Alkaline fens
7310	Aapa mires
7320	Palsa mires
	Dunes
2110	Embryonic shifting dunes
2120	Shifting dunes along the shoreline with Ammophila arenaria ("white dunes")
2130	Fixed coastal dunes with herbaceous vegetation ("grey dunes")
2140	Decalcified fixed dunes with Empetrum nigrum
2150	Atlantic decalcified fixed dunes (Calluno-Ulicetea)
2160	Dunes with Hippophaë rhamnoides
2170	Dunes with Salix repens ssp. argentea (Salicion arenariae)
2180	Wooded dunes of the Atlantic, Continental and Boreal region
2190	Humid dune slacks
2210	Crucianellion maritimae fixed beach dunes
2220	Dunes with Euphorbia terracina
2240	Brachypodietalia dune grasslands with annuals
2250	Coastal dunes with Juniperus spp.
2260	Cisto-Lavenduletalia dune sclerophyllous scrubs
2270	Wooded dunes with Pinus pinea and/or Pinus pinaster
2330	Inland dunes with open Corynephorus and Agrostis grasslands
2340	Pannonic inland dunes
91N0	Pannonic inland sand dune thicket (Junipero-Populetum albae)
	Forest
91E0	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)
9010	Western Taïga
9020	Fennoscandian hemiboreal natural old broad-leaved deciduous forests (Quercus, Tilia, Acer, Fraxinus or Ulmus) rich in epiphytes
9030	Natural forests of primary succession stages of landupheaval coast
9040	Nordic subalpine/subarctic forests with Betula pubescens ssp. czerepanovii
9050	Fennoscandian herb-rich forests with Picea abies
9060	Coniferous forests on, or connected to, glaciofluvial eskers
9080	Fennoscandian deciduous swamp woods
9110	Luzulo-Fagetum beech forests
9120	Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)
9130	Asperulo-Fagetum beech forests
9140	Medio-European subalpine beech woods with Acer and Rumex arifolius
9150	Medio-European limestone beech forests of the Cephalanthero-Fagion

HABITATCODE	HABITAT DESCRIPTION
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli
9170	Galio-Carpinetum oak-hornbeam forests
9180	Tilio-Acerion forests of slopes, screes and ravines
9190	Old acidophilous oak woods with Quercus robur on sandy plains
9210	Apeninne beech forests with Taxus and Ilex
9220	Apennine beech forests with Abies alba and beech forests with Abies nebrodensis
9230	Galicio-Portuguese oak woods with Quercus robur and Quercus pyrenaica
9240	Quercus faginea and Quercus canariensis Iberian woods
9250	Quercus trojana woods
9260	Castanea sativa woods
9270	Hellenic beech forests with Abies borisii-regis
9280	Quercus frainetto woods
9290	Cupressus forests (Acero-Cupression)
9310	Aegean Quercus brachyphylla woods
9320	Olea and Ceratonia forests
9330	Quercus suber forests
9340	Quercus ilex and Quercus rotundifolia forests
9350	Quercus macrolepis forests
9360	Macaronesian laurel forests (Laurus, Ocotea)
9361	lauriphyllous forests of the Azores
9370	Palm groves of Phoenix
9380	Forests of Ilex aquifolium
9390	Scrub and low forest vegetation with Quercus alnifolia
9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)
9420	Alpine Larix decidua and/or Pinus cembra forests
9430	Subalpine and montane Pinus uncinata forests (* if on gypsum or limestone)
9510	Southern Apennine Abies alba forests
9520	Abies pinsapo forests
9530	(Sub-) Mediterranean pine forests with endemic black pines
9540	Mediterranean pine forests with endemic Mesogean pines
9560	Endemic forests with Juniperus spp.
9570	Tetraclinis articulata forests
9580	Mediterranean Taxus baccata woods
9590	Cedrus brevifolia forests (Cedrosetum brevifoliae)
91A0	Old sessile oak woods with Ilex and Blechnum in the British Isles
91AA	Eastern white oak woods
91B0	Thermophilous Fraxinus angustifolia woods
91BA	Moesian silver fir forests
91C0	Caledonian forest
91CA	Rhodopide and Balkan Range Scots pine forests
91D0	Bog woodland
91F0	Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)
91G0	Pannonic woods with Quercus petraea and Carpinus betulus
91H0	Pannonian woods with Quercus pubescens
91I0	Euro-Siberian steppic woods with Quercus spp.
91J0	Taxus baccata woods of the British Isles
91K0	Illyrian Fagus sylvatica forests (Aremonio-Fagion)
91L0	Illyrian oak-hornbeam forests (Erythronio-Carpinion)
91M0	Pannonian-Balkanic turkey oak –sessile oak forests
91P0	Holy Cross fir forest (Abietetum polonicum)
91Q0	Western Carpathian calcicolous Pinus sylvestris forests
91R0	Dinaric dolomite Scots pine forests (Genisto januensis-Pinetum)
91S0	Western Pontic beech forests

HABITATCODE	HABITAT DESCRIPTION
91T0	Central European lichen Scots pine forests
91U0	Sarmatic steppe pine forest
91V0	Dacian Beech forests (Symphyto-Fagion)
91W0	Moesian beech forests
91X0	Dobrogean beech forests
91Y0	Dacian oak & hornbeam forests
91Z0	Moesian silver lime woods
92A0	Salix alba and Populus alba galleries
92B0	Riparian formations on intermittent Mediterranean water courses with Rhododendron ponticum, Salix and others
92C0	Platanus orientalis and Liquidambar orientalis woods (Platanion orientalis)
92D0	Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae)
93A0	Woodlands with Quercus infectoria (Anagyro foetidae-Quercetum infectoriae)
95A0	High oro-Mediterranean pine forests
	Grassland
1220	Perennial vegetation of stony banks
1520	Iberian gypsum vegetation (Gypsophiletalia)
1530	Pannonic salt steppes and salt marshes
1630	Boreal Baltic coastal meadows
2230	Malcolmietalia dune grasslands
6110	Rupicolous calcareous or basophilic grasslands of the Alysso-Sedion albi
6120	Xeric sand calcareous grasslands
6130	Calaminarian grasslands of the Violetalia calaminariae
6140	Siliceous Pyrenean Festuca eskia grasslands
6150	Siliceous alpine and boreal grasslands
6160	Oro-Iberian Festuca indigesta grasslands
6170	Alpine and subalpine calcareous grasslands
6180	Macaronesian mesophile grasslands
6190	Rupicolous pannonic grasslands (Stipo-Festucetalia pallentis)
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites)
6220	Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea
6230	Species-rich Nardus grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)
6240	Sub-Pannonic steppic grasslands
6250	Pannonic loess steppic grasslands
6260	Pannonic sand steppes
6270	Fennoscandian lowland species-rich dry to mesic grasslands
6280	Nordic alvar and precambrian calcareous flatrocks
6310	Dehesas with evergreen Quercus spp.
6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)
6420	Mediterranean tall humid grasslands of the Molinio-Holoschoenion
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
6440	Alluvial meadows of river valleys of the Cnidion dubii
6450	Northern boreal alluvial meadows
6460	Peat grasslands of Troodos
6510	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)
6520	Mountain hay meadows
6530	Fennoscandian wooded meadows
6540	Sub-Mediterranean grasslands of the Molinio-Hordeion secalini
7240	Alpine pioneer formations of the Caricion bicoloris-atrofuscae
8230	Siliceous rock with pioneer vegetation of the Sedo-Scleranthion or of the Sedo albi-Veronicion dillenii
9070	Fennoscandian wooded pastures

