The SEEA EEA condition account for the Netherlands

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Executive summary

Aim and context of the ecosystem condition account

The Ecosystem Condition Account is one of the interlinked accounts that together form the System of Environmental Economic Accounting (SEEA). There are five core ecosystem accounts – the ecosystem extent, condition, ecosystem services supply and use accounts in physical and monetary terms and the ecosystem monetary asset account. These are complemented with four thematic accounts, centred around the themes carbon, biodiversity, water and land. Within the project "Ecosystem accounting for the Netherlands" all the core accounts will be developed, as well as the thematic accounts on carbon (Lof et al., 2017) and biodiversity (under development). The extent account for 2006 and 2013, and the biophysical ecosystem services account have already been developed (Remme et al., 2018).

In this report the ecosystem condition account is presented. In line with the technical recommendations of the SEEA-EEA, the condition account presents indicators for the general condition or state of an ecosystem and indicators for pressure that can affect ecosystem functioning (UN, 2017). State indicators reflect the state or condition of vegetation, biodiversity (or nature value), soil, water and air. Pressure indicators reflect pressures from pollution, ground water management and urbanisation. Pressures can affect the condition (or state) of ecosystems and thereby affect the services provided by ecosystems. Ecosystems need to be in good condition to provide multiple ecosystem services. The measurement of ecosystem condition is a central aspect of ecosystem accounting since it provides information on the capacity of ecosystems to provide ecosystem services into the future (UN, 2017).

The ecosystem condition account is based on data and maps either developed within this project or kindly provided by others. Criteria were formulated to select the most relevant datasets for inclusion in this report. However, data quality and reliability of each of the indicators should be assessed in their original reports. **Inclusion of data in this report *does not imply* that all datasets were verified for reliability and quality by Statistics Netherlands: they were taken at face value.**

Data and maps were combined with the Ecosystem Unit map for the Netherlands (Statistics Netherlands, 2017) and, where relevant, with information on ecosystem specific thresholds and limits to show spatial explicit condition of specific ecosystems. Based on the resulting maps, the ecosystem condition table was populated. The ecosystem condition account table was developed for the Netherlands for a set of clustered ecosystem types (table 5.1) and in more detail per ecosystem type (forests, grasslands, heath, agriculture, and urban areas (Annex I)).

Results

The condition account shows that a very large fraction of the natural ecosystems experience eutrophication and acidification. Almost 100% of all forest, heath land, natural grassland and freshwater wetlands experience eutrophication, and almost 100% of the heathland and natural grasslands experience acidification. Due to the spatial distribution of nitrogen deposition (e.g. lower deposition near the coast and in the north of the Netherlands), dunes are relatively less affected by eutrophication. Nevertheless, still almost half of the dune area experiences eutrophication.

Eutrophication can affect the competition between plant species and therefore alter species composition. For instance, increased nutrient availability in heath land favors fast growing grasses over slow growing heath vegetation, which potentially affects the ecosystem services that the ecosystem provides.

The (non-spatial) biodiversity indicator “characteristic species” shows that the ecological quality of all natural ecosystems is lower than of an intact ecosystem for all monitored ecosystem types. For forest, heath and natural grasslands only about 33% of the characteristic species are present, while for dunes and fresh water wetlands about 47% of the characteristic species is present. In addition, the biodiversity indicator “Living Planet Index” shows that in several ecosystem types (e.g. heath, dunes, agricultural areas, urban areas and marine ecosystems) biodiversity has decreased since 1990. On the other hand, biodiversity in forests, coastal areas and the Wadden sea have remained relatively stable. The biodiversity of fresh water swamps has increased since 1990.

The air quality meets the limits for the annual daily mean set by EU in more than 99.9% of the area. However, in the majority of the area, the annual daily mean does exceed the more stringent threshold set by the World Health Organisation (WHO), especially for $PM_{2.5}$. For PM_{10}, the air quality exceeds the WHO threshold in more than 60% of the urban areas. Generally, the air quality is best in the north of the Netherlands.

Applications and future developments

The condition account brings together indicators on several aspects of ecosystem condition (such as vegetation cover, air quality, soil properties and biodiversity) in a comprehensive overview of the status of the Netherlands’ ecosystems. By bringing together information sets that have, to date, been reported separately, a more informed picture can be given of where there are critical trends in ecosystems, and which parts of ecosystem condition are most relevant for policy makers to focus on. The account shows which aspects of ecosystem condition are of priority for further policy action, and which are relevant to be monitored but do not require immediate action.

For the condition account, available data about different aspects of the state of ecosystems and pressures in the Netherlands on ecosystem condition were used. Generally, aspects of air quality (e.g. particulate matter concentration and pressures such as acidifying deposition) are measured and reported yearly and have a good spatial coverage. Furthermore, critical deposition loads (for pressures) and limit values (for air quality) are available, so that these indicators can be compared to these criteria. Information about the state of vegetation, biodiversity and soil of ecosystems is not readily available. If they are studied, the spatial coverage is low (i.e. only a few sample points) and they are not always repeated or monitored on longer timescales . This presents a challenge for describing the ecosystem condition, especially when one would like to look at temporal trends. In consequence, for soil only one indicator could be included. For biodiversity only two non-spatial indicators (measured on a yearly base) were included (Living Planet Index (LPI) and ecosystem quality). Another biodiversity indicator is measured in only in a small fraction of the ecosystems (Structure and Function of areas protected by the Habitat Directive) and reported on a longer time scale. Finally, the indicators for vegetation are not yet reported on regularly, but they are based on remote sensing data and thus repeated measures are possible in the future.

An important part of the policy applications stem from having the condition account for multiple years. However, for some of the indicators only one year was available for this account. Repeating the work for multiple years would further improve the strength of having all data presented in one consistent framework. This condition account is a first test of the SEEA-EEA condition accounting approach in the Netherlands. Based on this report, discussions will be held with stakeholders in which both the overall approach and the individual indicators will be assessed. This will provide clear guidance for condition accounting in the future; for instance it may appear that some indicators are not deemed essential and other indicators are missing in the accounts.

1 Introduction

The Ecosystem Condition Account is one of the core accounts the System of Environmental Economic Accounting Experimental Ecosystem Accounts (SEEA-EEA). The Ecosystem Condition “reflects the overall quality of an ecosystem asset in terms of its characteristics” (UN, 2017). In general terms the Condition Account captures, in a set of key indicators, the state or functioning of the ecosystem in relation to both its ecological condition and its capacity to supply ecosystem services.

The condition account is an integral part of the SEEA ecosystem accounts. It builds upon the extent account, that provides information on the extent of ecosystem types and changes therein, and which is taken as the basis for all other accounts (condition, physical and monetary services, assets, carbon and biodiversity). The condition account captures both the state of ecosystems (state indicators) and the pressures exerted on ecosystems (pressure indicators).

The condition account is complementary to the biodiversity account. The biodiversity account includes a number of indicators reflecting species and changes in species occurrence in the Netherlands as well as the protected status of ecosystems and species. Most indicators related to biodiversity are not included in the condition account since these are covered in the biodiversity account.

1.1 Data sources and criteria for indicator selection.

Data for the condition account in the Netherlands come from a variety of sources. Most important are several environmental monitoring systems that are maintained for the Netherlands (e.g. at RIVM, WENR, etc.). In part, these monitoring systems have been set up in response to national and international legal requirements to monitor specific environmental aspects. There are several relevant European directives which relate to ecosystem condition: the Water Framework Directive (EU, 2000), the EU Habitat Directive (EU, 1992), the EU Birds Directive (EU, 1979; EU, 2009), the EU Biodiversity Strategy (EU, 2011) and the EU Air Quality Directive (EU, 2008). Several indicators used here were derived from these directives. .

