Ecosystem Accounting Limburg Province, the Netherlands

Part I: Physical supply and condition accounts

This report presents the results of a pilot project which was carried out by Statistics Netherlands and Wageningen University. Funding was provided by the Ministries of Economic Affairs and of Infrastructure and the Environment.

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Front page image: Matthias Schröter

Abstract

Worldwide, ecosystems and their biodiversity are under severe environmental pressure. Consequently, the supply of valuable services provided by these ecosystems, such as the provisioning of timber, water regulation, air filtration or recreation, is being reduced or lost. Ecosystem accounting aims to quantify and monitor the interdependence between ecosystems (and their services) and economic activities, in an internationally consistent manner. The accounting system is based on tracking changes in the supply and economic use of ecosystem services. It also aims to monitor the extent and condition of ecosystems, which is needed to identify the causes for changes in ecosystem services supply. The methodology was developed by an international group of experts under auspices of the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA Statistical Committee) UN et al. (2014). Following endorsement by the UN Statistical Committee, ecosystem accounting is part of the international framework of the UN the System of Environmental Economic Accounts. In two reports we describe the results of a pilot study on ecosystem accounting in Limburg Province, the Netherlands. The current report focusses on the physical supply of ecosystem services and on ecosystem condition indicators. The second report describes the monetary valuation approach and monetary supply and use tables for the same ecosystem services. The two reports are thus complimentary.

1. Introduction

Ecosystems provide services, known as ecosystem services, that contribute to national economies and human welfare. For example, soils and vegetation form sinks for carbon dioxide, the air is filtered by vegetation and dunes protect against coastal floods and provide space for recreation and education. The supply and sustainability of such services depend on ecosystem condition and extent. Ecosystem accounting was developed in recognition of the vital importance of these ecosystem services and provides a tool for consistent monitoring and quantifying the supply and use of ecosystem services. This is highly relevant because ecosystems and their biodiversity are subject to increasing environmental pressures worldwide, a trend that was already signalled and described in the Brundtland Report in 1987 (WCED, 1987). These environmental pressures are in part related to expanding human populations and increased economic activities. The increased demand for food and materials, fuel and living space lead to pollution, severe land degradation, the transition of natural areas to cultivated land and to the loss of biodiversity (e.g. Butchart et al., 2010). In addition, climate change may severely impact ecosystems (IPCC, 2014). In time, these pressures may lead to a reduction of the supply of ecosystem services, which could have major consequences for human welfare and the economy .

Many nations now recognise the vulnerability and value of their ecosystems and have applied conservation and protection measures (e.g. TEEB, 2010). Currently, however, neither the ecosystem contributions to economies, nor the losses or increases of services are accounted for in national and international statistics. To fill this gap, the United Nations Statistics Department (UNSD) launched the System of Environmental Economic Accounts – Experimental Ecosystem Accounting in 2014 (SEEA-EEA, UN et al., 2014). This publication provides provisional guidelines and encourages nations to experiment with Ecosystem Accounting using methods that are consistent with the System of National Accounts (SNA). It is a novel approach to measure the contribution of ecosystem services to national economies. The SEEA-EEA were developed with the purpose to '*better inform individual and social decisions concerning the use of the environment by developing information in a structured and internationally consistent manner, based on recognition of the relationship between ecosystems and economies and other human activity' (UN et al., 2014).* The ecosystem accounting system is further explained in section 2.

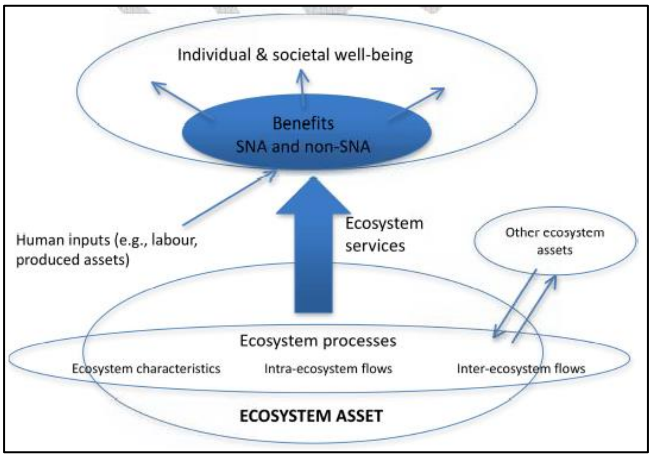
This report first provides an overview of the most important concepts of the SEEA-EEA guidelines and the project aims. Next, we present the methods and results for the developed maps, the physical supply of ecosystem services and for the conceptual condition account. Finally we discuss the implications of the findings and provide recommendations for future work. All information on the monetary valuation of ecosystem services (methods, results, discussion and conclusions) are included in Part II of the current report.

2. Theoretical background and project aims

2.1 The theoretical framework of Ecosystem Accounting: the SEEA EEA approach

The 'System of Environmental Economic Accounts – Experimental Ecosystem Accounting (SEEA-EEA)' was developed and published under the auspices of the United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA), as mandated by the UN Statistics Committee at its thirty-eighth session in 2007. The UNCEEA is a governing body comprising senior representatives from national statistical offices and international organizations. It is chaired by a representative of one of the country members of the Committee. The United Nations Statistics Division serves as Secretariat for UNCEEA (UN et al., 2014). SEEA EEA was based on the inputs of professionals from multiple disciplines such as economists, biologists, modellers and statisticians. International organisations such as the UNSD, World bank, UNEP (United Nations Environmental programme), Eurostat, EEA (European Environmental Agency) and NGO's were also involved. Ecosystem accounting aims to identify changes in the condition and extent of ecosystem units and the resulting changes in the quantity and - where possible - monetary value of the supplied ecosystem services. This provides insight in the full economic use of and dependencies on natural capital, and how these may change through time. Consequently, Ecosystem Accounting provides a powerful tool to monitor the economic impacts of pressures as well as protection measures on ecosystems and the subsequent changes in ecosystem services.

The SEEA EEA ecosystem accounting model is shown in figure 2.1.1) (source: UN et al, 2014). Starting at the bottom of the figure the model is based around accounting for an ecosystem asset that is a defined spatial area. Each ecosystem asset has a range of relevant ecosystem characteristics and processes that together describe the functioning of the ecosystem. The accounting model proposes that the stock and changes in stock of ecosystem assets is measured by considering the ecosystem asset's extent and condition which can be done using indicators of the relevant ecosystem's area, characteristics and processes. Each ecosystem asset generates a set of ecosystem services which, in turn, contribute the production of benefits. Benefits may be goods or services currently included in the economic production boundary of the SNA, SNA benefits, or they may be benefits received by individuals that are not produced by economic units (e.g. clean air). These are non-SNA benefits. Benefits, both SNA and non-SNA, contribute to individual and societal well-being or welfare.