HABITATCODE	HABITAT DESCRIPTION
21A0	Machairs (* in Ireland)
62A0	Eastern sub-Mediterranean dry grasslands (Scorzoneratalia villosae)
62B0	Serpentinophilous grassland of Cyprus
62C0	Ponto-Sarmatic steppes
62D0	Oro-Moesian acidophilous grasslands
	Marine
1110	Sandbanks which are slightly covered by sea water all the time
1120	Posidonia beds (Posidonion oceanicae)
1130	Estuaries
1150	Coastal lagoons
1160	Large shallow inlets and bays
1170	Reefs
1180	Submarine structures made by leaking gases
1620	Boreal Baltic islets and small islands
1650	Boreal Baltic narrow inlets
	Rocks
1230	Vegetated sea cliffs of the Atlantic and Baltic Coasts
1240	Vegetated sea cliffs of the Mediterranean coasts with endemic Limonium spp.
1250	Vegetated sea cliffs with endemic flora of the Macaronesian coasts
8110	Siliceous scree of the montane to snow levels (Androsacetalia alpinae and Galeopsietalia ladani)
8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)
8130	Western Mediterranean and thermophilous scree
8140	Eastern Mediterranean screes
8150	Medio-European upland siliceous screes
8160	Medio-European calcareous scree of hill and montane levels
8210	Calcareous rocky slopes with chasmophytic vegetation
8220	Siliceous rocky slopes with chasmophytic vegetation
8240	Limestone pavements
8310	Caves not open to the public
8320	Fields of lava and natural excavations
8330	Submerged or partially submerged sea caves
8340	Permanent glaciers
	Salt marshes
1140	Mudflats and sandflats not covered by seawater at low tide
1210	Annual vegetation of drift lines
1310	Salicornia and other annuals colonizing mud and sand
1320	Spartina swards (Spartinion maritimae)
1330	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)
1340	Inland salt meadows
1410	Mediterranean salt meadows (Juncetalia maritimi)
1510	Mediterranean salt steppes (Limonietalia)
1610	Baltic esker islands with sandy, rocky and shingle beach vegetation and sublittoral vegetation
1640	Boreal Baltic sandy beaches with perennial vegetation
5211	Pearlwort-saltmarsh grass swards
	Scrubs
1420	Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi)
1430	Halo-nitrophilous scrubs (Pegano-Salsoletea)
2310	Dry sand heaths with Calluna and Genista
2320	Dry sand heaths with Calluna and Empetrum nigrum
4010	Northern Atlantic wet heaths with Erica tetralix
4020	Temperate Atlantic wet heaths with Erica ciliaris and Erica tetralix
4030	European dry heaths
4040	Dry Atlantic coastal heaths with Erica vagans
4050	Endemic macaronesian heaths

HABITATCODE	HABITAT DESCRIPTION
4060	Alpine and Boreal heaths
4070	Bushes with Pinus mugo and Rhododendron hirsutum (Mugo-Rhododendretum hirsuti)
4080	Sub-Arctic Salix spp. scrub
4090	Endemic oro-Mediterranean heaths with gorse
5110	Stable xerothermophilous formations with Buxus sempervirens on rock slopes (Berberidion p.p.)
5120	Mountain Cytisus purgans formations
5130	Juniperus communis formations on heaths or calcareous grasslands
5140	Cistus palhinhae formations on maritime wet heaths
5210	Arborescent matorral with Juniperus spp.
5220	Arborescent matorral with Zyziphus
5230	Arborescent matorral with Laurus nobilis
5310	Laurus nobilis thickets
5320	Low formations of Euphorbia close to cliffs
5330	Thermo-Mediterranean and pre-desert scrub
5410	West Mediterranean clifftop phryganas (Astragalo-Plantaginetum subulatae)
5420	Sarcopoterium spinosum phryganas
5430	Endemic phryganas of the Euphorbio-Verbascion
9565	Macaronesian juniper woods
40A0	Subcontinental peri-Pannonic scrub
40B0	Rhodope Potentilla fruticosa thickets
40C0	Ponto-Sarmatic deciduous thickets
	Water courses and ponds
3110	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)
3120	Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean, with Isoetes spp.
3130	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea
3140	Hard oligo-mesotrophic waters with benthic vegetation of Chara spp.
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation
3160	Natural dystrophic lakes and ponds
3170	Mediterranean temporary ponds
3180	Turloughs
3190	Lakes of gypsum karst
3210	Fennoscandian natural rivers
3220	Alpine rivers and the herbaceous vegetation along their banks
3230	Alpine rivers and their ligneous vegetation with Myricaria germanica
3240	Alpine rivers and their ligneous vegetation with Salix elaeagnos
3250	Constantly flowing Mediterranean rivers with Glaucium flavum
3260	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation
3270	Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation
3280	Constantly flowing Mediterranean rivers with Paspalo-Agrostidion species and hanging curtains of Salix and Populus alba
3290	Intermittently flowing Mediterranean rivers of the Paspalo-Agrostidion
7160	Fennoscandian mineral-rich springs and springfens
7220	Petrifying springs with tufa formation (Cratoneurion)
31A0	Transylvanian hot-spring lotus beds
32A0	Tufa cascades of karstic rivers of the Dinaric Alps

Annex 2 Corine Land cover types

Table A2

Corine Land cover types

Code level 1	Level 1 name	Code level 2	Level 2 name	Code level 2	Level 3 name	Nr. CLC 3 class
1.	**Artificial surfaces**	1.1	urban fabric	1.1.1	continuous urban fabric	1
				1.1.2	discontinuous urban fabric	2
		1.2	industrial, commercial	1.2.1	industrial and commercial units	3
			transport units	1.2.2	road and rail networks and associated land	4
				1.2.3	port areas	5
				1.2.4	airports	6
		1.3	mine, dump and	1.3.1	mineral extraction sites	7
			construction sites	1.3.2	dump sites	8
				1.3.3	construction sites	9
		1.4	artificial non-agricultural	1.4.1	green urban areas	10
			vegetated areas	1.4.2	port and leisure facilities	11
2.	**Agricultural areas**	2.1	arable land	2.1.1	non-irrigated arable land	12
				2.1.2	permanently irrigated land	13
				2.1.3	rice fields	14
		2.2	permanent crops	2.2.1	vineyards	15
				2.2.2	fruit trees and berry plantation	16
				2.2.3	olive groves	17
		2.3	pastures	2.3.1	pastures	18
		2.4	heterogeneous agricultural areas	2.4.1	annual cops associated with permanent crops	19
			agricultural areas	2.4.2	complex cultivation patterns	20
				2.4.3	land principally occupied by agriculture with significant natural vegetation	21
				2.4.4	agro-forestry areas	22
3.	**Forests and semi-natural**	3.1	forest	3.1.1	broad-leaved forest	23
	Areas			3.1.2	coniferous forest	24
				3.1.3	mixed forest	25
		3.2	shrub and/or herbaceous	3.2.1	natural grasslands	26
			vegetation associations	3.2.2	moors and heath lands	27
				3.2.3	sclerophyllous vegetation	28
				3.2.4	transitional woodland-scrub	29
		3.3	open spaces with little or no	3.3.1	beaches, sand, dunes	30
			vegetation	3.3.2	bare rocks	31
				3.3.3	sparsely vegetated areas	32
				3.3.4	burnt areas	33

Code level 1	Level 1 name	Code level 2	Level 2 name	Code level 2	Level 3 name	Nr. CLC 3 class
				3.3.5	glaciers and perpetual snow	34
4.	**Wetlands**	4.1	inland wetlands	4.1.1	inland marshes	35
				4.1.2	peat bogs	36
		4.2	coastal wetlands	4.2.1	salt marshes	37
				4.2.2	salines	38
				4.2.3	intertidal flats	39
5.	**Water bodies**	5.1	inland waters	5.1.1	water courses	40
				5.1.2	water bodies	41
		5.2	marine waters	5.2.1	coastal lagoons	42
				5.2.2	estuaries	43
				5.2.3	sea and ocean	44

Annex 3 Aggregation of habitat types and vegetation associations

Table A3.

Aggregation of habitat types and vegetation associations into CLC 3 Corine land cover types to derive at single values of critical nitrogen loads for each CLC 3 type. Numbers refer to habitat types (see Table A1, Annex 1).