The general criteria applied for selecting indicators for the condition account are: (i) relevance to support policy making (including, but not limited, to the EU directives); (ii) responsiveness to changes in the management of ecosystems (e.g. soil organic matter content is considered a relevant indicator; soil texture, although highly relevant for soil management, is not selected as it is not generally expected to change due to management); (iii) the degree to which the indicator can be linked to measures of potential ecosystem supply; and (iv) the ease of communication to the users of the accounts including experts, but also the general public and policy makers. In addition, it was considered that (v) taken together the indicators must provide a comprehensive picture of key aspects of ecosystem condition; (vi) for each indicator a scientifically sound dataset is required; and (vii) modelling policy scenarios based on the condition account requires that the selected condition indicators are relevant for forecasting changes in ecosystem services supply over time.

The key methods and assumptions of the used datasets are described. However, for more detail references are provided to the original datasets. Datasets that lack a clear description of methods and assumptions have not been used in this account. In specific cases, mostly for pressure indicators, existing datasets have been combined with reference values or limit values per ecosystem type.

1.2 Policy uses.

One of the main benefits of compiling an ecosystem condition account lies in the integration of different sets of information on ecosystem condition. This integrated approach (based on a common understanding of the size, composition and types of ecosystem assets) offers a more comprehensive insight into changes in ecosystems compared to individual datasets, thereby expanding the policy use of environmental information. A key element of accounting is monitoring change over time. Therefore indicators are selected that are able to pick up changes. . Hence, when condition accounts will be produced for multiple years, the temporal dimension of ecosystem change will be further elucidated further enhancing policy uses. In addition, using the SEEA approach ensures coherence between such accounts for the Netherlands and for other countries, enabling comparison between countries as well as mutual learning on how to best monitor the state of ecosystems.

Jointly, the indicators provide the user of the accounts with a comprehensive overview of the changes in the physical state or the condition of ecosystems in the Netherlands. Because high resolution maps were used for most indicators, the accounts specify this condition by location. In some cases, it is possible to inform users on the status of ecosystem condition vis-a-vis a reference condition, allowing to indicate whether ecosystems are in a good or a poor condition. These reference conditions were based on policy standards (as in the Water Framework directive) or the scientific literature. However, not in all cases such reference conditions were available.. It is also possible to assess whether the largest challenges for the Netherlands' ecosystems are in relation to soil, air, water, habitat or other domains. Finally, as with the other accounts, potentially the greatest value added lies in the consistent application of the approach over time and space so that changes in ecosystems (as a function of naturally occurring trends, environmental pressures, or policies) can be clarified and assessed.

1.3 Structure of the condition account.

In line with the SEEA-EEA, the condition account was compiled by ecosystem type. Each ecosystem type has distinct characteristics that should be considered in assessing its condition. In accounting tables, the data are presented for different themes (e.g. soil, vegetation) and for different ecosystem types (urban areas, agricultural land, surface water, heath lands etc.)). For each ecosystem type, multiple indicators were used. These indicators may be relevant across different ecosystem types, or only for one or two specific ecosystem types. For instance, soil quality (for agricultural purposes) can be assessed using CEC, and water holding capacity. Furthermore, a clear distinction was made between environmental state and pressure indicators. As extent is an important characteristic to relate to the condition and pressure indicators information on the extent is also added to the condition account. Figure 1.1.1 shows the general set up of a condition account.

Figure 1.1.1 General set up of the condition account (for one point in time)

			Ecosystem types					TOTAL
			Forests	Agricultur	Urban	Wetlands	etc.	
Extent		extent						
State / condition indicators	Vegetation	indicator 1 indicator 2 etc.						
	Biodiversity	indicator 1 indicator 2 etc.						
	Soil	indicator 1 indicator 2 etc.						
	Water	indicator 1 indicator 2 etc.						
	Carbon	indicator 1 indicator 2 etc.						
Pressure indicators		indicator 1 indicator 2 etc.						

In the condition accounting tables, data are aggregated by the main ecosystem types in order to provide a macro-scale overview of the condition of ecosystems in a country. In the maps (in case datasets are based on sample points) there is a spatial aggregation. Spatially distributed characteristics can be aggregated to a small set of numbers describing the characteristic at a larger scale. The type of aggregate is dependent on the type of characteristic. In some cases averaging is appropriate, but in other cases summarizing the distribution across classes is more fitting. Second, multiple characteristics can be combined into a simple indictor. Again, this may be either a single number, (e.g. an average 'score', or the number of 'positive' and 'negative' evaluations of characteristics). For each indicator, it is explained if and how data have been aggregated.

1.4 Aim of this report.

This report aims to present a first (experimental) condition account for the Netherlands. Based on policy relevance and data availability a first account for environmental state and pressure indicators was constructed that is fully consistent and coherent with the ecosystem accounts that have been previously published for the Netherlands (Lof et al., 2017, Remme et al., 2018). When available, time series of indicators and pressures were included. In general, time series were mostly present for pressures and not yet available for state indicators (with the exception of air quality and biodiversity). Indicators from the Water Framework Directive and the Habitat Directive are reported with a frequency of 6 years. For soil and vegetation no consistent time series were available. The condition account can also inform policy makers on which indicators are most relevant to measure (e.g. because of rapid changes in (part of) the Netherlands, or based on their impact on the supply of ecosystem services (which is not yet explored in this report).

1.5 Structure of the report.

First an overview is provided of the condition account methodology. Starting from the SEEA perspective, how it can be operationalized for the Netherlands and how it is linked to the other Ecosystem Accounts (Chapter 2). Subsequently, in chapters 3 and 4, state and pressure indicators for the Netherlands and the relevant reference values or threshold values are presented and discussed. In Chapter 5 the condition account for 2013 is presented. Chapter 6 visualises the results for specific ecosystem types, namely urban areas, agriculture, forests, grasslands, heath, wetlands and dunes. Finally, in chapter 7 the conclusions are presented and recommendations for future work are given.

Note: This condition account is a first test of the SEEA-EEA condition accounting approach in the Netherlands. Based on this report, discussions will be held with stakeholders in which both the overall approach and the individual indicators will be assessed. This will provide clear guidance for condition accounting in the future; for instance it may appear that some indicators are not deemed essential and other indicators are missing in the accounts.

2 Methods and data sources

2.1 Key concepts and definitions

In this paragraph we first present the key concepts and definitions related to the condition account.

Ecosystem assets. The SEEA-EEA specifies that "*Ecosystem condition reflects the overall quality of an **ecosystem asset** in terms of its characteristics.*" (UN, 2017). Hence, ecosystems are defined as "*a dynamic complex of [living] communities and their nonliving environment interacting as a functional unit*". Examples of ecosystems, as included in the extent account, are forests, heathlands, and fresh water wetland areas, but also croplands, meadows and public parks. In accounting, the focus is on the ecosystem as an asset, i.e. as a store of value for people. This value may be derived from both intrinsic properties of the ecosystem (e.g. it's beauty as understood by people, or for instance in terms of endemic and/or threatened species that find a habitat in the ecosystem), as well as from the ecosystem's capacity to provide services at present and, if properly managed, in the future. While in theory each pond or field is an ecosystem, which in principle may overlap, for accounting purposes it is required to delineate ecosystems in well-defined, contiguous and non-overlapping spatial units, each corresponding with an individual ecosystem asset, as done in the Netherlands Ecosystem Types map (formerly the LCEU map: Van Leeuwen et al., 2015).

Ecosystem quality. As stated in the SEEA-EEA framework: "*Ecosystem condition reflects the overall **quality** of an ecosystem asset **in terms of its characteristics.***" (UN, 2017). Hence, ecosystem assets are characterized by both their quantity (i.e. extent) and their quality or state. Ecosystem quality has meaning for both the ecosystem itself (intrinsic quality, measuring the ecosystem health), and for the services it provides to humanity (outward or functional quality). Both aspects are considered in this account. For instance, a forest may be appreciated for its naturalness (as reflected in species composition and structure, for example) and for its capacity to supply ecosystem services (e.g. timber or recreational opportunities. Quality is made concrete by linking it to measurable ecosystem indicators reflecting various relevant properties or *characteristics*. The choice of characteristics will generally vary depending on the type and use of ecosystem asset and can either describe the current *state* of the ecosystem (e.g., soil nitrogen content) or the pressures being exerted upon them (e.g., nitrogen deposition). In specific cases, indicators are related to reference conditions, which may indicate the state of the ecosystem vis-a-vis a reference condition. Often, but not always, these reference conditions are grounded in local, national or European legislation, such as the EU Water Framework Directive.