2.1.1 Ecosystem accounting model (UN et al., 2014 Figure 2.2)

The SEEA –EEA is thus based on the dual concepts of ecosystem assets and ecosystem services. The accounting logic for SEEA EEA is as follows: ecosystem extent and condition determine the possible supply of ecosystem services to the economy (capacity), whereas the actual supply also depends on the demand for services (ES use). Next, following the SNA methodology and definitions, supply equals use. Accounting tables are then developed for ecosystem condition (including extent), and for the supply and use of ecosystem services (e.g. kg · yr^{-1}), in physical terms. In addition, the monetary supply of ecosystem services (€ · yr^{-1}) can be analysed (ES supply and ES Use). In the current study, the physical supply and use tables and the condition table were developed and populated where possible. In addition, monetary supply and use tables were developed by Wageningen University (see Report II).

The SEEA-EEA also provides information on the concepts of monetary asset and capacity accounts. These potentially provide insight into the balance of ecosystem services and in the sustainability of their use. In addition, a set of supporting accounts (biodiversity, carbon, land, water) was envisaged in the guidelines. For example, biodiversity has been recognised as a key ecosystem property and therefore a separate account for biodiversity was proposed to enable the monitoring of biodiversity over time in a consistent manner. Key indicators from this account form input for the condition account (UNEP-WCMC, 2015). However, these accounts were outside the scope of the current pilot project.

The relation of the ecosystem accounts to the National Accounts is complex. SEEA EEA was developed to specifically address ecosystem contributions to national economies, and to thereby show the dependence of economic activities on ecosystems. A number of ecosystem services are currently already included in the National Accounts, without being recognized separately as contributions from ecosystems. Examples of such services are the contributions of ecosystems to e.g. crop, fodder and timber production. Regulating services are not included in the National Accounts. Examples of this are carbon sequestration, air filtration, flood protection and the prevention of soil erosion. For several cultural ecosystem services the ecosystem contribution is not recognized independently, but its value is included in the National Accounts, for example in the case of nature tourism (revenues of hotels and other accommodation included). Other types of cultural ecosystem services (e.g. nature education) are not included in the National Accounts. Similarly, ecosystem assets are excluded from the non-financial balance sheets of the National Accounts; ground prices are estimated for built up areas and for agricultural land, but not for non-economic uses. Hence, there are currently no estimated ground prices for e.g. heath lands, forests or wetland areas, and there is no separate balance sheet for ecosystem services.

2.2 Ecosystem services

Types of ecosystem services

Ecosystem services represent the flow of material and immaterial services through human and economic activities that provide benefits to the economy (UN et al., 2014). These contributions are manifold and are subdivided into three types of services. Provisioning services reflect material and energy contributions of the ecosystems (e.g. timber, ground water). Regulating services result from the capacity of ecosystems to regulate climate, hydrological and bio-geochemical cycles and a broad variety of biological processes. For example, air filtration by trees contributes to clean air, which is important for public health. Similarly, natural flood protection, for example by dune areas, contributes to public safety and the protection of property. Cultural services are generated from the physical settings, locations or situations giving rise to recreational, intellectual or symbolic benefit. For example, the possibility for recreation in nature or the enjoyment of a 'green' living environment contributes to wellbeing and health.

The supply of ecosystem services

The character of supplied ecosystem services varies between ecosystem units. For example, in the Netherlands, crop production primarily takes place on agricultural land and timber is mainly produced in forest, whereas recreation by bike is a service that is provided by both ecosystem types. The supply and use of a service also depend on ecosystem condition and on economic demand. For example, an extensive forest with a high biodiversity will provide a different quantity and set of services than a monoculture production forest: timber production will be highest in the latter, and bike recreation will likely be higher in the former type of forest, as long as it can be reached by bike in a feasible amount of time by a significant number of people.

This example illustrates the interdependence of ecosystem services within one ecosystem type, as well as the influence of factors that determine use. The current supply of ecosystem services per ecosystem unit depends on the extent and condition of that unit with regard to the ecosystem service under consideration, and taking into account parameters that influence the economic use of that service. These parameters are geographically highly variable, therefore an EU_NL map was needed.

2.3 Project objectives

The objectives of the project are listed below, followed by a short description.

1) **Develop and compile land accounts (use and activity) for the Netherlands: The spatial** delineation of ecosystem types lies at the basis of all subsequent ecosystem accounts. In a national accounting sense, ecosystem units are the equivalent of economic sectors. Each sector (ecosystem unit) produces a certain set of (ecosystem) services and products, the quantity of which depends on the size (extent) of the unit and its condition. Therefore, a highly detailed map showing ecosystem units in the Netherlands was essential to carry the project forward (the Ecosystem Units or 'EU_NL' map). In addition, an economic users (ISIC) map was developed to identify the economic users of location-specific services.

2) **Carry out an inventory of available data for the Netherlands, on ecosystem services, asset and condition:** For the Netherlands, a large amount of data and maps containing information on ecosystem services, condition and assets are already available. An inventory was needed to find all suitable data (e.g. of sufficient quality and resolution, no double counting, transparency on modelling assumptions, etc.) and to establish the possibility of developing a comparison over time on ecosystem extent and services supply.

3) **Develop and conceptually design Natural Capital Accounting Tables:** In the current SEEA EEA guidelines, the design and development of accounting tables is not made explicit for all accounts. In addition, the potential content of the tables depends on data availability and quality, which is country specific.

4) **Populate the proposed tables for a chosen area, for a selected number of services and ecosystem types, in physical and where possible monetary data:** Populating the accounts with all possible data was the main objective of this pilot project. Accounts for Limburg were populated for a selection of 8 (physical supply table) or 7 (monetary supply table, monetary use table) ecosystem services, for 31 ecosystem units. In addition, a test-case was developed for hedonic pricing of the amenity service (green living environment).

All objectives were achieved within this project.

2.4 Relation to other projects on Natural Capital Accounting

The ecosystem accounting project for Limburg is complementary to other initiatives carried out in the field of Natural Capital Accounting. The project builds upon the **Ecospace** project of Wageningen University. **Ecospace** is a European Research Council funded project aimed at developing and testing methods for ecosystem accounting. The project started in 2010 and was finalized in November 2015. In this project physical and monetary ecosystem accounts, covering both capacity and services, were developed for three test sites: Limburg province, Telemark province, Norway and Central Kalimantan province, Indonesia. In each area, around 8 ecosystem services were mapped, analysed and, in the case of Limburg and Central Kalimantan, valued in monetary terms. Outcomes of the project have been presented in the form of scientific papers (10 papers published to date) and in terms of contributions to discussions on SEEA and ecosystem accounting with the World Bank, UNSD, EEA and

Eurostat. **The Atlas Natural Capital** (RIVM, funded by Min. Infrastructure and the Environment) provides essential information on the geographical extent and characteristics of a number of ecosystem services and ecosystem condition. There is a strong collaboration between the project partners and RIVM and other contributors to the Atlas to ensure that presently available information in the Atlas is incorporated in the ecosystem accounts, and that future developments of the Atlas are, where possible, mutually beneficial. The **ESD report by Alterra** (Wageningen) provides semi-quantitative information (e.g. % percentage of demand fulfilled by natural supply) on a large number of ecosystem services in the Netherlands. The **Material Monitor+** by Statistics Netherlands (initiative by Min. EZ) project describes a wide range of policy questions related to the extraction, use and scarcity of natural resources as well as a range of related topics, such as the circular economy and ecosystem services. The Monitor focusses exclusively on flows that can be expressed in tonnes or kg's of material. The **MAES project** (by BISE, a partnership between the European Commission and the European Environment Agency) aims to support the knowledge base for the implementation of the EU 2020 Biodiversity Strategy. The database contains maps of ecosystem services on a regional, national, European and global scale, presented for a range of ecosystem types.