CLC 3	Land cover class	Habitat types and vegetation associations
3.1.1	broad-leaved forest	9160A, 9160B, 9190, 91E0A, 91E0B, 91E0C, 91F0, 9110, 91D0, Fago-Quercetum
3.1.2	coniferous forest	Leucobryo-Pinetum, Betulo-Quercetum roboris
3.1.3	mixed forest	9120
3.2.1	Natural grassland: dry soil	Lolio-Cynosuretum, Ornithopodo-Corynephoretum, Festuco-Thymetum serpylli, 6510A, 6510B, 6210, 6230dka
3.2.1	Natural grassland: wet soil	6120, 6130, 6230vka, 6410, Crepido-Juncetum acutiflori, Ranunculo-Senecionetum, Rhinantho-Orchietum morionis, Ranunculo-Senecionetum, Ranunculo-Alopecuretum geniculati quatici
3.2.2	moors and heath lands	4010A, 4010B, 4030
3.2.3	sclerophyllous vegetation	5130, 2160, 2170
3.2.4	transitional woodland-scrub	2180Abe, 2180Ao, 2180B, 2180C, 6430C, Polygonato-Lithospermetum, Balloto-Arctietum, Echio-Verbascetum, Rhamno-Crataegetum
3.3.1	beaches, sand, dunes	2110, 2120, 2130A, 2130B, 2130C, 2140A, 2140B, 2150
3.3.3	sparsely vegetated areas	2310, 2320, 2330, 6110
4.1.1	inland marshes	6430A, 6430B, 7210, 7230, 7140A, 7140B, 2190D, Caricetum gracilis
4.1.2	peat bogs	7140A, 7140B, 7110A, 7110B, 7120ah, 7120vh, 7120hb
4.2.1	salt marshes	1310A, 1310B, 1320, 1330A, 1330B
4.2.2	salines	1310A, 1310B, 1320, 1330A, 1330B
4.2.3	intertidal flats	1110A, 1110B, 1110C, 1140A, 1140B
5.1.1	water courses	3260A, 3260B, 3270, Pellio epiphyllae-Chrysosplenietum oppositifolii, Cicuto-Caricetum pseudocyperi
5.1.2	water bodies	7220, 3110, 3130, 3140hz, 3140lv, 3140az, 3150baz, 3150az, 3160, 2190Aom, 2190Ae
5.2.1	coastal lagoons	1160
5.2.2	estuaries	1130
5.2.3	sea and ocean	1170

Annex 4 Cost estimates of recurrent management from different sources

Table A4-1

Activities related to recurrent management, derived from De Jong et al. (2007) and EU management handbooks on habitat types.

Habitat type	Activity	Source
	Grasslands	
6110, 6120, 6130, 6210, 6230, 6410, 6430, 6510	Recurrent management in the Netherlands aims at removal of nitrogen in vegetation and preventing successional change into shrub land or forest (encroachment). Management may vary between grazing by sheep, a combination of 50% grazing by cattle and 50 % mowing and removal and in low productivity grasslands low frequency mowing (2-3 years)	De Jong *et al.*
6220, 7170	Grazing by sheep/goats/cattle, some removal shrubs	EU handbook
6210, 6450	Grazing, mowing and removal material (yearly)	EU handbook
6230	Grazing, mowing and removal, cutting and chopping	EU handbook
6440	Low frequency mowing (1/2 years)	EU handbook
6260	No recurrent management, low intensity grazing	EU handbook
	Shrub land	
4010, 4030	Low frequency mowing (1/15 year), extensive grazing, low frequency sod cutting (1/50 year)	De Jong *et al.*
5130	Extensive grazing by sheep	De Jong *et al.*
9360	Selective cuttings	EU handbook
4060	Extensive grazing (1/10 years), burning (1/50 years)	EU handbook
5210	Controlled grazing (with fences), mowing, cutting	EU handbook
	Dunes	
2110, 2120	No recurrent management	De Jong *et al.*
2140	Mowing (1/2 years), grazing by sheep (1/2 years)	De Jong *et al.*
2170, 2180, 2190	Grazing, periodic removal encroachment, mowing and removal material	De Jong *et al.*
2310, 2320, 2330	Grazing (1/2 years), sod cutting (1/50 years)	De Jong *et al.*
2130	Extensive grazing	EU handbook
2250	Scrub clearance	EU handbook
	Water courses and ponds	
3110, 3130, 3160	Low frequency dredging (1/50 years)	De Jong *et al.*
3140, 3150, 3260, 3270	No recurrent management	De Jong *et al.*
3170	Clearing and mowing	EU handbook
	Salt marches	
1310	No recurrent management	De Jong *et al.*
1320, 1330	Grazing by sheep (1/2 years)	De Jong *et al.*
1120	Protection of reefs, No recurrent management	EU handbook
1530	Grazing by sheep	EU handbook
	Bogs	
7110	Maintenance of dams etc. (water management)	De Jong *et al.*
7120, 7140, 7150, 7210, 7230	Low frequency removal of encroachment, low frequency mowing and removal (1/4 years), low frequency sod cutting (1/50 years)	De Jong *et al.*
7220	No recurrent management	De Jong *et al.*

Habitat type	Activity	Source
	Forests	
9110, 9120, 91D0, 91E0, 91F0	No recurrent management	De Jong *et al.*
9160	Coppice maintenance (1/2 years)	De Jong *et al.*
9190	Coppice management (1/10 years)	De Jong *et al.*
9070	Continuous grazing	EU handbook
9360	Selective cutting	EU handbook
9530	No recurrent management	EU handbook

Table A4-2

Cost estimates of recurrent management derived from the management reports on 'Management of Natura 2000 Habitats' of DG Environment (http://ec.europa.eu/environment/nature/natura2000/management/habitats/models_en.htm).

Habitat type	Activity	Costs	Comments
	Grasslands		
6220	Grazing	€22-200/ha/yr	
6230	grazing	€120-270/ha/yr	
	mowing	€120-375/ha/yr	
6210	ext. grassland grazing	€69/ha/yr	
	ext. grass and mowing	€25/ha/yr	
	Org. grassland grazing	€76/ha/yr	
	Org. grassland mowing	€32/ha/yr	
	mobile fences	€15/ha/yr	
	Mobile electric fences	€0.3 /m	
	Electric mobile separation fences	€0.3 to 0.46 /m	
	Cutting material by hand	25€/ha/yr	
	removal cut material	€137/ha/yr	
	Cutting material mechanical	€624/ha/yr	
6360	grassland grazing	€107/ha/yr	AE + Natura payment scheme
	grassland mowing	€63/ha/yr	
	Salt marches		
1330	management permanent grassland	€330/ha/yr	
	grazing	€120-270/ha/yr	
	mowing	€120-380/ha/yr	
1530	grazing	€107/ha/yr	AE + Natura payment
	mowing	€63/ha/yr	AE + Natura payment
	grazing zonal scheme	€114.ha/yr	AE + Natura payment
	mowing zonal scheme	€116/ha/yr	AE + Natura payment
	Bogs		
7230	haymaking	€300-500/ha/yr	
	hand mowing	€315/ha/yr	
	Machine mowing	€450/ha/yr	
	Scythe mowing	€700/ha/yr	
	management	€307.4/ha/yr	Agri-enivronmental payments

Habitat type	Activity	Costs	Comments
	Shrub land		
4010	mowing	€380/ha/yr	
	fencing	€4.60 – 5.20/m/yr	
	maintenance Upland moorland	€52/ha/yr	
	maintenance of rough grazing	€104/ha/yr	
	supplement management	€9/ha/yr	
	maintenance lowland heath	€260/ha/yr	
4060	manual cutting	€60/ha	
	removal of clumps	€760/ha	
	manual hedge cutting	€2600/ha	
	mechanical cutting	€1200-1380/ha	
	mechanical trimming of shrubs	€1150-2700/ha	
	Dunes		
2130	mowing	€330/ha/yr	
	maintenance sand dunes	€285/ha/yr	
	grazing	€120/ha/yr	
2190	grazing	€120/ha/yr	
	Forests		
9070	clearing	€220/ha/yr	
	grazing	€120-270/ha/yr	
	pollarding	€215/ha/yr	
	management	€450/ha/yr	agri-environmental schemes
	clearing shrubs	€178-435ha/yr	

Table A4-3

Recurrent management costs and costs of restoration of Dutch habitattypes. Data: De Jong et al. (2007).