State and pressure indicators. In line with the technical recommendations of the SEEA-EEA the condition account presents indicators for the general condition or state of an ecosystem and indicators for pressure that can affect ecosystem functioning (UN, 2017). State indicators reflect the state or condition of vegetation, biodiversity (or nature value), soil, water and air. Pressure indicators reflect pressures from urbanisation, pollution in the form of harmful chemical substances or energy (such as noise, heat or light) or drainage/ground water management.

2.2 Selection of the state indicators

The Condition Account includes state (condition) indicators that reflect, respectively, environmental quality with respect to vegetation structure, biodiversity, soil, water and air (Table 2.1). For biodiversity, air and water, indicators were included that are legally required by the respective framework directives (the Habitat, Air Quality and Water Framework Directives). The data quality and reliability of each of the indicators should be assessed in the original reports. Inclusion of data in this report does not imply that all datasets were verified for reliability and high quality by Statistics Netherlands: they were taken at face value.

Vegetation. Vegetation is characterized by means of carbon stock and Net Primary Productivity as well as vegetation height. Primary productivity is the measure of carbon intake by plants during photosynthesis. The production of plant biomass is essential for many ecosystem services, among others crop production, timber production and carbon sequestration. Plant productivity also plays a major role in the global carbon cycle by absorbing some of the carbon dioxide released by human activities. Vegetation cover in three height classes (trees, shrubs and low vegetation) is also included. It provides an indication of the type of vegetation and vegetation cover in an area. The added value is that these data are available for each ecosystem type, including the built-up areas, which is relevant for various ecosystem services such as recreation, air filtration, carbon sequestration and pollination.

Biodiversity. Next to the monitoring of habitat conservation status for the Habitat Directive, two more monitoring systems are included that describe biodiversity in the Netherlands, the Living Planet Index (LPI) and ecosystem quality (Statistics Netherlands et al., 2018 a; Statistics Netherlands et al., 2017 d). The Living Planet Index or LPI for the Netherlands reflects the average population trend for 361 land and freshwater animal species, from 1990- present. Apart from a general trend for the Netherlands, here we also provide a general trend for several ecosystem types. The strengths and limitations of the LPI and other methods shown here are discussed in more detail in the Biodiversity Account (forthcoming).

The indicator ecosystem quality was based on a specific set of characteristic and target species per ecosystem type selected from 457 species from four groups (breeding birds, butterflies, reptiles and vascular plants). It uses the trend in the degree of occurrence of characteristic and target species as a proxy for the mean ecosystem quality. It relates the representation of the current quality to a relatively intact ecosystem. Between these indicators there is some overlap in the data used, but they present different aspects of ecosystem state. The LPI shows a trend of all present animal species, while the ecosystem quality specifically focusses on characteristic and target animal and plant species that should be present in an intact ecosystem.

Soil. In 2006, the EU adopted a soil thematic strategy including a proposal for a framework to protect soils across the EU. However, in 2014 the European Commission took the decision to withdraw the proposal for a Soil Framework Directive. Soil is not subject to a comprehensive and coherent set of rules in the Union. Therefore, there is no pre-set indicator for soil condition available. Furthermore, for most datasets on soils it is unclear how an indicator was derived or whether this measurement will be repeated(for example datasets included in ANK on physical and chemical properties such as water holding capacity and on soil fertility). Therefore only the biological property soil organic matter could be included (Conijn and Lesschen, 2015).

Water. The status of European surface water bodies and ground water bodies are assessed following the methodology of the European Water Framework Directive (EU, 2000). The status of the water bodies is reported every 6 years. As indicator for water quality we include chemical quality, biological quality, ecological quality, transparency, total N and total P. It calculates the state as compared to a reference.

Air. The Air quality is assessed based on the mean annual concentration of four important air pollutants (PM_{10}, $PM_{2.5}$, NO_2 and SO_2) that are monitored for the EU Air Quality Directive (EU, 2008). Particulate Matter (PM) is an indicator for the overall air quality and has been related to health effects of air pollution. NO_2 is an indicator that has recently received much attention, in relation to the emissions by in particular diesel cars. SO_2 is a main driver of acidification and is also a building block of PM once aggregated with other pollutants in the atmosphere. Although excluded in the current account, in the future it may be of interest to include ammonia (NH_3), which is a major source for secondary PM formation.

2.3 Selection of pressure indicators

Pollution, land use change, economic development and population growth influence the state of ecosystems. The SEEA-EEA recommends including indicators that reflect pressures being exerted on ecosystems (UN, 2017). Pressures are relevant for the assessment of ecosystem condition because they can help in understanding the drivers for change in condition over time. They are also, by themselves, policy relevant. In general, policies aimed at ecosystem management or rehabilitation can address these pressures and/or the state of ecosystems directly. The following pressures are included in the account: eutrophication, acidification, desiccation in peat lands, urbanisation and the urban heat island effect (Table 2.2). Fragmentation of ecosystems is also generally considered a pressure on ecosystems. This indicator is not included yet, but could be incorporated in the future.

Eutrophication. Eutrophication involves the deposition of plant nutrients, in particular nitrogen and phosphorous. In many terrestrial systems nitrogen is the most limiting plant nutrient. Therefore only nitrogen deposition was included as a pressure indicator for terrestrial ecosystem types. For the condition of water total phosphorus was also included (see above). Eutrophication can affect vegetation composition by enhancing growth and changing species composition (essentially by favouring the species that are able to best take advantage of a higher nutrient availability).

Acidification. Acidification of soils and water is a result of emission of airborne pollutants (sulfur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), ammonia (NH_3) and volatile organic compounds (VOC)) by industry, farms, power plants and traffic. Excessive deposition of acidic compounds on soils with a low buffer capacity leads to a change in species composition in vegetation and a decline in biodiversity. Also soils with high buffer capacity can be affected by acidification; when the soil buffers the acid deposition, it releases toxic metals (such as aluminum and nitrate). These then leak into ground water or open water.

Desiccation. In the current account, only desiccation in peatlands was considered even though its effectsinfluence ecosystems on other soil types as well. . . This is due to a lack of data on desiccation in other ecosystems, but alsot because desiccation of peat results in greenhouse gas emissions. For peatlands, we analyse desiccation in the form of drainage depth. In their natural state, vegetation in peat lands capture carbon dioxide (CO_2) which is retained in the ecosystem because of a slow breakdown of organic matter. Whilst natural peat lands act as carbon sinks, agriculturally used peat lands act as sources of carbon. This is related to drainage, which is required for agricultural activities. As shown in the Carbon account, managed and drained peat and peaty soils annually emit in total 6.9 Mtonne CO_2 in the Netherlands (Lof et al., 2017), while vegetation in the Netherlands captures approximately 3.6 Mtonne CO_2 per year in its biomass. This means that annually, more carbon dioxide is emitted by peat soils than is captured in the biomass. There is a high policy relevance to measure drainage of peat soils. We therefore included the indicator drainage of organic soils (i.e. peat and peaty soils).

Urbanisation. Cities are often located, and tend to expand, in areas important for biodiversity such as estuaries, coastlines and fertile plains. Land use change from (semi-) natural ecosystems to built-up and paved surfaces not only affect ecosystem services provided, but potentially also affects the state of the (semi)natural ecosystems close to the urban areas. To capture the pressure of urban areas on ecosystems, we include an indicator for the percentage of paved surfaces in the local landscape and compare how this changed between 2006 and 2013. Sealed surfaces within the city boundaries have a negative effect on water infiltration in the city, especially during heavy rainfall events. Statistics Netherlands is currently developing a map for sealed surfaces in the city. If sufficiently reliable this will be included in a future update of the condition account.