3. Methods

3.1 Ecosystem Unit (EU_NL) Map

Ecosystem accounting was designed to be spatially explicit: ecosystem services and conditions are spatially modelled or mapped, or otherwise attributed to spatial units. This implies that both the physical and monetary supply tables are based on mapped ecosystem services as much as possible. Within our current project an Ecosystem Unit (EU_NL) map was developed for the Netherlands. This map is essential to model and quantify ecosystem services and to assign supplied services spatially to a set of ecosystem units. Therefore, the EU_NL map reflects a division into ecosystem units that was, as far as possible, consistent with other mapping efforts (MAES, SEEA EEA Ecosystem Unit types, see section 3.2), as well as practical for the purpose of modelling ecosystem services. The map needs to provide full spatial coverage, implying that all built up terrain is also assigned to a set of ecosystem units. The aim was to provide a detailed map that reflects land use and vegetation properties at a high level of detail. On top of that, essential location features were mapped for two natural assets: coastal dune areas and river floodplains. For the Netherlands, both assets are of critical importance in the protection against coastal and river floods, on local, regional and national scales. Information on all ecosystem units within these regional scale features is also available at a lower legend level.

The EU_NL map was based on a strategic combination of a number of maps and datasets covering the Netherlands: the cadastral map, agricultural crops grown, address based business register, addresses of buildings, the basic topographical registry and land use statistics for the Netherlands. Maps were combined following a strict hierarchical approach. Once a unit is assigned, it can no longer be changed. For built up areas, the cadastral unit was taken as the base unit. However, where cadastral parcels were dissected by roads, water or railways, the smaller parcels were taken as the initial unit.

First all water was assigned. In a series of following steps, the different units for built up areas (residential areas, business areas etc.) were assigned, followed by roads and other paved surfaces.

For non-residential built-up areas economic use was decisive, so that the map provides information on whether built up terrain is used by main ISIC sections such as government, the services sector, manufacturing etc. Next, for all agricultural land, the agricultural crops grown in 2013 were used to divide parcels into perennial and non-perennial crops. Meadows for grazing were defined based on the same registry. Natural grasslands were defined based on the position of meadows; grazing meadows within the EHS (National Ecological Network) were considered to represent this category. Finally, all unpaved surfaces without agricultural activities remained. These were assigned using the basic topographical registry for remaining types of land cover and the land use map for functional areas such as unpaved agricultural and nature roads. A number of other delineations of policy-based locations (Natura 2000, delineation of river floodplains) are superimposed on the EU_NL map. Thus, the map is multi-layered: details on land use within e.g. river floodplains is still available, so that e.g. agricultural production within this legend unit can be calculated from this map. The resulting map is a highly detailed polygon map that also contains fine line elements (e.g. gravel paths and hedgerows wider than 6m). It contains all available information on agricultural land use and detailed information on natural and semi-natural areas.

3.2 Relation to other international mapping efforts

The current classification can be translated into the MAES classification level 2 without any major obstacles, as shown in Table 3.2.1. The classification developed for the EU map is, however, a bit more detailed (see MAES levels B, E, H, I and J) and places specific focus on the river floodplains and dunes. Because the map is multi-layered, however, it is easy to convert the river floodplain areas into MAES units, if desired.

The ecosystem types suggested in the SEEA EEA (Table 3.2.1) are somewhat similar to those in MAES, however, the linkages are not always clear and the classifications in the SEEA EEA appear to be overlapping. For example, SEEA EEA recognizes 'open wetlands' separately, whereas a large number of wetland types (e.g. bogs and mires) may be covered with (sparse to dense) trees and shrubs. In addition, SEEA EEA distinguishes between rain fed versus irrigated cropland. It is not clear what to do with temporarily irrigated lands, where the occurrence of irrigation depends on the rainfall in a particular season or year. In general, the SEEA EEA classification does not generally provide suitable classes for the Netherlands, and in its current form it does not contain enough detail for the analyses that were required in this study. However, at a high aggregation level the classifications can be linked so that reporting at the international level would be possible with the classes used in the pilot study, as shown in the Table above.

Table 3.2.1

Ecosystem Units in the Netherlands	MAES: level 1	MAES: level 2	tentative link to SEEA EEA
Sea	A Marine Habitats	A2	Sea
Tidal salt marshes	A Marine Habitats	X1-X2-X3	
Dunes with permanent vegetation	B Coastal habitats	B1	Natural vegetation associations and mosaics
Active coastal dunes		B1	Sparsely vegetated areas
Beaches		B1	Barren land (tbc)
Lakes and ponds	C Inland surface waters	C1	Inland water bodies
Rivers and streams	C Inland surface waters	C2	
Fresh water wetlands	D Mires, bogs and fens	D4-D5-D6	Open wetlands
Meadows (for grazing)	E Grasslands and lands dominated by forbs, mosses or lichens	E2	Pasture and natural grassland
Natural grassland		E2	
Heath land	F Heathland, scrub and tundra	F4	Shrubland, bushland, heathland
Deciduous forest	G Woodland, forest and other wooded land	G1	Forest tree cover
Coniferous forest	G Woodland, forest and other wooded land	G3	
Mixed forest	G Woodland, forest and other wooded land	G4	
Hedgerows	G Woodland, forest and other wooded land	G5	Natural vegetation associations and mosaics
Inland dunes	H Inland unvegetated or sparsely vegetated habitats	H5	Sparsely vegetated areas
Other unpaved terrain		H5	
Non-perennial plants	I cultivated agricultural, horticultural and domestic habitats	I1	Medium to large fields of rain-fed herbaceous cropland
Perennial plants		I1	Permanent crops, agriculture plantations
Residential areas	J Constructed, industrial and other artificial habitats	J1	Urban and associated developed areas
Industry: offices and other terrain		J1	
Services sector: offices and other terrain		J1	
Public administration: offices and other terrain		J1	
Forestry: offices and other terrains		J1	
Fishery: offices and other terrains		J1	
Non-commercial services: offices and other terrains		J1	
Greenhouses		J1	
Farmyards and barns	J Constructed, industrial and other artificial habitats	J2	Agriculture associations and mosaics
Roads, parking lots, runways and other paved surfaces	J Constructed, industrial and other artificial habitats	J4	Urban and associated developed areas
River flood basin (see text)			

3.3 Economic Users map

To identify the users of ecosystem services, two approaches were applied: 1) conceptual selection of users, and 2) geographical allocation of users, with the help of an Economic Users map. The Economic Users map was based on the same data and delineations as the EU_NL map (see Fig. 4.2.1). The classification for the economic users map was based on the ISIC classification for businesses (NL: SBI with 21 sections (A-U). In addition to these ISIC units, four non-economic land use types were distinguished to ensure full map coverage: roads, households , water and (semi) natural areas. Using this map, it is possible to identify the users of ecosystem services that are spatially explicit, such as the users (beneficiaries) of flood protection or noise reduction.