		€ / ha / year	
Number	Name habitat type	Recurrent	Restoration
	Salt marches		
1140a	Laagdynamische zandplaten	0	0
1140b	Hoogdynamische zandplaten	0	0
1310a	Zeekraalbegroeiingen	0	0
1310b	Inslagbegroeiingen van het Zeevetmuurverbond	0	0
1320	Schorren met slijkgrasvegetatie (Spartinion maritimae)	0	0
1330a	Schorren en zilte graslanden (buitendijks)	67	0
1330b	Schorren en zilte graslanden (binnendijks)	490	0
	Marine		
1110a	Overstromende zandbanken in getijdengebied	0	0
1110b	Zandbanken van de buitendelta's	0	0
1110c	Paralelle zandbanken in de Noordzee	0	0
1110d	De Doggersbank	0	0
1130	Estuaria	0	0
1160	Grote, ondiepe kreken en baaien	0	0

		€ / ha / year	
Number	Name habitat type	Recurrent	Restoration
	Dunes		
2110	Embryonale wandelende duinen	0	0
2120	Wandelende duinen op de strandwal ('Witte duinen')	0	0
2130a	Grijze duinen (kalkrijk)	91	2167
2130b	Grijze duinen (kalkarm)	91	2167
2130c	Grijze duinen (heischraal)	91	2167
2140a	Duinheiden met kraaihei in vochtige duinvalleien	447	2167
2140b	Duinheiden met kraaihei in droge duinen	53	49
2150	Duinheiden met struikhei	48	1484
2160	Duindoornstruwelen	47	0
2170	Kruipwilgstruwelen	50	0
2180a	Duinbossen (droog)	44	108
2180b	Duinbossen (vochtig)	19	108
2180c	Duinbossen (binnenduinrand)	19	108
2190a	Vochtige duinvalleien met open water	765	2167
2190b	Vochtige duinvalleien met lage begroeiingen, kalkrijk	627	2167
2190c	Vochtige duinvalleien met lage begroeiingen, ontkalkt	627	2167
2190d	Vochtige duinvalleien met hoge moerasplanten	880	1468
2330	Zandverstuivingen	46	659
	Shrubs		
2310	Stuifzandheiden met struikhei	206	659
2320	Binnenlandse kraaiheibegroeiingen	144	659
4010a	Vochtige heiden van de hogere zandgronden	167	659
4010b	Vochtige heiden van het laagveengebied	107	0
4030	Droge heiden	200	659
5130	Jeneverbesstruwelen	41	0
	Water courses and ponds		
3110	Zeer zwakgebufferde vennen	600	3000
3130	Zwakgebufferde vennen	600	3000
3140	Kranswierwateren	0	0
3150	Meren met krabbenscheer en fonteinkruiden	0	0
3160	Zure vennen	600	3000
3260a	Beken en rivieren met waterplanten (waterranonkels)	0	0
3260b	Beken en rivieren met waterplanten (grote fonteinkruiden)	0	0
3270	Slikkige rivieroevers	0	0
7220	Kalktufbronnen	0	0
	Grasslands		
6110	Pionierbegroeiingen op rotsbodem	344	0
6120	Stroomdalgraslanden	369	0
6130	Zinkweiden	1179	2356
6210	Kalkgraslanden	192	659
6230	Heischrale graslanden	144	659
6410	Blauwgraslanden	1063	642
6430a	Ruigten en zomen (Moerasspirea)	278	0
6430b	Ruigten en zomen (Harig wilgenroosje)	277	0

		€ / ha / year	
Number	Name habitat type	Recurrent	Restoration
6430c	Ruigten en zomen van droge bosranden	225	0
6510a	Glanshaver- en vossenstaarthooilanden (Glanshaver)	1011	0
6510b	Glanshaver- en vossenstaarthooilanden (Grote vossenstaart)	826	0
	Bogs		
7110a	Actieve hoogvenen (hoogveenlandschap)	30	125
7110b	Actieve hoogvenen (heideveentjes)	30	125
7120	Herstellende hoogvenen	70	530
7140a	Overgangs- en trilvenen (trilvenen)	1498	1250
7140b	Overgangs- en trilvenen (veenmosrietlanden)	844	1250
7150	Pioniervegetaties met snavelbiezen	155	659
7210	Galigaanmoerassen	288	0
7230	Alkalisch Laagveen	1021	0
	Forests		
9110	Veldbies-beukenbossen	0	0
9120	Beuken-eikenbossen met hulst	24	0
9160a	Eiken-haagbeukenbossen van de hogere zandgronden	0	0
9160b	Eiken-haagbeukenbossen van het heuvelland	248	0
9190	Oude eikenbossen	67	0
91D0	Hoogveenbossen	0	0
91E0a	Vochtige alluviale bossen (zachthoutooibossen)	0	0
91E0b	Vochtige alluviale bossen (essen-iepenbossen)	0	0
91E0c	Vochtige alluviale bossen (beekbegeleidende bossen)	0	0
91F0	Droge hardhoutooibossen	0	0

Table A4-4

Recurrent management costs in EU member states (in €/ha/year) divided by type of activity. Data: Gantioler et al. (2010).

Country	Management planning	Habitat management and monitoring	Total
Austria	2.44	31.16	33.61
Belgium	13.48	52.14	65.62
Bulgaria	17.4	7.84	25.24
Cyprus	86.91	219.67	306.58
Czech Rep	3.22	35.83	39.05
Denmark	-	-	10.71
Estonia	0.56	16.78	17.34
France	3.29	33.6	36.89
Germany	20.26	59.39	79.65
Greece	1.97	17.48	19.45

Country	Management planning	Habitat management and monitoring	Total
Hungary	9	56.49	65.5
Ireland	0.44	109.86	110.31
Italy	3.62	18.66	22.28
Latvia	2.63	13.78	16.41
Lithuania	3.63	26.94	30.57
Luxembourg	166.56	163.02	329.58
Malta	38.16	465.61	503.77
Netherlands	-	98.05	98.05
Poland	1.24	12.62	13.86
Portugal	6.14	49.5	55.64
Slovakia	0.67	11.69	12.36
Slovenia	3.26	10.07	3.65
Spain	23.43	49.68	73.12
Sweden	1.1	16.88	17.98
UK	4.84	28.32	33.17

To separate costs for different land cover types, Gantioler *et al.* (2010) described some member states provided a detailed overview of such differentiation. These data however, are not published. The data allocated by type of land cover are retrieved from DG Environment, which hold these data (see Table A4-5).

Table A4-5

*Recurrent management costs in different land cover types, in a selected number of countries (in €/ha/year). Data of DG Environment, based on Gantioler et al. (2010). ** = data were not speficied for the particular land cover type.*

Country	Agricultural	Forests	Other terrestrial	Inland waters	Wetlands	Coastal	Marine
Sweden	53.28	0.21	0.45	1.19	0.31	2.076	0.17
UK	122.54	26.49	12.79	15.57	34.87	6.45	2.57
Portugal (mainland only)	56.15	56.15	56.15	7.62	44.32	45.40	
Cyprus	108.01	333.59	**	35.56	33.65	48.21	
France	104.89	5.71	**	285.36	372.99	5.76	4.02
Hungary	65.49	65.49	65.49	65.49	65.49		
Malta	1562	7693	734	13222	7657	64	
Italy	7.71	2.35	**	11.25	10.34	7.84	0.77
Estonia	56.78	19.50	99.50	5.24	5.30	5.39	
Poland	18.18	18.18	18.18	18.18	18.18	18.18	18.18

Country	Agricultural	Forests	Other terrestrial	Inland waters	Wetlands	Coastal	Marine
Czech Republic	64.77	3.09	61.86	958.72	73.56		
Ireland	900.76	0.29	4.22	2.13	0.57	9.56	5.42
Latvia	45.51	9.37					
Austria	66.42	24.38	10.40	77.64	125.18		

Table A4-6

Recurrent management costs of Dutch nature management types (beheertypen) in IKN, based on ‘Index N&L’ and standardized norm costs.

English Name	Dutch name	Costs (€/ha/yr)
	Salt marches	
Sea and mud flats	Zee en wad	1.94
Brackish water	Brak water	65.99
Sea inlet	Afgesloten zeearm	1.94
Salt marsh	Schor of kwelder	131.02
Salt marh	Zilt- en overstromingsgrasland	577.61
	Water courses	
River	Rivier	6.67
Stream, pond	Beek en bron	88.10
	Kranswierwater	51.33
Pool	Zoete plas	53.50
Ponds	Zwakgebufferd ven	63.41
Acidic ponds	Zuur ven of hoogveenven	85.64
	Dunes	
Dune landschape	Duin- en kwelderlandschap	100.84
Sand drift	Zandverstuiving	93.09
Embryonic dunes	Strand en embryonaal duin	10.48
Open dunes	Open duin	219.45
Dune valley	Vochtige duinvallei	1,110.86
Dune heathland	Duinheide	177.08
	Bogs	
Swamp	Moeras	640.97
Reed	Gemaaid rietland	813.41
Moorland	Veenmosrietland en moerasheide	2,013.32