Urban heat island effect. Several factors influence temperatures in urban areas. Urban areas contain more material like asphalt and concrete that have a higher absorption of sunlight and a slower release of heat. Furthermore, soil sealing reduces cooling due to natural evaporation and buildings reduce cooling from wind by reducing wind speed. As a result, the temperature in urban areas can be

Table 2.1 State (condition) indicators included in the Condition account, by theme

Theme/ Indicator	Unit	Relevant ecosystems											Monitoring and reporting required by EU (yes/no)	Reference condition (yes/no)
		U	P	C	M	SRL	F	H	G	W	D	O		
Vegetation														
Tree cover	%	●	●	●	●		●	●	●	●	●	●		no
Shrub cover	%	●	●	●	●		●	●	●	●	●	●		no
Low vegetation cover	%	●	●	●	●		●	●	●	●	●	●		no
Tree height	M	●	●	●	●		●	●	●	●	●	●		no
Carbon stock	Mton C		●	●	●		●	●	●	●	●	●		no
NPP	Ton C /ha		●	●	●		●	●	●	●	●	●		no
Biodiversity														
% protected areas	% area			●	●		●	●	●	●	●	●	Yes : EU HD, EU BD, EU BS. NNN	no
LPI	Index	●		●		●	●	●		●	●			yes
Characteristic species	Index						●	●	●	●	●			yes
Structure and Function	% area						●	●	●	●	●		Yes: EU HD	yes
Soil														
SOM	% area with SOM>3%		●	●	●		●	●	●	●	●	●		no
Water														
Chemical quality	% area					●							Yes: EU WFD	yes
Biological quality	% area					●							Yes: EU WFD	yes
Ecological quality	% area					●							Yes: EU WFD	yes
Transparency	% area					●							Yes: EU WFD	yes
Total P	% area					●							Yes: EU WFD	yes
Total N	% area					●							Yes: EU WFD	yes
Air														

PM_{10}	µg PM_{10} /m³	●	●	●	●	●	●	●	●	●	●	●	Yes: EU AQD	Limit
	% area	●	●	●	●	●	●	●	●	●	●	●		no
$PM_{2.5}$	µg $PM_{2.5}$ /m³	●	●	●	●	●	●	●	●	●	●	●	Yes: EU AQD	Limit
	% area	●	●	●	●	●	●	●	●	●	●	●		no
NO_2	µg NO_2 /m³	●	●	●	●	●	●	●	●	●	●	●	Yes: EU AQD	Limit
	% area	●	●	●	●	●	●	●	●	●	●	●		no
SO_2	µg SO_2 /m³	●	●	●	●	●	●	●	●	●	●	●	Yes: EU AQD	Limit
	% area	●	●	●	●	●	●	●	●	●	●	●		no

Table notes: U = urban, P = urban green area, C = cropland, M = agricultural grassland, SRL= sea, river and lakes, F = forest and woodland, H = heathland, G = (semi-) natural grassland, W = fresh water wetlands, D = dunes and beaches, O = other unpaved area, EU HD = EU Habitat Directive (EU, 1992), EU BD = EU Birds Directive (EU, 1979; EU, 2009), EU BS = EU Biodiversity Strategy (EU, 2011), NNN = Nature Network Netherlands (formerly EHS), EU WFD = EU Water Framework Directive (EU, 2000), EU AQD = EU Air Quality Directive (EU, 2008)

Table 2.2 Pressure indicators included in the Condition account, by theme

Theme/ Indicator	Unit	Relevant ecosystems											Reporting and monitoring required (yes/no)	Reference condition (yes/no)
		U	P	C	M	SRL	F	H	G	W	D	O		
Eutrophication	mol N/ ha/ yr		●	●	●		●	●	●	●	●	●	Yes: PAS	Threshold
	% area						●	●	●	●	●			no
Acidification	mol H⁺/ ha/ yr		●	●	●		●	●	●	●	●	●	Yes: PAS	Threshold
	% area						●	●	●	●	●			no
Desiccation (peat soils)	cm drainage			●	●		●	●	●	●	●	●		no
	% area			●	●		●	●	●	●	●	●		no
Urbanisation	% paved	●	●	●	●		●	●	●	●	●	●		no
	% increase	●	●	●	●		●	●	●	●	●	●		no
Urban Heat Island effect	°C increase	●	●											no
	% area	●	●											no

Table notes: U = urban, P = urban green area, C = cropland, M = agricultural grassland, SRL= sea, river and lakes, F = forest and woodland, H = heathland, G = (semi-) natural grassland, W = fresh water wetlands, D = dunes and beaches, O = other unpaved area, PAS = Programma Aanpak Stikstof (EZ and IenM, 2015; LNV and IenW, 2017)

several degrees higher than in the rural surrounding. This phenomenon is known as the urban heat island (UHI) effect. The elevated urban temperature can lead to additional heat-stress or heat related illness during hot days.

2.4 Data sources

To compile the condition account's indicators many different data sources were used. Some of these data were collected and analysed by (or in close collaboration with) Statistics Netherlands, such as the Living Planet Index (CBS/Network Ecological Monitoring). However, most data comes from other sources. Data on vegetation indicators (like vegetation cover, tree height and NPP) were provided by the Atlas Natuurlijk Kapitaal ("ANK", www.atlasnatuurlijkkapitaal.nl). Data on the UHI effect was also supplied by the ANK. The urban heat maps are for one year (or time period) and are not available for multiple years. Data on air quality, eutrophication and acidification was provided by the National Institute for Public Health and the Environment (RIVM). For these indicators time series were available from 2011 to 2016 (RIVM, 2016a,b). Data on water quality are collected for the EU Water Framework Directive by the Waterkwaliteitsportaal (www.waterkwaliteitsportaal.nl). Data on soil organic matter were provided by Alterra (Conijn and Lesschen, 2015). In chapter 3 the data sources for each indicator are described in detail.

3 Indicators for the condition account

Ecosystem condition accounts are presented for a number of indicators for ecosystem characteristics. First, we consider indicators for vegetation and biodiversity, then we look at the indicatorsrelated to soil, water and air quality.

3.1 Vegetation

Natural ecosystems provide ecosystem services. These services are influenced by an interplay of characteristics (i.e. soil, water, vegetation and biodiversity) of an ecosystem. Above ground vegetation facilitates several ecosystem services such ascarbon sequestration, air filtration and water infiltration. Vegetation also has a positive effect on human health. People that live in a green environment do not only feel healthier, they are healthier. A study in the Netherlands shows that the annual prevalence rate of several diseases was lower in living environments with more green space in a 1 km radius. The relation was strongest for anxiety disorder and depression (Maas et al., 2009).

3.1.1 Vegetation cover

High resolution maps are available for cover with trees, shrubs and low vegetation (data: Atlas Natuurlijk Kapitaal (ANK), 2017 a,b,c). These maps provide additional information to land cover maps, as these maps also show tree and shrub cover within individual ecosystem type units like urban land uses. The vegetation cover maps are based on the AHN2 and AHN3 (Actueel Hoogtebestand Nederland at a resolution of 0.5 meter and Infrared Aerial Photographs (CIR file,) in infra-red at a resolution of 0.25 meter. Vegetation with a minimum height of 2.5 meter is classified as trees, vegetation with heights between 1 meter and 2.5 meter are classified as shrubs, and vegetation lower than 1 meter (outside agricultural fields) is classified as low vegetation. Cropland and meadows are excluded from 'vegetation cover' in this analysis.

Figure 3.1.1 shows the vegetation cover by trees, shrubs and low vegetation in the Netherlands, expressed as % vegetation cover per spatial area of 100 m^2. Gelderland has the highest % of area covered with vegetation closely followed by Utrecht and Limburg (Table 3.1.1). Groningen, Friesland and Zeeland have the lowest % of area covered with (non-agricultural) vegetation.. In most provinces less than half of the area is covered with vegetation, the remaining land is covered by croplands and meadows (that are not included in the vegetation maps) or are built-up (with for instance houses, offices or roads). Agricultural coverage ranges from 42% in Limburg to 71% in Groningen and built-up coverage ranges from 10% in Flevoland to 30% in Zuid Holland. To assess the density of trees, shrubs and low vegetation, the mean cover *within* ecosystem units was also determined (Figure 3.1.2) Vegetation cover is also measured in built-up areas, therefore total coverage can exceed 100%. Vegetation cover is highest in forest ecosystems, dunes with permanent vegetation, public green spaces and heath land (Figure 3.1.2).