3.4 Physical supply of ecosystem services

Remme et al. (2014) provide a detailed description of the modelling approaches used to estimate the physical supply of the selected ecosystem services. For the current study, the approach was updated by using the newly developed EU_NL map as a basis and new data where relevant. In summary (all based on Remme et al., 2014), the provisioning of crops was modelled for the most common crop types in the base registry for crops grown (> 10 crop types for human consumption). Fodder was modelled using data on yields of two main sources of fodder: maize and pasture. Groundwater provisioning was modelled for eleven (shallow) groundwater extraction wells and surrounding protected areas, where groundwater is extracted to supply drinking water. Meat obtained by hunting was modelled for 43 hunting districts in Limburg for wild boar (*Sus scrofa*) and European roe deer (*Capreolus capreolus).*The regulating service capture of PM_{10} reflects the filtering of particulate matter from the air. It was modelled using published values for PM_{10} capture by different types of land cover, combined with ambient PM_{10} concentration maps. Terrestrial carbon sequestration is the storage of carbon in vegetation and soils. It was mapped using published data on carbon storage in different land cover types. The cultural service recreation by bike was modelled using the national cycle path network, a map of attractiveness of the landscape and population density. The total number of recreational biking trips (excluding race biking and mountain biking) was known from previous publications. Nature tourism was modelled using data on accommodation capacity and visiting statistics for three regions in Limburg. For more details see Remme et al., 2014.

3.5 The extent account and the physical Supply and Use tables

All tables were designed according to SEEA-EEA guidelines. The ecosystem extent account for Limburg Province was compiled based on the EU_NL map. This presents a major refinement compared to the previous study carried out for Limburg, because ecosystem services can be linked to a more detailed and more accurate map. Ecosystem supply was analysed for each ecosystem unit (columns) and for all ecosystem services (rows) that were included in this study. The physical quantities of the services supply were based directly on the modelled ecosystem services maps. So, to determine the physical supply of ecosystem services per ecosystem unit, for example the physical supply of the service fodder production, the physical supply of fodder was modelled based on the information available in the EU_NL map.

The Use tables were constructed differently. Although a detailed economic users map (based on the ISIC registry) was developed within this project, none of the ecosystem services that were included in this study had spatially explicit economic users, as would have been the case for e.g. flood protection and noise reduction. Therefore, users were defined depending on the physical and monetary model characteristics, following the ISIC classification as much as possible. Because the physical use table was based directly on the monetary use table (shown in report II), it is not shown here.

3.6 Conceptual Condition Account

The ecosystem condition account records information on the various characteristics that reflect the condition or quality of an ecosystem. (SEEA EEA; UN et al, 2014).The purposes of a condition account can be manifold: it summarizes which condition indicators are relevant for the functioning of a given ecosystem, it can include condition indicators that control the supply of ecosystem services, or it can contain condition indicators that more explicitly policy relevant. At the minimum, it should include those indicators that, if they change over time, lead to a change in the supply of ecosystem services (UN et al., 2014). This latter group includes all parameters that were used in the development of the biophysical ecosystem service supply model. For example, for the modelling of bicycle tourism, input parameters into the model included population density, attractiveness of the landscape and the location of the Dutch national biking network. Out of these, only the attractiveness of the landscape may be interesting for policy reasons, whereas none of these are vital indicators for the functioning of the ecosystems themselves. In short, we propose that there are three sets of condition indicators that could be considered, which is also aligned with the forthcoming Technical Recommendations for SEEA EEA to be published by UNSD early 2016 (note that the description of the indicators is based upon the upcoming Technical Recommendations as well as our experiences in the pilot project:

a. **Physical state indicators:** These indicators concern the recording of relatively fixed characteristics of ecosystem assets such as measures of soil type, slope, altitude, climate and rainfall. These are important inputs in the modelling of ecosystem services, but by themselves not necessarily policy-relevant. They may be included in an Annex of the accounts.

b. **Environmental state indicators**: The second group reflects measures of impacts or pressures on the environmental state, for example, measures of pollution, emissions or waste. Accounting for these flows is described in the SEEA Central Framework although more spatial detail is required for ecosystem accounting purposes. While primarily needed for measuring regulating services, they will also be relevant in the assessment of ecosystem condition. This group of indicators may also be of interest from a policy monitoring perspective.

c. **Ecosystem state indicators**: These measures reflect for example, the degree of fragmentation, leaf area index, nutrient status of the ecosystem, biodiversity, the attractiveness of the landscape or the degree of 'naturalness' of vegetation. These indicators are of vital importance to understand how the ecosystem is currently functioning and how the ecosystem can supply ecosystem services. This information is also relevant for specifying biodiversity conservation priorities, however not all indicators (such as leaf area index) are policy relevant.

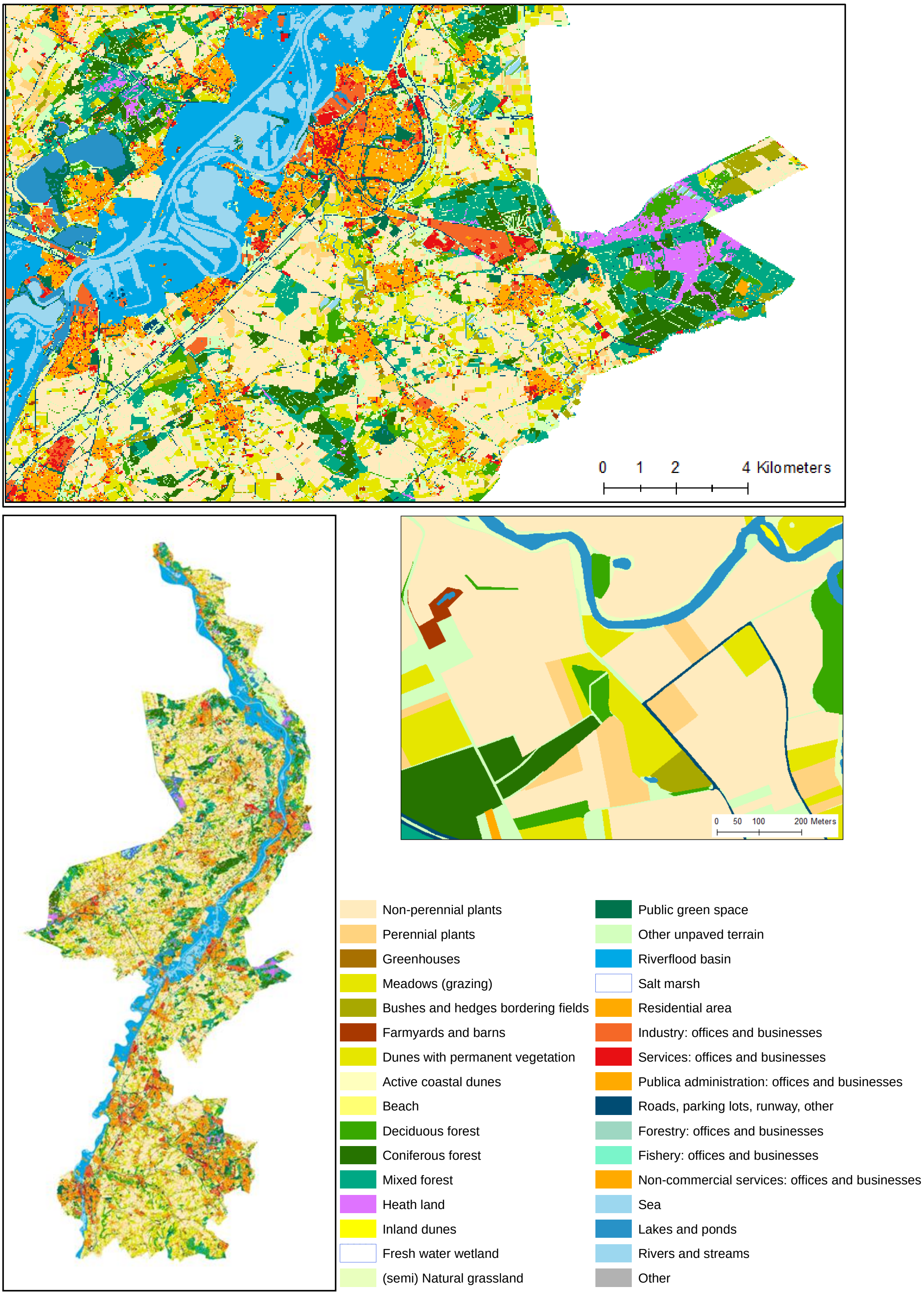
The condition account should, like all accounts in this report, be based on geographically explicit information that can be updated at a regular basis.