English Name	Dutch name	Costs (€/ha/yr)
Bogs	Trilveen	2,321.82
Moorland	Hoogveen	158.26
	Shrubs	
Heath Erica	Vochtige heide	208.47
Heath Calluna	Droge heide	219.61
	Grasslands	
Wet grassland	Nat schraalgrasland	2,036.49
Moist grassland	Vochtig hooiland	1,281.98
Dry grassland	Droog schraalgrasland	683.87
Dikes	Bloemdijk	1,657.69
Grassland	Kruiden- en faunarijk grasland	365.23
Grassland	Glanshaverhooiland	921.35
Arable land	Kruiden- en faunarijke akker	1,274.01
Rough grassland	Ruigteveld	81.50
Rough grassland	Vochtig weidevogelgrasland	628.18
Rough grassland	Wintergastenweide	91.60
	Forests	
Gallery forest	Rivier- en beekbegeleidend bos	42.45
Peatland forest	Hoog- en laagveenbos	31.91
Quercus forest	Haagbeuken- en essenbos	115.01
Dune forest	Duinbos	90.29
Lowland forest	Dennen-, eiken en beukenbos	153.17
Dry production forest	Droog bos met productie	89.10
Moist production forest	Vochtig bos met productie	112.21
Moist production forest	Vochtig hakhout- en middenbos	3,181.27
Dry production forest	Droog hakhout	380.29
Parkland forest	Park- en stinzenbos	347.40

Annex 5 Activities related to recurrent management

Table A5

Activities related to recurrent management, the costs (in €/hour) and labour force (hour/ha) involved. Data are split up for wet and dry soils, since wet soils need more expensive equipement. All data derived from Anonymous (2009) and prices are for the Dutch situation. - = no data or estimates available.

Type of nature	Measure	Activity	Cost (€/hour)				Hour/ha				Cost (€/hour)		Hour/ha		€/hour	Hour/ha
			wet soil		dry soil		wet soil		dry soil		wet soil	dry soil	wet soil	dry soil		
			low	high	low	high	low	high	low	high	average	average	average	average	average	average
Bogs	Ditch mowing	mowing and picking	70.11	70.11	-	-	0.46	0.46	-	-	70.11	-	0.46	-	70.11	0.46
Bogs	Ditch mowing	removal	89.81	89.81	-	-	0.93	0.93	-	-	89.81	-	0.93	-	89.81	0.93
Bogs	Mowing	mowing and picking	53.44	53.44	-	-	27.00	27.00	-	-	53.44	-	27.00	-	53.44	27.00
Bogs	Mowing	removal	89.80	89.80	-	-	6.20	6.20	-	-	89.80	-	6.20	-	89.80	6.20
Forest	Coppice	cutting	38.15	44.11	38.15	44.11	5.20	6.00	5.20	6.00	41.13	41.13	5.60	5.60	41.13	5.60
Forest	Coppice	shredding	116.40	116.40	116.40	116.40	2.00	2.00	2.00	2.00	116.40	116.40	2.00	2.00	116.40	2.00
Forest	Ditch mowing	mowing and picking	70.00	70.00	69.57	69.57	0.02	0.02	0.02	0.02	70.00	69.57	0.02	0.02	69.78	0.02
Forest	Ditch mowing	removal	90.00	90.00	90.00	90.00	0.02	0.02	0.02	0.02	90.00	90.00	0.02	0.02	90.00	0.02
Forest	fence maintenance	cattle	73.75	73.75	73.53	73.53	0.56	0.56	0.34	0.56	73.75	73.53	0.56	0.45	73.64	0.51
Grasslands	fence maintenance	cattle	64.67	73.93	-	-	0.56	11.33	-	-	69.30	-	5.95	-	69.30	5.95
Grasslands	fence maintenance	sheep	50.37	50.37	54.42	54.42	27.87	27.87	2.79	2.79	50.37	54.42	27.87	2.79	52.39	15.33
Grasslands	Grazing	care of animals	44.89	44.89	37.82	37.82	1.60	1.60	1.20	1.20	44.89	37.82	1.60	1.20	41.36	1.40
Grasslands	Grazing	drinking water	67.43	67.43	67.47	67.47	0.60	0.60	0.60	0.60	67.43	67.47	0.60	0.60	67.45	0.60
Grasslands	Mowing	mowing and picking	213.01	213.01	98.70	98.70	8.46	8.46	3.12	3.12	213.01	98.70	8.46	3.12	155.85	5.79
Grasslands	Mowing	removal	89.79	89.79	89.79	89.79	3.10	3.10	4.65	4.65	89.79	89.79	3.10	4.65	89.79	3.87
Salt	Grazing	care of animals	43.48	43.48	-	-	2.00	2.00	-	-	43.48	-	2.00	-	43.48	2.00

Type of nature	Measure	Activity	Cost (€/hour)				Hour/ha				Cost (€/hour)		Hour/ha		€/hour	Hour/ha
			wet soil		dry soil		wet soil		dry soil		wet soil	dry soil	wet soil	dry soil		
			low	high	low	high	low	high	low	high	average	average	average	average	average	average
marches																
Salt marches	Grazing	drinking water	52.63	52.63	-	-	1.20	1.20	-	-	52.63	-	1.20	-	52.63	1.20
Salt marches	Mowing	mowing and picking	98.72	98.72	-	-	3.12	3.12	-	-	98.72	-	3.12	-	98.72	3.12
Salt marches	Mowing	removal	89.85	89.85	-	-	3.87	3.87	-	-	89.85	-	3.87	-	89.85	3.87
Shrubland	Fence maintenance	cattle	-	-	73.50	73.50	-	-	0.34	0.34	-	73.50	-	0.34	73.50	0.34
Shrubland	fence maintenance	sheep	54.64	54.64	54.29	54.29	0.55	0.55	0.35	0.35	54.64	54.29	0.55	0.35	54.46	0.45
Shrubland	Grazing	care of animals	37.82	37.82	37.82	37.82	0.60	1.20	0.50	0.50	37.82	37.82	0.90	0.50	37.82	0.70
Shrubland	Grazing	drinking water	37.80	37.80	97.10	97.10	0.30	0.30	0.30	0.30	37.80	97.10	0.30	0.30	67.45	0.30
Shrubland	Mowing	mowing and picking	98.72	98.72	98.72	98.72	3.12	3.12	3.12	3.12	98.72	98.72	3.12	3.12	98.72	3.12
Shrubland	Mowing	removal	89.74	89.74	89.80	89.80	1.55	1.55	89.80	89.80	89.74	89.80	1.55	89.80	89.77	45.67
Shrubland	Removing top layer	chopping/removal	123.08	123.08	123.08	123.08	10.40	10.40	10.40	10.40	123.08	123.08	10.40	10.40	123.08	10.40
Shrubland	Removing top layer	converting/composting	91.00	91.00	90.00	90.00	5.00	5.00	5.00	5.00	91.00	90.00	5.00	5.00	90.50	5.00
Shrubland	Removing top layer	removal to central depot	89.70	89.70	90.00	90.00	1.50	1.50	1.50	1.50	89.70	90.00	1.50	1.50	89.85	1.50
Shrubland	Removing top layer	sod cutting/removal	499.06	499.06	499.06	499.06	8.00	8.00	8.00	8.00	499.06	499.06	8.00	8.00	499.06	8.00
Water	Dredging	dredging	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Annex 6 Conversion factors

Tabel A.6

Conversion factors (GDP corrected PPS, GDP growth rate and population) derived from Eurostat.

Country	GDP per capita in PPS (Index EU28 = 100)		Real GDP growth rate - volume		Population	
	2009	2013	2009	2013	2009	2013
Belgium	118	119	-2.8	0.2	10,753,080	11,161,642
Bulgaria	44	47	-5.5	0.9	7,467,119	7,284,552
Czech Republic	82	80	-4.5	-0.9	10,425,783	10,516,125
Denmark	123	125	-5.7	0.4	5,511,451	5,602,628
Germany	115	124	-5.1	0.4	82,002,356	80,523,746
Estonia	64	72	-14.1	2.2	1,335,740	1,320,174
Ireland	128	126	-6.4	-0.3	4,521,322	4,591,087
Greece	95	75	-3.1	-3.9	11,190,654	11,062,508
Spain	103	95	-3.8	-1.2	46,239,273	46,727,890
France	109	108	-3.1	0.2	64,350,226	65,578,819
Italy	104	98	-5.5	-1.9	59,000,586	59,685,227
Cyprus	100	86	-1.9	-5.4	796,930	865,878
Latvia	54	67	-17.7	4.1	2,162,834	2,023,825
Lithuania	58	74	-14.8	3.3	3,183,856	2,971,905
Luxembourg	252	264	-5.6	2.1	493,500	537,039
Hungary	65	67	-6.8	1.1	10,030,975	9,908,798
Malta	84	87	-2.8	2.9	410,926	421,364
Netherlands	132	127	-3.7	-0.8	16,485,787	16,779,575
Austria	126	129	-3.8	0.3	8,335,003	8,451,860
Poland	60	68	1.6	1.6	38,135,876	38,533,299
Portugal	80	75	-2.9	-1.4	10,563,014	10,487,289
Romania	50	54	-6.6	3.5	20,440,290	20,020,074
Slovenia	86	83	-7.9	-1.1	2,032,362	2,058,821
Slovakia	73	76	-4.9	0.9	5,382,401	5,410,836
Finland	114	112	-8.5	-1.4	5,326,314	,5426,674
Sweden	120	127	-5	1.6	9,256,347	9,555,893
United Kingdom	112	106	-5.2	1.7	6,2042,343	6,3905,297

Annex 7 Price level index for EU 28

Tabel A.7

Price level index to compare differences in price levels between EU member states. The price level index is calculated, based on the quotient of GDP purchasing power parities (PPP) and exchange index. Price level index derived from Eurostat and index = 100 set for the Netherlands. Data of 2009.