Table 3.1.1 Vegetation coverage (% of area per province covered with vegetation (i.e. >1% cover)) and mean vegetation cover (mean % vegetation cover per spatial area of 100 m^2 (with >1% cover)) given for all vegetation combined and split up in tree cover, shrub cover and low vegetation cover (denoted as grass). Note that a spatial area of 100m^2 can contain trees, shrubs and low vegetation. Therefore, the sum of tree coverage, shrub coverage and low vegetation coverage can be higher than the total vegetation coverage.

	vegetation coverage % of area	mean vegetation cover %	tree coverage % of area	shrub coverage % of area	grass coverage % of area	mean tree cover %	mean shrub cover %	mean grass cover %
Groningen	27.6	66.7	12.3	14.1	24.9	31.0	9.0	53.6
Friesland	30.9	66.9	11.9	14.0	28.0	30.7	8.0	56.6
Drenthe	40.5	77.7	24.9	26.4	37.2	47.9	8.5	46.6
Overijssel	40.1	70.2	25.4	27.2	35.4	46.5	7.6	40.4
Flevoland	34.6	72.8	18.8	22.5	32.9	38.6	8.5	48.7
Gelderland	51.3	71.8	33.6	36.9	46.5	44.9	7.5	40.8
Utrecht	50.9	66.2	28.9	32.8	47.8	39.4	7.6	41.5
Noord-Holland	44.9	61.6	19.2	23.6	43.5	32.5	8.5	44.7
Zuid-Holland	46.9	58.0	17.4	22.3	45.5	23.5	8.8	46.6
Zeeland	29.6	63.3	9.4	13.4	27.2	25.9	9.5	55.4
Noord-Brabant	47.5	69.5	30.3	32.7	43.1	46.9	7.2	38.1
Limburg	49.0	68.2	31.7	34.3	42.2	49.7	6.9	36.4

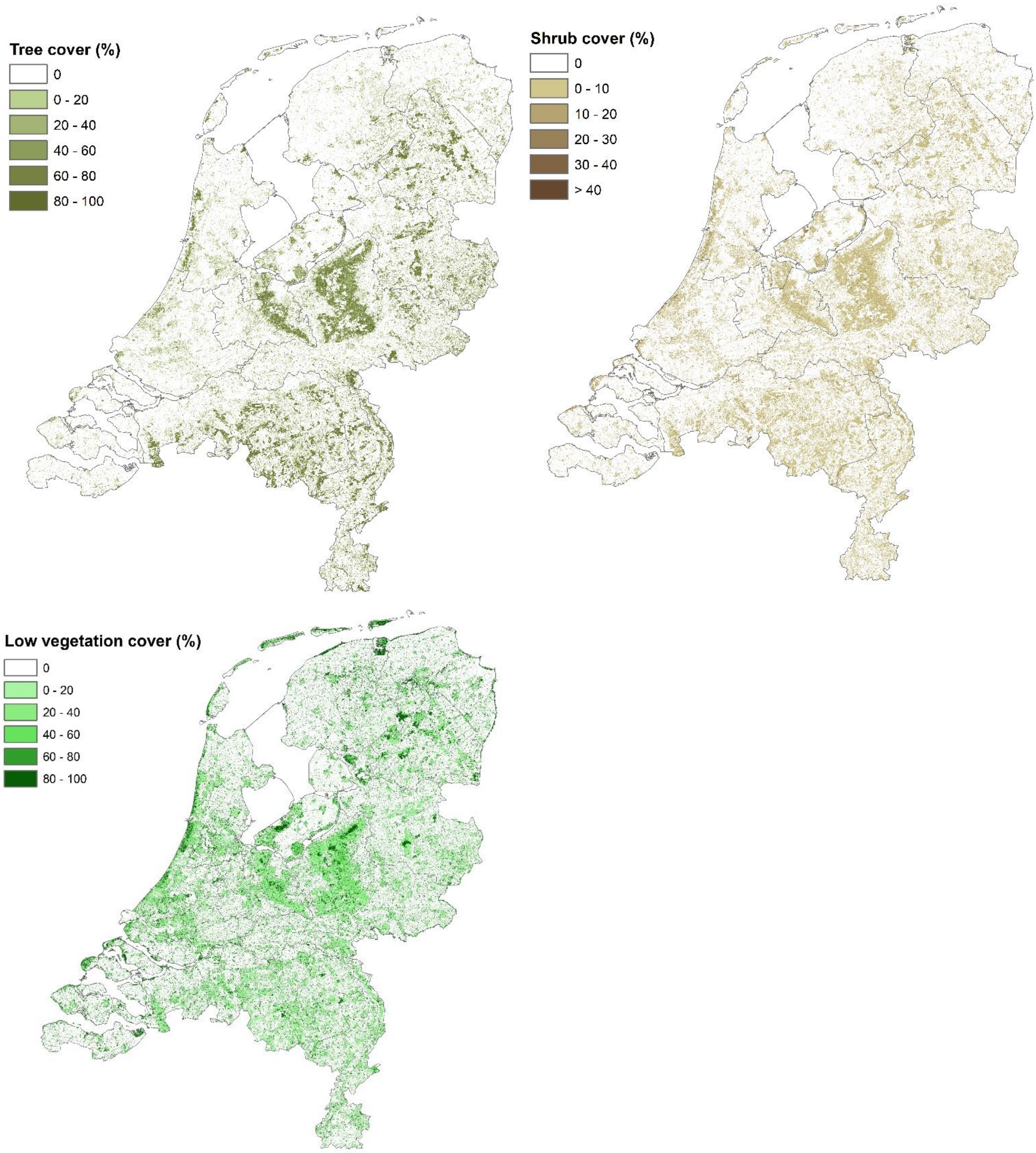


Figure 3.1.1 Vegetation cover in the Netherlands a) percentage tree cover, b) percentage shrub cover and c) percentage low (grasses and herbs) vegetation cover (excluding cropland and agricultural meadows) (data: ANK, 2017 a,b,c)