4. Results and interpretation

4.1 EU_NL map

The EU_NL map was constructed for the Netherlands (see Annex). The map has already been made available to the Atlas Natural Capital (RIVM) to be used as the basis for further ecosystem service modelling, and will be made publicly available in 2016. Figure 4.1.1 provides examples of the many different units that are discerned and the high level of detail. The province of Limburg is shown in Figure 4.1.1b. Figure 4.1.1a shows a part of the map for the municipality of Roerdalen in the central part of Limburg. National Park 'de Meinweg' is located at the border with Germany and is characterized by deciduous, mixed and coniferous forest types and heathland. The city of Roermond (to the West) shows up as a mixture of all built up ecosystem unit types. It lies directly along the river Maas. The streambed of the river Maas and adjacent artificial lakes (from gravel extractions, all in light blue) and the entire floodplain (the area where flooding may occur during runoff peaks, shown in dark blue) are shown in detail. In Limburg a number of villages were built within the floodplain of the river as can also be seen in this figure. Parts of these villages are situated on naturally higher ground, whereas other parts and villages in Limburg are situated at lower elevations and were flooded in 1993 and 1995. Figure 4.1.1c provides an example of the high level of detail by showing a part of the small river Roer. The Roer has several meander cut-offs (oxbow lakes) that are overgrown with deciduous trees, and small sandy islands within the streambed. Gravel roads in this rural area also show up clearly (light green lines).

Next page: Figure 4.1.1, showing the EU_NL map for: a) the municipalities of Roermond (centre) and Roerdalen (east), b) Limburg province, and c) a detail of the stream the Roer.


0 1 2 4 Kilometers
0 50 100 200 Meters
Non-perennial plants
Perennial plants
Greenhouses
Meadows (grazing)
Bushes and hedges bordering fields
Farmyards and barns
Dunes with permanent vegetation
Active coastal dunes
Beach
Deciduous forest
Coniferous forest
Mixed forest
Heath land
Inland dunes
Fresh water wetland
(semi) Natural grassland
Public green space
Other unpaved terrain
Riverflood basin
Salt marsh
Residential area
Industry: offices and businesses
Services: offices and businesses
Publica administration: offices and businesses
Roads, parking lots, runway, other
Forestry: offices and businesses
Fishery: offices and businesses
Non-commercial services: offices and businesses
Sea
Lakes and ponds
Rivers and streams
Other

4.2 Economic Users (ISIC) map

Figure 4.2.1 shows a comparison of the EU_NL map (left) and the Economic Users map (right) for the same part of Limburg. The Economic Users map shown here is an aggregated version of the original map. The Economic Users map allows for the identification of economic land use by ISIC section. So for example, the industrial area in the centre of the map is used primarily by the industry and services sections, whereas the floodplain of the river Maas is used for agriculture.

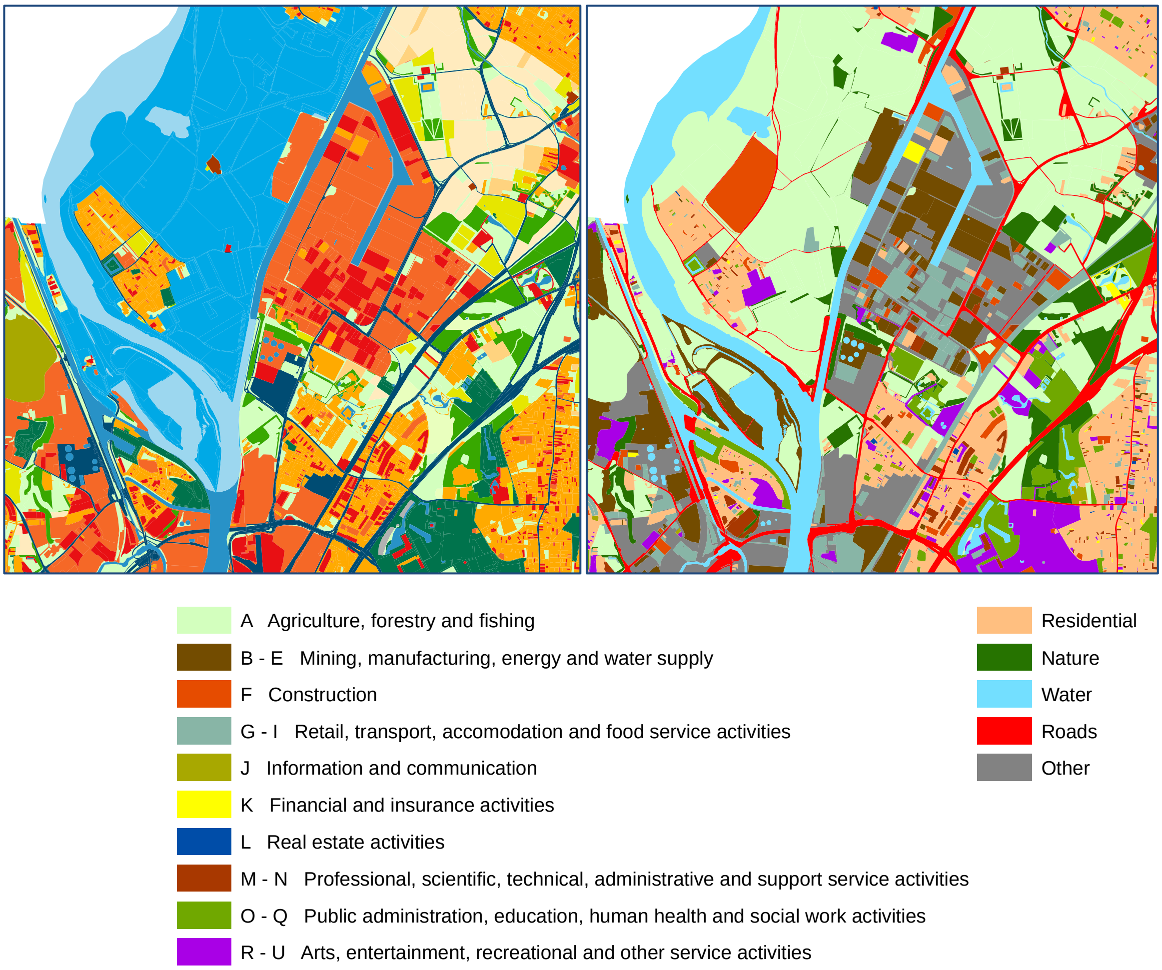


Figure 4.2.1 Comparison of the EU_NL map (left) and Economic Users map (right). The legend shown here belongs to the Economic Users (ISIC) map to the right. For the legend to the EU_NL map, see figure 4.1.1.