Country	Index (NL=100)
Belgium	102
Bulgaria	40
Czech Republic	62
Denmark	125
Germany	96
Estonia	62
Ireland	106
Greece	83
Spain	84
France	102
Croatia	62
Italy	93
Cyprus	79
Latvia	61
Lithuania	55
Luxembourg	108
Hungary	53
Malta	65
Netherlands	100
Austria	100
Poland	51
Portugal	75
Romania	44
Slovenia	77
Slovakia	61
Finland	107
Sweden	100
United Kingdom	87

Annex 8 Cost estimates for restoration

Table A8

Cost estimates of various restoration associated activities derived from the management reports on 'Management of Natura 2000 Habitats' of DG Environment (http://ec.europa.eu/environment/nature/natura2000/management/habitats/models_en.htm).

Habitat type	Activity	Costs	Comments
	Grasslands		
6220	creation of hedges and green infrastructure	€500-1,000/km	
	Creating water points	€10/ha	
	Land preparation and sowing	€200-400/ha	
6210	land conversion arable to grassland	€135/ha	
6450	Basic clearing	€421/ha	
	harvesting cut material	€211/ha	
	Transport cut material	€130/ha	
	Burning cut material	€226/ha	
6210	Mechanical trimming of shrub of small dimensions (rate of infestation not above 50%)	€1,150/ha	
	Mechanical trimming of shrubs of medium and large size with cutting of branches, uprooting of stumps, building up and burning of debris (rate of infestation above 50%)	€2,700/ha	
	Mechanical cutting of shrubs with removal of debris (rate of infestation not above 30%)	€576/ha	
	Mechanical cutting of shrubs on mildly-invaded areas (shrubby coverage among 30% and 60%) with removal of debris	€815/ha	
	Mechanical cutting of shrubs performed on – almost totally invaded areas (shrubby coverage above 60%) with removal of debris	€1,049/ha	
	Salt marches		
1330	full restoration costs in UK	€22,763/ha	
1530	arable to nature conservation land use change	€170-175 /ha	AE and Natura payments
	Bogs		
7150	small scale peat cutting	€500,000/ha	
	large scale peat cutting	€20,300/ha	
7230	removal material	€450/ha	
	Scythe mowing	€700/ha	
	labour costs	€2,700/ha	
	clearing overgrown land	€1,500/ha	
	Shrub land		
4010	restoration of Upland moorland	€54/ha	AE payments
	Creation of Upland moorland	€78/ha	AE payments
	Restoration of Upland rough grazing for birds	€104/ha	AE payments
	Upland moorland re-wetting	€13/ha	AE payments
	restoration of lowland heathland from neglected sites	€260/ha	AE payments
	restoration of forestry areas to lowland heath	€260/ha	AE payments
	creation of lowland heath from arable/grasslands	€585/ha	AE payments
	creation of lowland heath on mineral sites	€195/ha	AE payments
4060	bracken control	€325/ha	
	chemical use	€260/ha	

Habitat type	Activity	Costs	Comments
	Dunes		
2130	creation dunes on grassland	€285/ha	
	creation dunes on arable land	€460/ha	
2190	restoration slacks	€4,000/ha	
2250	Pine clearance	€2,500/ha	
	Eucalyptus clearing	€278/ha	
	removal vegetation	€1,380/ha	
	planting vegetation	€12,260/ha	
9070	restoration by clearing	€1,320/ha	
	clearing	€860-1,500/ha	
9530	clearing and pruning	€3,030/ha	

Annex 9 Areas under agri-environmental schemes

Table A9

Area under agri-environmental support (2012) (Ha), total utilized agricultural area (2007) (Ha) and share of area under agrienvironmental support (%). Data retrieved from 28 different PDF-documents at ENRD (2015).

Country	Area under agri-environmental support	Total utilised agricultural area	Share of area under agricultural support
Austria	2,181,453	3,189,110	68%
Belgium	199,050	1,374,430	14%
Bulgaria	388,888	3,050,740	13%
Cyprus	24,028	146,000	16%
Czech	1,069,741	3,518,070	30%
Germany	5,039,302	16,931,900	30%
Denmark	160,817	2,662,590	6%
Estonia	600,041	906,830	66%
Spain	5,091,250	24,892,520	20%
Finland	2,181,247	2,292,290	95%
France	6,000,000	27,476,930	22%
Greece	500,000	4,076,230	12%
Hungary	1,153,910	4,228,580	27%
Ireland	2,526,950	4,139,240	61%
Italy	2,356,962	12,744,200	18%
Lithuania	251,837	2,648,950	10%
Luxembourg	118,335	130,880	90%
Latvia	235,050	1,773,840	13%
Malta	2,042	10,330	20%
Netherlands	228,303	1,914,330	12%
Poland	2,048,430	15,477,190	13%
Portugal	954,134	3,472,940	27%
Romania	1,840,559	13,753,050	13%
Sweden	1,907,589	3,118,000	61%
Slovakia	357,175	1,936,620	18%
Slovenia	217,749	488,770	45%
United Kingdom	5,312,613	16,130,490	33%
EU27	42,947,455	172,485,050	25%

Annex 10 One-off cost estimates of DG Environment

Gantioler *et al.* (2010) provides information on one-off costs related to management and infrastructure. According to Gantioler *et al.* (2010) management costs include one-off costs for preparing management plans, establishing management bodies, consultations etc., while infrastructure costs include costs for restoration of habitats and species as well as public access and interpretation. One-off costs also include investment costs; one-off payments of compensation for development rights, other infrastructure costs contributing to conservation, e.g. for public access, interpretation works, observatories and kiosks, etc. These costs are thus covering more than one-off costs in IKN, which is only restricted to costs for recreation. Table A10-1 provides the management and infrastructural costs, associated with the one-off costs, described by Gantioler *et al.* (2010). These values show a very large range in one-off costs between countries. Lowest values are ca 2.3 €/ha (Bulgaria), while highest values are found in Luxemburg (9800 €/ha). The lowest values do not match (at all) the indicative one-off costs that are estimated for both new nature sites as restoration of existing sites, based on Dutch data.

Table A10-1

Area of the network (in ha) and one-off costs of management and infrastructure. Annualized costs in million €. Source: Gantioler et al., 2010).

Country	Area	Management	Infrastructure
Austria	1,232,904	2.32	6.73
Belgium	387,131	39.29	41.39
Bulgaria	3,861,300	8.8	0.13
Cyprus	210,959	2.65	49.15
Czech Rep	1,503,411	14.4	2.42
Denmark	1,667,600	-	-
Estonia	1,489,000	1.3	12.23
France	12,300,000	1.24	0.37
Germany	5,775,366	-	-
Greece	3,407,551	3.56	3.92
Hungary	1,968,218	1.92	13.81
Ireland	1,335,535	4.86	8.79
Italy	6,721,590	0.46	1.58
Latvia	811,309	0.99	59.29
Lithuania	781,479	2.85	2.4
Luxembourg	45,260	7.03	436.53
Malta	23,257	134.41	242.97
Netherlands	1,121,900	4.8	178.27
Poland	7,954,710	0.62	-
Portugal	2,026,954	2.19	9.86
Slovakia	1,343,000	2.73	1.37
Slovenia	720,270	3.85	15.46
Spain	14,200,000	6.83	26.23
Sweden	5,816,650	1.23	1.2
UK	3,793,095	1.91	1.22

The data presented by Gantioler *et al.* (2010) do not provide information on nature (habitat) types. Data request from DG Environment resulted in a selected number of specifications in which one-off costs are distributed among land uses. In Table A10-2 these costs are depicted as annualized cost per hectare. Also here we see large differences in one-off costs, while it remain unclear if these costs include management activities to restore degraded ecosystems.