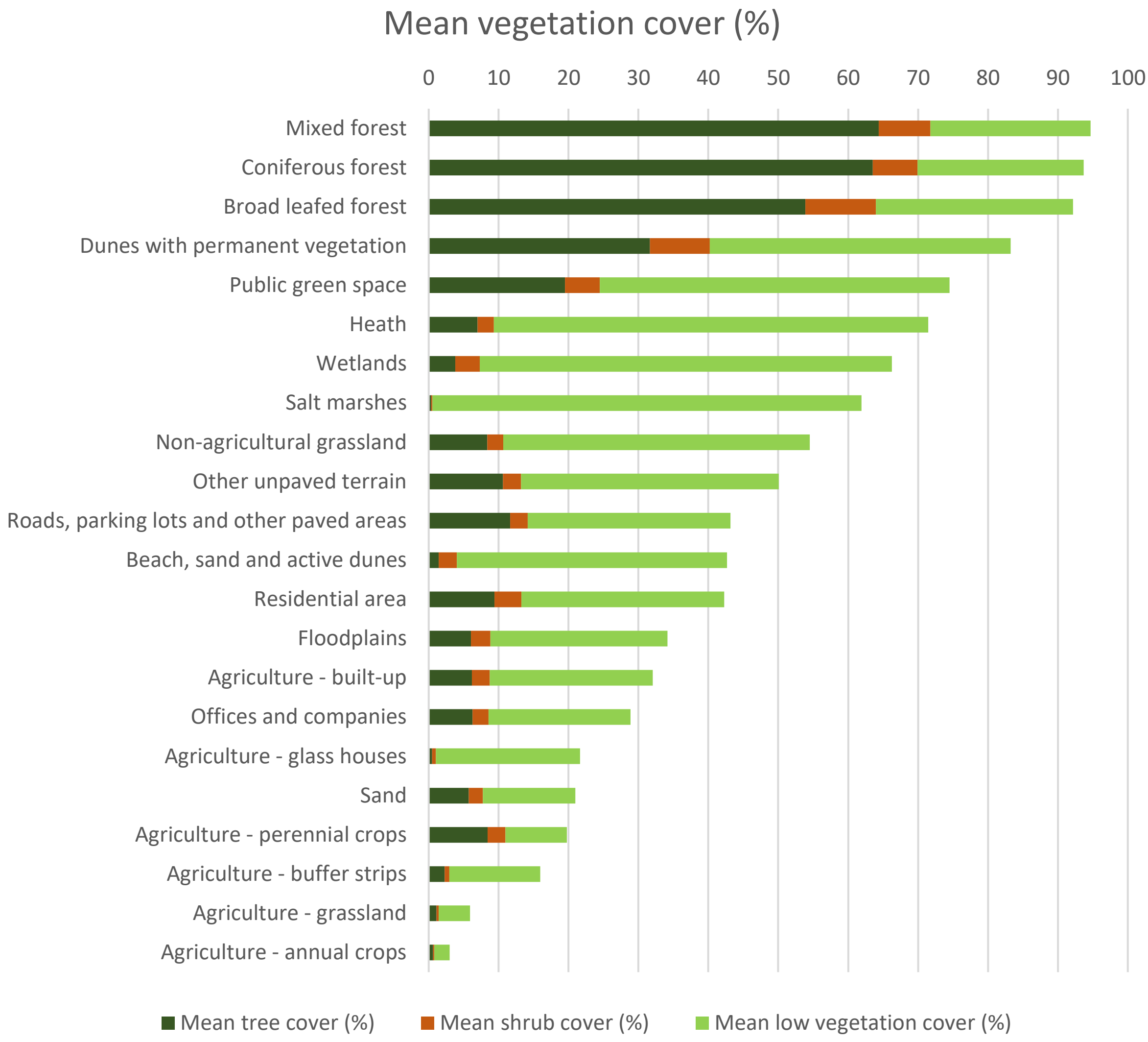


Figure 3.1.2 Mean tree, shrub and low vegetation cover in percentage per 10m grid depicted per ecosystem type. Note that mean low vegetation cover does not include cropland and agricultural meadows.

3.1.2 Tree height

Tree height influences the intra and interspecific competition for light. Furthermore, tree height can, in combination with tree diameter, be used to assess timber volume and carbon stock. High resolution maps are available of tree height (ANK, 2017 d). Like the vegetation cover maps, this map also shows tree height within individual LCEU units like urban land uses. The tree height map is based on the AHN2 and AHN3) at a resolution of 0.5 meter, the BAG buildings (Basisregistratie Adressen en Gebouwen) and Infrared Aerial Photographs (CIR file) , in infra-red at a resolution of 0.25 meter. Vegetation with a minimum height of 2.5 meter is classified as trees. To aggregate from individual trees to 10m x 10m, the 90-percentile is used (ANK, 2017 d). On average, coniferous trees are tallest (Table 3.1.2). The mean tree height in coniferous and mixed forest are the highest. Deciduous trees are on average about 2 meter shorter. For the ecosystem types agricultural grassland, annual crops, green houses and salt marshes not only the cover with trees within a 10m x 10m area is low, also less than 4% of the total extent has trees present (for salt marshes less than 1% of the total extent).

Table 3.1.2 Mean tree height in meter per ecosystem type. For reference, the mean cover with trees (%) and extent of 10m x 10m grids with trees are given (this gives only the portion of the total extent per ecosystem that contains trees).

	Heigth (*m*)	Extent (1000 ha)	Mean cover (%)
Mixed forest	13.5	115.9	64.4
Coniferous forest	13.5	80.3	63.5
Broad leafed forest	11.4	102.4	53.9
Dunes with permanent vegetation	8.9	9.6	31.6
Public green space	9.1	36.1	19.5
Roads, parking lots and other paved areas	8.6	43.7	11.6
Other unpaved terrain	8.9	88.6	10.6
Residential area	7.1	106.3	9.4
Agriculture - perennial crops	9.4	15.2	8.4
Non-agricultural grassland	9.0	13.8	8.4
Heath	7.4	10.8	7.0
Offices and companies	7.4	46.6	6.3
Agriculture - built-up	7.0	9.3	6.2
Floodplains	8.0	13.3	6.1
Sand	7.6	0.5	5.7
Wetlands	5.7	5.9	3.8
Agriculture - buffer strips	8.2	3.0	2.3
Beach, sand and active dunes	4.6	3.0	1.4
Agriculture – grassland	8.3	41.3	1.1
Agriculture - annual crops	8.3	19.8	0.6
Agriculture – greenhouses	3.7	0.3	0.5
Salt marshes	9.1	0.1	0.4

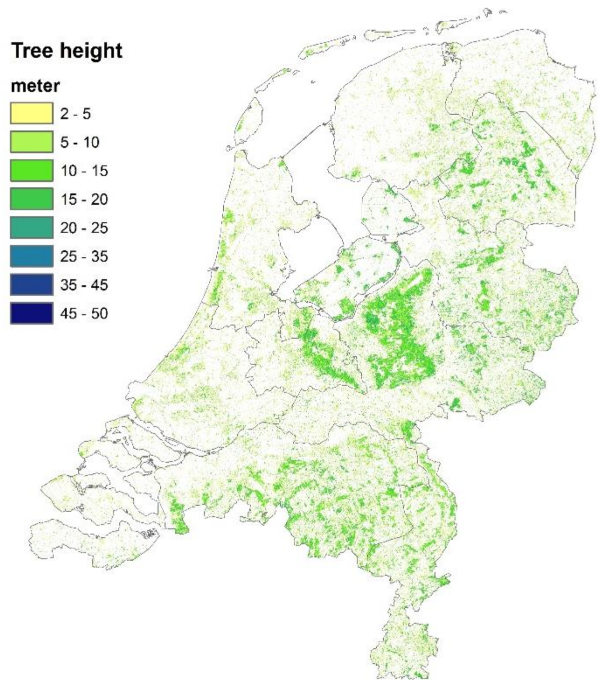


Figure 3.1.3 Height of trees in meter (data: ANK, 2017 d).

3.1.3 Net primary production (flow) and carbon stock in biomass

Plant productivity plays a major role in the global carbon cycle because growing plants absorb some of the carbon dioxide released by human activities, . The carbon plants absorb becomes part of the plants biomass both above ground (in stems and leaves), and below ground (in roots) and ultimately in the soil. The production of plant biomass is essential for many ecosystem services, among others crop production, timber production and carbon sequestration.

Primary productivity is the measure of carbon intake by plants during photosynthesis. This measure is an important indicator for studying the condition of plant communities. Net Primary Productivity (NPP) is the amount of carbon uptake after subtracting Plant Respiration (RES) from Gross Primary Productivity (GPP). GPP is the defined as the rate at which plants produce chemical energy, whereas NPP is defined as the total amount of chemical energy stored by plants.
In 2013, the net primary production was, on average, highest in deciduous forests and in coniferous forests.
The highest carbon stock in biomass is found in forests (Figure 3.1.4). Forests also contain the highest total carbon stock in above ground biomass. The mean carbon stock per unit area is much lower in meadows than in forest, but due to the large extent (927,000 ha) of meadows they have a large contribution to the total carbon stock in above ground biomass (Table 3.1.3).