4.3 Physical Supply and Use Tables

The physical supply tables are based on biophysical models for each ecosystem service. These are shown in Fig. 4.3.1., shown below and continued on the next page.

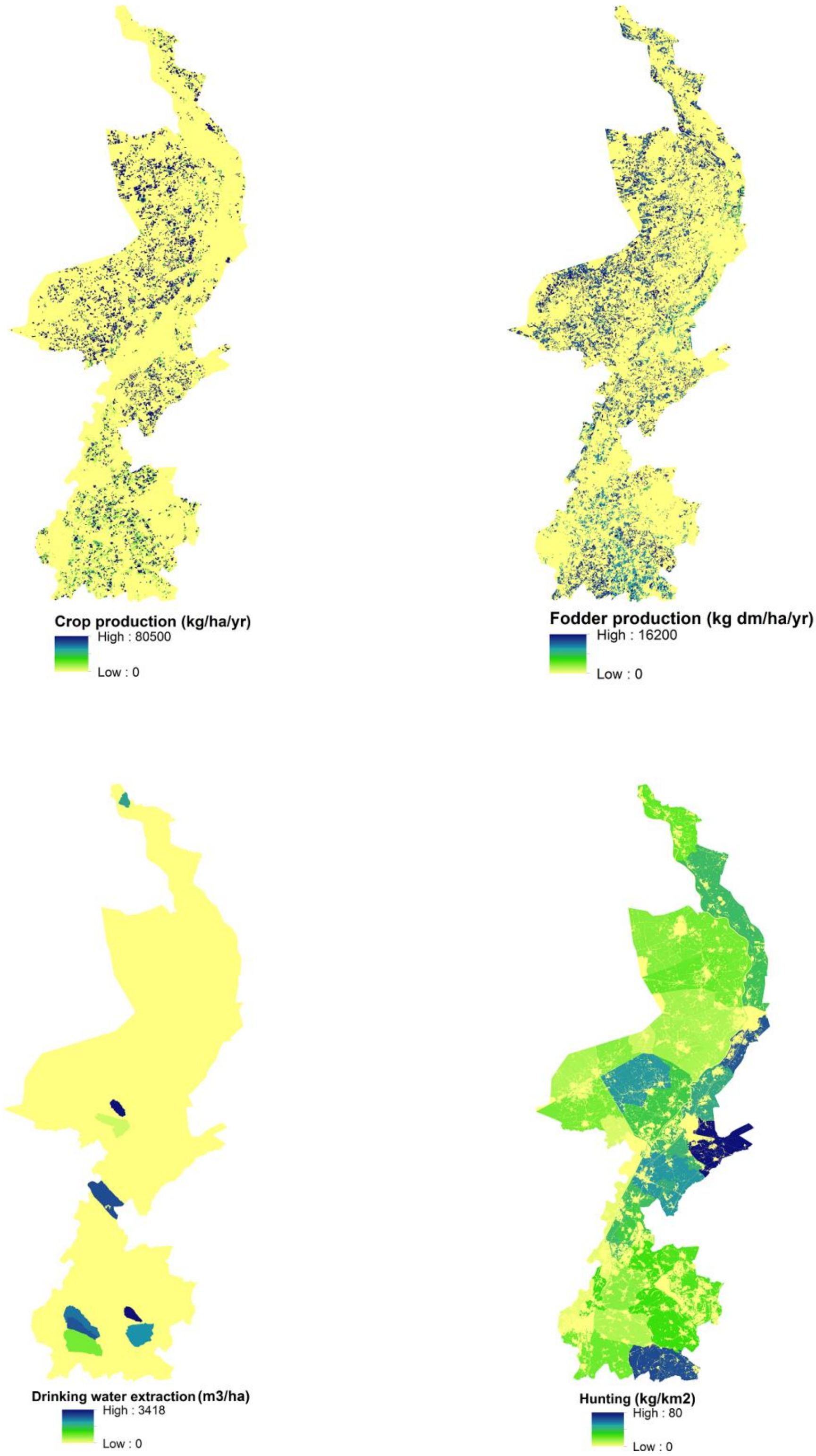
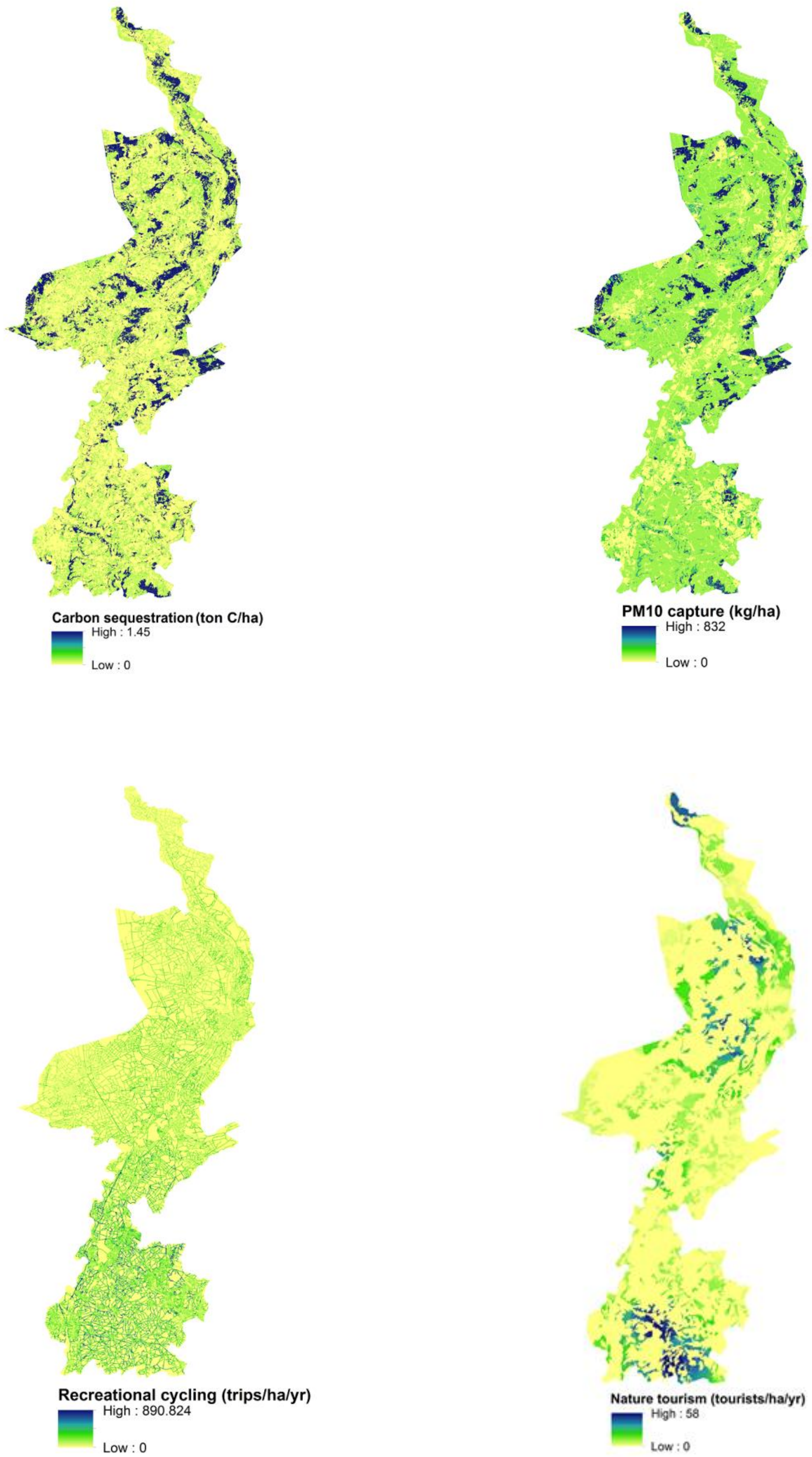