Table A10-2

*Annualized one-off cost by land use (€/ha) of a selected number of countries Source: DG Environment, based on Gantioler et al., 2010).** indicates no data available due to the fact no information could be provided on the area of land use.*

Country	Agricultural	Forests	Other terrestrial	Inland waters	Wetlands	Coastal	Marine
Portugal	9.55	9.55	9.55	9.55	16.49	55.11	-
Italy	6.56	2.36	**	7.26	5.75	9.13	0.97
Cyprus	44.09	307.74	**	47.63	60.92	735.47	6.07
Hungary	25.89	25.89	25.89	25.89	25.89	-	-
Estonia	51.16	194.45	194.37	464.14	42.63	43.51	-
Poland	0.67	0.67	0.67	0.67	0.67	0.67	0.67

Annex 11 Construction costs used for scenarios

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
1	2.4.3	3.1.3	12618	445
3	2.4.3	3.2.4	0	0
4	3.2.4	3.1.3	0	0
5	3.2.4	3.1.2	0	0
6	2.3.1	3.1.1	12618	445
7	2.4.3	3.1.2	12618	445
8	2.4.3	3.2.4	0	0
9	2.3.1	3.2.4	0	0
10	2.4.3	3.1.2	12618	445
11	4.1.2	3.1.2	0	0
12	2.3.1	3.2.1	425	15
13	3.2.4	3.1.2	0	0
14	2.4.3	3.1.1	12618	445
15	2.1.1	3.2.1	850	30
16	2.1.1	3.2.4	0	0
17	2.3.1	3.1.2	12618	445
18	2.4.3	3.1.3	12618	445
19	2.1.1	3.1.2	12618	445
20	2.1.1	2.4.3	135	5
21	2.3.1	2.4.3	0	0
22	2.1.1	3.1.3	12618	445
23	2.1.1	3.1.2	12618	445
24	2.3.1	3.1.3	12618	445
25	2.1.1	2.4.3	135	5
26	2.3.1	2.4.3	0	0
27	2.1.1	3.1.3	12618	445
28	3.2.1	3.1.2	0	0
29	2.1.1	3.1.1	12618	445
31	3.1.2	3.2.4	503	18
32	2.3.1	3.1.1	12618	445
33	2.1.1	3.1.1	12618	445
34	3.2.4	5.1.1	45479	1604
35	3.1.3	1.4.1	3030	107
36	4.1.1	3.2.4	0	0
37	3.1.1	2.4.3	2520	89
38	2.4.3	3.2.1	0	0
39	2.1.1	3.1.1	12618	445
40	2.4.3	4.1.2	34218	1206
41	3.2.1	3.1.1	0	0
42	3.2.1	3.1.1	0	0
43	2.4.3	3.2.1	0	0
44	2.1.1	3.1.1	12618	445
45	2.4.3	3.2.1	0	0
46	2.3.1	3.1.1	12618	445
48	2.4.2	3.1.2	12618	445
49	4.1.2	3.2.2	28370	1000
50	3.2.4	3.1.1	0	0

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
51	2.4.2	3.2.4	0	0
52	4.1.2	3.1.1	0	0
53	3.2.4	2.4.3	750	26
54	3.1.3	2.4.3	2520	89
55	3.2.4	5.1.2	66865	2358
56	3.2.4	2.4.3	750	26
57	2.4.2	3.1.2	12618	445
58	3.1.1	2.4.3	2520	89
59	3.1.2	2.4.3	2520	89
60	2.4.2	3.1.3	12618	445
61	3.1.2	5.1.1	45479	1604
62	3.1.2	2.4.3	2520	89
63	2.4.3	3.2.1	0	0
64	2.1.1	1.4.1	8187	289
65	3.1.2	1.4.1	3030	107
66	2.1.1	4.2.1	25663	905
67	2.1.1	4.1.2	34218	1206
68	2.4.2	3.1.3	12618	445
69	3.2.4	1.4.1	2010	71
71	5.1.2	3.1.2	79931	2818
72	2.1.1	1.4.1	8187	289
73	3.1.2	1.4.1	3030	107
74	3.2.4	1.4.1	2010	71
76	3.2.1	3.1.3	0	0
77	3.2.4	3.2.1	3510	124
78	3.1.3	3.2.1	3510	124
80	3.2.1	3.1.3	0	0
82	3.1.3	3.2.4	503	18
83	3.1.2	2.4.3	2520	89
85	3.2.4	2.4.3	750	26
89	3.2.1	3.1.3	0	0
90	2.4.2	3.1.1	12618	445
92	3.1.3	5.1.2	66865	2358
93	5.1.2	1.4.1	0	0
98	2.3.1	4.1.2	34218	1206
99	2.4.2	2.4.3	0	0
100	2.4.3	1.4.1	8187	289
101	2.4.2	2.4.3	0	0
105	2.4.2	2.4.3	0	0
106	2.4.3	1.4.1	8187	289
109	2.4.2	3.1.1	12618	445
111	2.4.3	1.4.1	8187	289
113	2.4.2	3.2.1	1700	60
114	2.3.1	3.2.2	28370	1000
116	2.4.2	3.1.1	12618	445
117	3.1.3	1.4.1	3030	107
118	3.2.4	1.4.1	2010	71
120	3.2.1	3.1.2	0	0
121	2.4.3	3.2.2	28370	1000
122	3.1.1	1.4.1	3030	107
123	2.4.2	3.2.1	1700	60
124	2.4.2	1.4.1	8187	289
125	3.2.1	2.4.3	500	18

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
126	2.1.1	4.1.1	25663	905
127	2.4.2	3.1.1	12618	445
128	2.2.2	2.4.3	2258	80
129	2.4.2	1.4.1	8187	289
130	3.2.1	2.4.3	500	18
131	3.1.1	1.4.1	3030	107
133	2.1.1	3.2.2	28370	1000
134	2.4.2	3.2.2	28370	1000
136	3.1.1	1.4.1	3030	107
138	2.4.2	1.4.1	8187	289
139	3.2.1	2.4.3	500	18
140	2.4.3	3.3.3	0	0
141	2.4.2	5.1.2	66865	2358
142	2.2.2	2.4.3	2258	80
143	3.1.1	1.4.1	3030	107
144	2.3.1	4.2.3	0	0
146	2.2.2	3.1.1	3943	139
147	2.2.2	1.4.1	1058	37
148	2.1.1	3.3.3	0	0
150	2.3.1	1.4.1	8187	289
151	2.4.2	3.2.2	28370	1000
153	3.1.1	3.2.1	3510	124
154	2.3.1	3.3.3	0	0
155	2.2.2	3.1.3	3943	139
156	2.2.2	3.1.1	3943	139
158	2.1.1	3.2.2	28370	1000
159	2.4.2	1.4.1	8187	289
160	2.2.2	1.4.1	1058	37
161	2.4.2	5.1.1	45479	1604
162	3.2.1	2.4.3	500	18
163	2.4.2	4.1.2	34218	1206
164	2.3.1	3.3.3	0	0
165	2.4.2	3.3.3	0	0
166	2.2.2	1.4.1	1058	37
167	3.1.2	3.2.1	3510	124
168	2.2.2	3.2.1	3510	124
169	2.2.1	2.4.3	3030	107
170	2.3.1	1.4.1	8187	289
171	2.2.2	1.4.1	1058	37
173	2.2.1	3.2.4	0	0
174	2.2.1	3.1.1	3943	139
175	2.2.1	3.1.2	3943	139
176	2.2.2	3.1.1	3943	139
177	2.1.1	3.3.1	0	0
178	2.2.2	3.2.4	0	0
179	2.2.2	3.1.2	3943	139
180	2.2.1	3.1.3	3943	139
181	2.2.2	3.1.3	3943	139
183	2.2.2	3.2.4	0	0
184	2.3.1	5.1.1	45479	1604
185	2.2.1	1.4.1	1058	37
186	2.2.1	3.1.1	3943	139
190	2.2.1	3.1.3	3943	139