Table 3.1.3 Net primary production by plants, and total carbon stock in plant biomass in the Netherlands

Ecosystem unit	(1000 ha)	Net primary production in 2013 (ton C/ha/yr)	Mean Carbon stock in biomass (ton C/ha)	Total Carbon stock in biomass (Mton C)
Annual crops	781	4.9	2	1.56
Perennial crops	79	4.9	17	1.35
Meadow	927	4.1	2	1.85
Hedgerows	36	3.9	2	0.07
Dunes with perm. veg.	16	3.5	84	1.34
Deciduous forest	109	6.0	86	9.39
Coniferous forest	82	2.1	81	6.64
Mixed forest	119	4.5	84	9.96
Heath land	41	3.2	8	0.33
Fresh water wetlands	34	4.0	1	0.03
Natural grassland	54	4.7	2	0.11
Public green space	68	4.6	6	0.41
Other unpaved terrain	295	2.8	2	0.59
River flood basin	73	3.9	2	0.15
Tidal salt marshes	11	3.1	12	0.13
Total				33.91

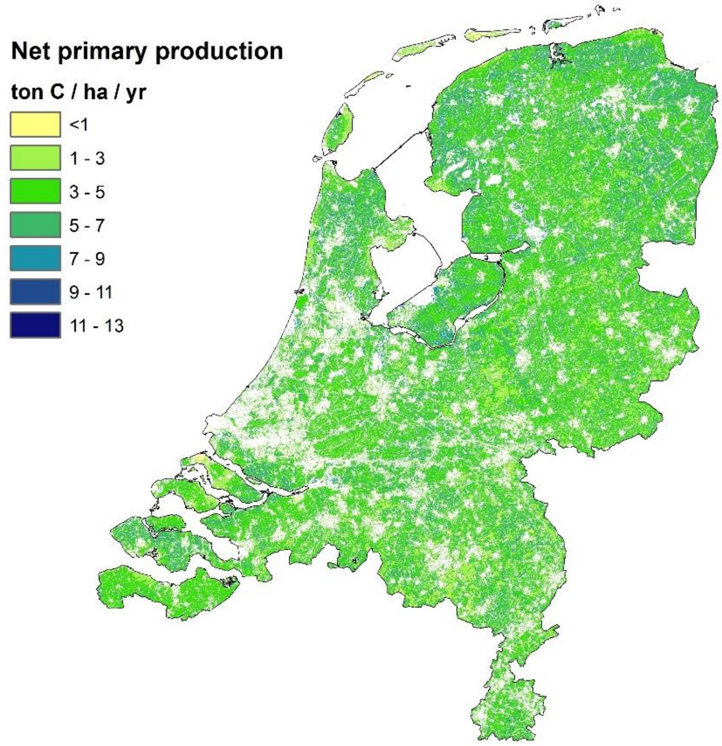


Figure 3.1.4 Net primary production by plants in the Netherlands in 2013 (data: ANK, 2017 e)

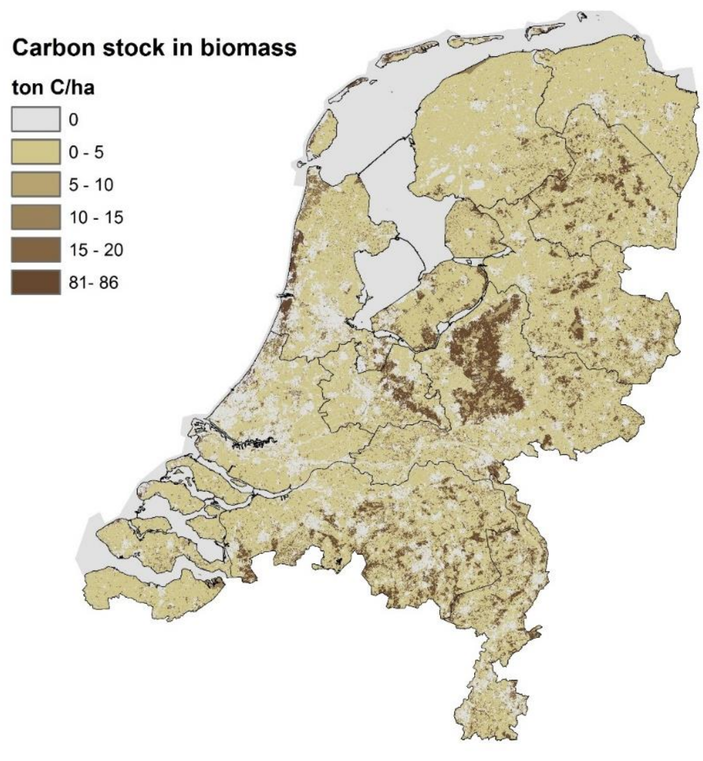


Figure 3.1.5 Carbon stock in the above ground biomass in the Netherlands in 2013 (data: Lof et al., 2017)

3.2 Biodiversity

Biodiversity is the variety of life on Earth. It includes all organisms, species, and populations; the genetic variation among these; and their complex assemblages of communities and ecosystems (UNEP, 2010). Biodiversity typically measures variation at the genetic, the species and the ecosystem level. Here, genetic diversity refers to the diversity in all the different genes contained in all the living species. Species diversity refers to the diversity in all the different species and within species. Ecosystem diversity refers to the variation in all the different habitats, biological communities and ecological processes, as well as variation within individual ecosystems. We present the state of Dutch ecosystems based on species diversity and ecosystem diversity. Biodiversity is one of the thematic accounts of the SEEA-EEA(work in progress).

3.2.1 Area of protected nature

TheEU Biodiversity Strategy aims to protect and improve , the state of biodiversity in Europeby 2020 (EU,2011). Its first target is to halt the loss of biodiversity. The Birds Directive (EU, 1979; EU, 2009) and Habitats Directive (EU, 1992) are the backbone of EU biodiversity policy. A goal of the Biodiversity Strategy is reaching a favourable conservation status of all habitats and species of European importance and adequate populations of naturally occurring wild bird species. The goal of the Biodiversity Strategy for 2020 is that the assessments of species and habitats protected by the EU nature law must show better conservation or a secure status for 100 % more habitats and 50 % more species. The percentage protected areas of an ecosystem (especially the Natura2000 areas), indicates the percentage of area where the Netherlands has an obligation to halt biodiversity loss and to restore nature to reach a favourable conservation status.

The coverage of the Natura2000 areas (the Habitat Directive and the Bird Directive) is largest in the sea and in rivers and streams, 96.5% respectively 89.8% of the water area is protected by either the Bird Directive, the Habitat Directive or both (Table 3.2.1). About 75% of Dutch heath is protected within Natura2000. About 40% of the coniferous and mixed forests are designated as Natura2000 area, while only 14% of the deciduous forests is designated as Natura2000 area. Of the semi-natural grasslands, 23% of the area is protected within the NNN (Natuur netwerk Nederland, formerly named EHS) and outside Natura2000 areas (another 10% is within a Natura2000 area). In general, a large percentage of the (semi)natural areas is protected.

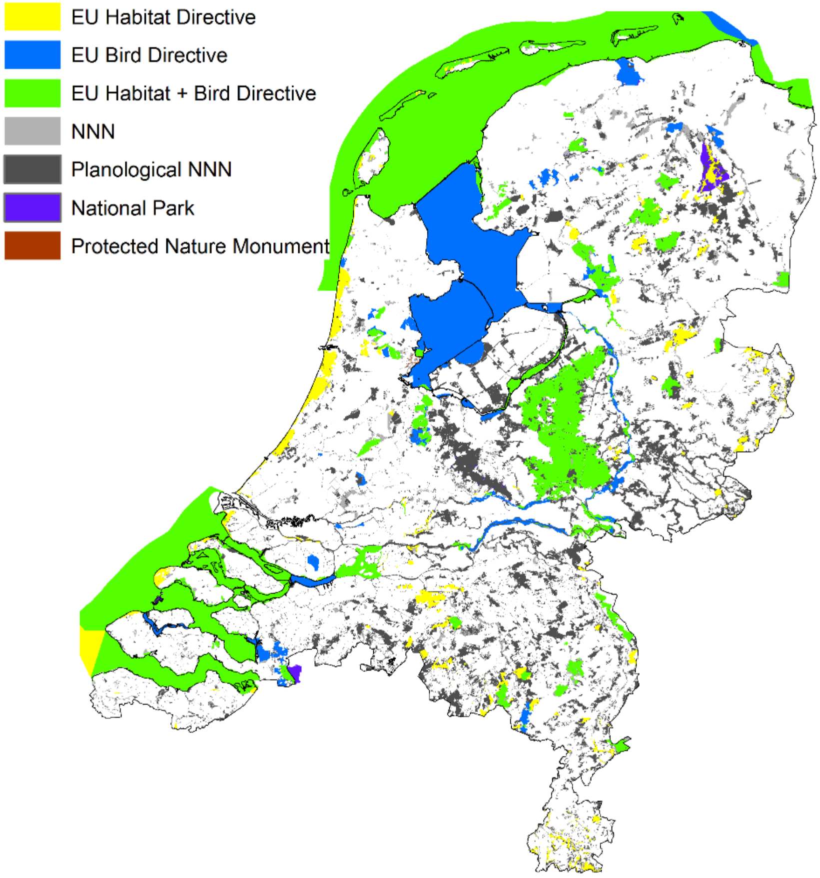


Figure 3.2.1 Protected areas in the Netherlands.