Figure 4.3.1: Biophysical model results for eight ecosystem services. Modelles were based on the methods described in Remme et al., 2014, but were updated and extended for the current study.



Tables 4.3.2 and 4.3.3 show the physical supply tables for the included ecosystem services in this study, as total values per ecosystem unit and as values per ecosystem unit per hectare.

The total extent of each ecosystem unit in Limburg (total of all land parcels assigned to the same ecosystem unit) is also provided. Some interesting results can be obtained from these tables. For example, the largest amount of fodder is produced mainly on meadows used for grazing, giving a yield of 328.800 tonnes in 2013 (Table 4.3.1). Carbon sequestration primarily takes place in forests, which represent 10-15 thousand tonnes of carbon per year. A cultural ecosystem service is nature tourism. This ecosystem service is provided by multiple ecosystem units. Table 4.3.2 shows the relative contribution of each ecosystem types for this service with regards to the extent. Although the total number of visitors to forests nearly equals the total for non-perennial plants (94.000), the values per hectare clearly indicate the importance of forests and of hedgerows in particular. The high score for hedgerows may seem spurious. However, in South Limburg, where the supply of the ecosystem service nature tourism is relatively highest (see Remme et al., 2015), hedgerows are an important part of the attraction of the landscape. Many of them are located alongside so-called hollow roads, which are part of very old cultural landscapes. Many of these are part of, or situated in the vicinity of nature reserves.

Although these tables provide interesting data, it is important to keep in mind that the ecosystem services included in this pilot project only represent a small part of all ecosystem services provided in Limburg. Other important ecosystem services (e.g. timber supply, water recreation, pollination) were not included in the current study.

4.3.2 Physical supply table (summarized) for selected ecosystem services in Limburg Province

Ecosystem services		Ecosystem Units	Non-perennial plants	Perennial plants	Meadows (for grazing)	Hedgerows	Farmyards and barns
extent (ha)			53.600	8.100	27.100	2.900	2.100
Provisioning	**Crops**	**tonnes/yr**	1.427.300	65.000	-	-	-
	Fodder	**tonnes/yr**	140.800	4.700	328.700	-	-
	Meat (from game)	**kg/yr**	11.500	1.500	5.900	800	400
	Ground water (drinking water only)	**in 1000 m3/yr**	9.000	1.400	4.200	500	100
Regulating	**capture of PM10**	**tonnes/yr**	400	100	200	-	-
	Carbon sequestration	**tonnes C/yr**	-	2.400	4.900	500	-
Cultural	**Recreation (cycling)**	**1000s of bike trips/yr**	1.800	300	1.000	100	100
	Nature tourism	**# tourists/yr**	94.000	22.000	136.800	57.000	-

4.3.3 Physical supply table per hectare

	Ecosystem services	Ecosystem Units	Non-perennial plants	Perennial plants	Meadows (for grazing)	Hedgerows	Farmyards and barns
Provisioning	**Crops**	**tonnes/ha/yr**	26,63	8,02	-	-	-
	Fodder	**tonnes/ha/yr**	2,63	0,58	12,13	-	-
	Meat (from game)	**kg/ha/yr**	0,21	0,19	0,22	0,28	0,19
	Ground water (drinking water only)	**1000m3/ha/yr**	0,17	0,17	0,15	0,17	0,05
Regulating	**capture of PM10**	**tonnes/ha/yr**	0,01	0,01	0,01	-	-
	Carbon sequestration	**tonnesC/ha/yr**	-	0,30	0,18	0,17	-
Cultural	**Recreation (cycling)**	**1000s of bike trips/ha/yr**	0,03	0,04	0,04	0,03	0,05
	Nature tourism	**#tourists/ha/yr**	1,75	2,72	5,05	19,66	-

Deciduous forest	Coniferous forest	Mixed forest	Heath land	Inland dunes	Fresh water wetlands	Natural grassland	Public green space	Other unpaved terrain	River flood basin	paved surfaces	Lakes and ponds	Rivers and streams	Totals
11.400	7.100	10.400	2.100	100	900	3.100	4.800	22.600	14.100	42.300	3.100	3.800	**220.900**
-	-	-	-	-	-	-	-	-	-	-	-	-	**1.492.400**
-	-	-	-	-	-	-	-	-	66.900	-	-	-	**541.100**
2.500	1.700	2.900	600	-	200	800	900	4.700	2.400	-	-	-	**36.800**
1.900	100	500	100	-	-	700	400	2.400	1.300	3.800	500	-	**27.000**
300	400	500	-	-	-	-	100	200	100	-	-	-	**2.300**
16.500	10.300	15.100	400	-	200	600	1.200	4.100	2.800	-	-	-	**59.000**
600	200	400	-	-	-	100	200	1.300	600	2.100	100	-	**9.100**
160.300	93.800	147.400	22.700	1.000	11.600	55.400	11.800	65.900	94.500	-	100	-	**974.300**

Deciduous forest	Coniferous forest	Mixed forest	Heath land	Inland dunes	Fresh water wetlands	Natural grassland	Public green space	Other unpaved terrain	River flood basin	paved surfaces	Lakes and ponds	Rivers and streams
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	4,74	-	-	-
0,22	0,24	0,28	0,29	-	0,22	0,26	0,19	0,21	0,17	-	-	-
0,17	0,01	0,05	0,05	-	-	0,23	0,08	0,11	0,09	0,09	0,16	-
0,03	0,06	0,05	-	-	-	-	0,02	0,01	0,01	-	-	-
1,45	1,45	1,45	0,19	-	0,22	0,19	0,25	0,18	0,20	-	-	-
0,05	0,03	0,04	-	-	-	0,03	0,04	0,06	0,04	0,05	0,03	-
14,06	13,21	14,17	10,81	10,00	12,89	17,87	2,46	2,92	6,70	-	0,03	-

4.4 Condition account

Table 4.4.1 shows the conceptual lay-out of a condition table representing data for a single year. If more data, also within years, are available, the opening and closing values can be included for those indicators for which this is relevant. First, the table shows information on ecosystem extent and degree of protection. The table shows that the largest part of all forests, wetlands and heathlands in Limburg are under a form of environmental protection. For the degree of protection the EU_NL map was combined with the Natura2000 map. Therefore, the degree of protection varies within this category, because national parks for example have a different degree of protection than areas that are only part of the EHS. Such detailed information can also be made available depending upon information needs of the users.