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
191	2.2.1	3.2.1	3510	124
192	2.4.1	3.1.2	12618	445
193	2.3.1	4.2.1	25663	905
194	2.4.1	2.4.3	0	0
195	2.4.1	3.1.3	12618	445
196	2.4.1	3.1.1	12618	445
197	2.2.3	2.4.3	0	0
198	2.2.1	2.4.3	3030	107
199	2.2.3	3.1.1	3943	139
200	2.2.1	4.1.1	25663	905
202	3.2.3	3.1.1	0	0
203	2.3.1	1.4.1	8187	289
204	3.2.3	3.1.3	0	0
205	2.2.1	3.1.2	3943	139
206	3.2.3	3.1.2	0	0
207	2.2.2	3.2.4	0	0
208	2.3.1	2.4.4	15773	556
209	2.4.3	5.2.1	0	0
210	2.4.4	3.1.1	0	0
211	2.1.3	2.4.3	135	5
212	2.2.1	1.4.1	1058	37
213	2.4.3	2.4.4	15773	556
214	2.2.1	2.4.3	3030	107
215	2.1.1	2.4.4	15773	556
216	2.2.3	3.2.1	3510	124
217	2.4.2	4.1.1	25663	905
218	2.2.3	3.1.3	3943	139
219	2.4.2	3.2.3	0	0
220	2.2.1	3.1.2	3943	139
221	2.4.1	3.1.3	12618	445
222	2.4.1	2.4.3	0	0
223	3.2.1	1.4.1	5258	185
224	2.4.3	3.2.3	0	0
225	2.1.1	3.2.3	0	0
226	2.2.3	3.1.2	3943	139
227	2.2.3	2.4.3	0	0
228	2.2.3	3.2.4	0	0
229	3.2.3	2.4.3	750	26
230	3.2.3	3.1.3	0	0
231	3.2.3	3.1.2	0	0
233	2.4.3	3.3.1	0	0
234	2.3.1	3.2.3	0	0
235	2.3.1	2.4.4	15773	556
236	2.4.4	3.1.1	0	0
237	2.2.3	1.4.1	1058	37
238	2.2.3	3.2.3	0	0
239	2.4.1	3.2.4	0	0
240	2.2.3	3.1.2	3943	139
241	2.1.1	2.4.4	15773	556
242	2.4.4	3.3.3	2010	71
243	2.4.4	3.2.1	3030	107
244	2.4.2	2.4.4	15773	556
245	2.2.2	3.2.3	0	0

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
246	2.2.1	1.4.1	1058	37
247	2.2.3	3.1.3	3943	139
248	2.2.1	3.2.3	0	0
249	2.4.3	2.4.4	15773	556
251	3.1.1	5.1.1	45479	1604
252	3.2.1	1.4.1	5258	185
253	2.4.3	3.2.3	0	0
254	2.4.4	2.4.3	0	0
255	3.3.1	4.1.1	25663	905
256	2.2.3	3.2.4	0	0
257	2.4.1	3.2.3	0	0
258	2.4.4	3.2.1	3030	107
259	2.2.1	5.1.2	66865	2358
260	2.2.1	4.1.1	25663	905
261	2.4.3	4.1.1	25663	905
262	3.2.1	4.1.1	25663	905
263	2.2.3	3.2.1	3510	124
264	3.1.1	4.1.1	25663	905
265	4.1.1	3.2.1	0	0
266	2.4.4	3.2.3	2010	71
267	2.2.3	1.4.1	1058	37
268	2.4.4	3.2.4	503	18
269	2.2.2	3.2.1	3510	124
270	2.1.1	4.2.2	25663	905
271	2.4.1	3.2.4	0	0
272	2.4.1	3.1.2	12618	445
273	3.2.1	2.4.4	15773	556
274	2.4.1	3.1.1	12618	445
275	2.2.3	3.1.1	3943	139
276	2.4.2	2.4.4	15773	556
277	3.2.3	2.4.4	15773	556
278	2.4.1	2.4.3	0	0
280	2.2.1	3.2.3	0	0
281	2.4.4	3.1.2	0	0
282	2.1.2	3.1.1	12618	445
283	2.4.1	3.2.1	1700	60
284	2.4.4	3.2.2	28370	1000
285	2.4.1	3.2.1	1700	60
286	3.2.4	2.4.4	7887	278
288	2.4.4	3.1.3	0	0
289	3.1.1	2.4.4	6268	221
290	3.1.3	2.4.4	6268	221
291	3.1.3	3.2.1	3510	124
292	3.1.2	3.2.1	3510	124
293	2.4.4	2.4.3	0	0
294	2.3.1	3.2.3	0	0
295	2.1.2	3.2.4	0	0
296	2.1.2	3.2.3	0	0
297	2.2.1	3.2.3	0	0
298	2.2.3	3.2.2	28370	1000
299	2.4.4	3.1.1	0	0
300	2.4.3	3.2.3	0	0
301	2.2.3	3.2.3	0	0

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
302	2.4.1	3.2.3	0	0
303	2.1.1	3.2.3	0	0
304	2.4.1	3.3.3	0	0
305	2.2.1	3.3.3	0	0
306	2.4.4	2.4.3	0	0
307	2.4.4	3.2.1	3030	107
308	2.4.4	3.3.3	2010	71
309	2.2.3	3.2.1	3510	124
310	2.2.3	3.1.2	3943	139
311	2.4.4	3.2.3	2010	71
312	3.2.3	3.1.2	0	0
313	2.4.4	3.2.4	503	18
314	3.2.3	3.2.1	3510	124
315	3.2.1	2.4.4	15773	556
316	2.1.2	3.2.1	850	30
317	2.1.2	3.2.3	0	0
318	2.2.3	3.2.3	0	0
319	3.2.1	2.4.4	15773	556
320	2.3.1	2.4.4	15773	556
321	2.2.1	3.3.3	0	0
322	2.2.2	3.2.3	0	0
323	2.1.2	3.2.2	28370	1000
324	3.2.3	2.4.4	15773	556
325	2.4.1	3.3.1	0	0
326	2.4.3	4.2.2	25663	905
327	2.2.1	3.2.2	28370	1000
328	3.2.4	2.4.4	7887	278
331	2.1.2	3.2.1	850	30
332	2.2.3	1.4.1	1058	37
335	3.2.4	2.4.4	7887	278
337	2.4.4	3.2.3	2010	71
338	2.2.1	3.3.1	0	0
339	3.1.1	2.4.4	6268	221
340	2.2.3	3.3.1	0	0
341	3.1.3	2.4.4	6268	221
343	2.1.3	5.1.1	45479	1604
344	2.1.2	5.1.2	66865	2358
345	3.2.1	2.4.4	15773	556
348	2.1.3	4.2.1	25663	905
349	2.1.2	5.2.2	0	0
350	2.1.2	2.4.3	135	5
351	2.2.2	3.3.1	0	0
352	2.2.3	3.3.3	0	0
353	2.4.2	5.2.1	0	0
357	2.4.4	3.2.4	503	18
358	2.1.3	3.1.2	12618	445
359	2.4.1	3.3.3	0	0
360	2.4.4	3.1.2	0	0
362	2.4.3	2.4.4	15773	556
363	2.4.4	3.2.3	2010	71
364	3.2.4	2.4.4	7887	278
365	2.4.1	3.2.3	0	0
366	3.1.3	2.4.4	6268	221

Transition nr.	t0	t1	Full costs (€ / ha)	Annualized costs (€ / ha / yr)
368	2.4.4	3.1.3	0	0
371	2.4.1	3.2.1	1700	60
373	2.1.3	3.1.1	12618	445
374	2.1.3	3.1.3	12618	445
376	2.4.1	3.2.2	28370	1000
379	2.4.4	5.1.2	66865	2358
382	2.1.1	2.4.4	15773	556
385	2.4.4	3.2.2	28370	1000
388	2.4.2	2.4.4	15773	556
389	2.1.2	5.1.2	66865	2358
392	2.2.3	3.3.3	0	0
397	2.2.3	3.2.2	28370	1000
402	3.2.1	2.4.4	15773	556
405	2.4.2	5.2.2	0	0
407	2.2.1	4.2.1	25663	905
410	2.1.3	5.2.2	0	0
411	2.1.3	3.1.2	12618	445
413	3.1.2	3.2.3	2010	71
416	2.2.2	3.3.3	0	0
417	2.1.3	3.2.3	0	0
428	2.2.2	3.2.2	28370	1000
429	3.2.1	1.4.1	5258	185
431	3.1.1	3.2.3	2010	71

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