As described previously, condition indicators can be separated into physical, environmental state and ecosystem state indicators. The table shows examples of a few possible indicators per category. The physical state indicators contain data that describe the physical boundaries under which an ecosystem is functioning. Examples are all climatic parameters (e.g. rainfall, wind regime, temperature indicators etc). In practical applications, this type of information would be shown in an annex. For environmental state and ecosystem state indicators a few examples are provided. The Environmental state indicators reflect environmental, policy relevant indicators, but do not necessarily reflect to the state of the ecosystem. For example, air pollution levels is an environmental state indicator. It varies in time and in space, is highly policy-relevant, and is relevant for the accounts because the higher the concentration of pollutants, in principle, the more air filtration ecosystems can provide. The set of indicators can be extended in the future, depending on data availability and the requirements of users.

As an example, annual mean particulate matter concentration values are also provided. The data show that for this indicators the spatial differences are very small, which reflects the blanket cover of PM in Limburg, with the highest concentrations in and near urban zones. The table also shows only the background concentration of PM, not the local peak concentrations, which is the reason that higher concentrations in urban zones do not show up in the Table. The example for PM is only provided as an illustration, and more discussion with account users is needed to specify the condition indicators and how they should be included in the account. The intention is to do this as part of the process where the accounts would be scaled up.

Table 4.4.1, Conceptual layout of the Condition table with data for Limburg Province

			EU extent 2013			Phys. state ind.			Env. State indic.					Ecosys. state ind.				
	EU map unit number	Ecosystem Units	extent in ha	of which protected*	protected in %	annual rainfall	annual no. growing days	depth to groundwater table	nitrogen content	heavy metal content	PM2.5 concentration (ug per m3)	PM10 concentration (ug per m3)	nitrous oxide exceedance days	degree of fragmentation	naturalness of biota	species richness	red-listed species	water quality
Agricultural land	1	Non-perenn. plants	53.629	3.530	7						15,1	23,1						
	2	Perennial plants	8.133	1.012	12						15,1	23,1						
	3	Greenhouses	995	-	-						15,2	23,1						
	4	Meadows	27.066	5.224	19						15,1	23,0						
	5	Hedgerows	2.940	2.481	84						14,9	22,4						
	6	Farmyards, barns	2.142	45	2						15,2	23,5						
		totals	94.905	12.293														
Dunes and beaches	11	Dunes perm. veg.	-	-														
	12	Active coastal dunes	-	-														
	13	Beaches	-	-														
		totals	-	-														
Forests and other (semi) natural environments incl. unpaved terrain	21	Deciduous forest	11.414	8.297	73						15,1	22,7						
	22	Coniferous forest	7.091	6.694	94						14,8	22,6						
	23	Mixed forest	10.437	9.498	91						14,8	22,5						
	24	Heath land	2.149	2.091	97						14,7	22,2						
	25	Inland dunes	114	99	87						14,6	22,1						
	26	Fresh water wetlands	936	919	98						15,0	23,1						
	27	Natural grassland	3.121	2.847	91						15,0	22,5						
	28	Public green space	4.761	-	-						15,1	22,6						
	29	Other unp. terrain	22.591	3.623	16						15,1	22,9						
		totals	62.614	34.067														
Temp. inundated lands	31	River flood basin	14.126	5.494	39						15,0	22,4						
	32	Salt marshes	-	-							15,1	22,7						
		totals	14.126	5.494														
Built up areas		(units 41-48)	42.349	-							15,2	22,7						
Water	51	Sea																
	52	Lakes and ponds	3.122	1.105	35						15,1	22,5						
	53	Rivers and streams	3.807	2.407	63						15,0	22,7						
		totals	6.929	3.512														
		Totals Limburg	**220.922**	**55.366**														

5 Discussion and further recommendations

This pilot project has explored the possibilities of ecosystem accounting for a selected set of ecosystem services in Limburg Province. The study illustrates the strong potential of the data that are made available with the ecosystem accounting approach, following the SEEA – EEA guidelines. However, the study also illustrates that a lot of work remains to be done; for Limburg several economically and socially important ecosystem services were not yet included in the current pilot project. Biophysical models are needed for a large number of additional ecosystem services, at a level of detail that is sufficient to allow for both national scale accounting as well as small scale (municipalities) comparisons. In addition, the quality of already existing biophysical supply models for ecosystem services can be improved. Both tasks require collaboration with national institutes, in particular (but not only) the ANK. Once completed for the Netherlands and for a broad set of ecosystem services, the supply accounts provide information on the amount and location of supplied ecosystem services. This gives insight in the wide range of services that are offered primarily by natural and semi-natural vegetation, and it shows the locations of supply in detail. The spatial information can be used to optimise the current use of ecosystem services, and to determine where changes are most needed to protect or optimise ecosystem service supply. At the same time, ecosystem condition indicators should be collected in a consistent manner. These sets of information are vital to monitor the progress towards the goals set by the Dutch Government: to achieve a sustainable use of ecosystem services and prevent further loss of biodiversity (Min. Economic Affairs, 2013; Min. Economic Affairs et al., 2015). Protection of the natural environment is highly important not just because of its (potentially incalculable) intrinsic value, but also because of the services that provide clear economic benefits to businesses, governments and households.

To explore the full potential of ecosystem accounting, it is necessary to set up physical (and monetary, see Report II) supply and use accounts at regular temporal intervals, where possible based on the detailed EU_NL maps (also updated at the same temporal interval). The condition account is essential to interpret spatial and temporal changes in the supply tables. In addition, the condition account provides information on ecologically and policy relevant ecosystem parameters. In addition to these accounts, the SEEA-EEA guidelines propose the development of a number of additional accounts, which would provide information on the sustainability of ecosystem services supply and the monetary balance of ecosystems. Ideally, such accounts would be developed at least at the national and provincial scale, whereas ecosystem service supply maps and condition indicators provide meaningful information on smaller scales as well.

The data on services supply and use for a single year, as presented in this study, help to identify economic dependencies on ecosystem services and the location and relative importance of contributors to ecosystem service supply. However, the main strength of the accounting approach lies in the consistent, regular monitoring of ecosystem condition and services supply and use. Such timeseries (which can be developed on national but also on smaller spatial scales) can be compared to policy measures as well as economic and social developments.

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Annex 1, EU_NL map for the Netherlands, 2013