Table 3.2.1 Overview of percentage protected area per forest, heath, grassland, crop and water ecosystem type. Where, NNN denotes Nature Network Netherlands, Natura2000 is the combined area of the Habitats and Birds Directive and BNM, denotes Protected Nature Monument.

	Deciduous forest	Coniferous forest	Mixed forest	Heath	Agricultural grassland	semi-natural grassland	Annual crop	Perennial crop	Sea	Lakes and ponds	Rivers and streams
Habitats Directive	5.6	6.6	5.2	12.8	0.6	7.2	0.2	0.5	2.1	1.9	0.1
Birds Directive	0.7	2.5	1.1	1.4	1	6.4	0.1	0.1	1.7	8.8	64.4
Habitats and Birds Directive	8	35	32.1	61	0.8	10.1	0.2	2.4	92.7	10.6	25.2
NNN, excl. Natura2000	1.8	0.1	0.3	0.9	4.2	23	1.3	1	0	2.6	0.2
Total protected	17.7	48.7	43	80.6	6.9	47.7	2.2	4.4	96.5	24.8	90.1
Of which:											
NNN, total	2.4	0.1	0.3	1.5	5.5	32.8	1.5	1.2	0	4.1	0.7
National Park, total	4.8	13.8	11.4	24.9	0.6	6.2	0.4	1.1	1	6.4	13
PNM, total	0.5	0.3	0.4	2.1	0	0.3	0	0.1	0	0.3	0
National Park, excl. Natura2000 and NNN	1.7	4.4	4.3	4.6	0.3	1	0.3	0.4	0	0.7	0.1
PNM, excl. Natura2000 and NNN	0.5	0.3	0.4	2.1	0	0.2	0	0.1	0	0.3	0
Total without protection	82.3	51.3	57	19.4	93.1	52.3	97.8	95.6	3.5	75.2	9.9
Of which:											
Planned NNN, excl. above	45.2	48.6	50.2	17.6	5.8	36.9	3	8.1	0	21.5	4.3

3.2.2 Living Planet Index (LPI)

The Living Planet Index (LPI) is a well-known and much-used biodiversity indicator, originally developed by WWF and ZSL to track the development of global population sizes of vertebrate species, from 1970 onwards. A national application of this indicator was developed by Statistics Netherlands: the LPI for the Netherlands reflects the average population trend for 361 land and freshwater animal species, from 1990-present (Statistics Netherlands et al., 2018 a). It is based on the population size of practically all native species of breeding birds, reptiles, amphibians, butterflies and dragonflies, as well as a significant part of the mammals and freshwater fish. Hence, the national application includes invertebrate as well as vertebrate species, as opposed to the global LPI. However, marine species are excluded for statistical reasons, although separate marine indicators are available. We present the LPI for the Netherlands in total and per ecosystem type, as these are more closely linked to ecosystem condition. It should be noted though that the division into ecosystem units used for the calculation of the LPI is not the same as used for the ecosystem units within the system used here. For example, for the calculation of the LPI in forest, all forests were taken together (by selection species typical for forests only). The strengths and limitations of the LPI and other methods shown here are discussed in more detail in the Biodiversity Account (forthcoming).

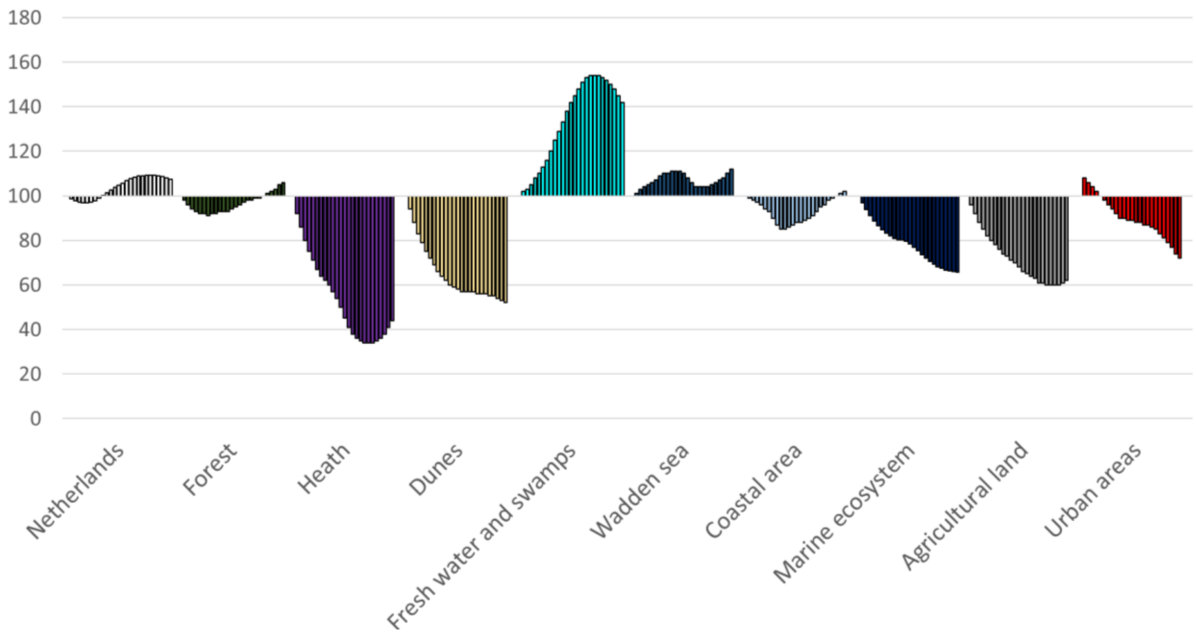


Figure 3.2.2 Trends (1990-2015) in the Living Planet Index, by species group, in the Netherlands (index 1990=100).

There is a moderate to strong reduction in the LPI of urban areas, marine ecosystem, agricultural land, dunes and heath. The deterioration of many characteristic animal species of dunes is related to the increase in grass and shrubs in the dunes and reduction of active dunes. The causes of this deterioration are the fixation of the dune landscape and the high nitrogen deposition. High nitrogen deposition is also an important factor in the deterioration of heath (see §4.1 Eutrophication). High nitrogen deposition accelerates the succession from heath land to grasses and shrubs and eventually into forest. Between 1990 and 2015 the LPI in coastal areas, Wadden Sea, forests, and the Netherlands in total fluctuated around the reference value of 1990. The LPI of fresh water and swamps showed a strong increase (Figure 3.2.2). The recovery of populations of characteristic species of fresh water and swamps that have occurred after a long period of decline is mainly due to improved water quality of the fresh waters thanks to national and international environmental policy (see §3.4 Water quality). However, even though there has been an increase relative to 1990, the overall quality of freshwater wetlands is still not sufficient (Statistics Netherlands et al., 2018 b).

3.2.3 Ecosystem quality – trend in characteristic and target species

The indicator "ecosystem quality" uses the trend in the degree of occurrence of characteristic and target species as a proxy for the mean quality of forest, heath, marsh, open dune and semi-natural grassland (Statistics Netherlands et al., 2017 d). It relates the representation of the current quality to a relatively intact ecosystem, i.e. an ecosystem that is not affected by eutrophication, desiccation, acidification, or fragmentation. The characteristic and target species are a set of target species as described in Bal et al. (2001) supplemented with characteristic species with available data. In total, for all five ecosystems combined, 457 species from four groups (breeding birds, butterflies, reptiles and vascular plants are included. The mean for all these species is presented in "terrestrial nature". For each characteristic species a degree of occurrence is determined. When a species is more abundant than the reference value for an intact ecosystem, the index is set at the maximum of 100%. In this way, a species that is more abundant does not compensate for species with lower abundance. Data on population size is derived from data collected by the national measuring networks in the Network Ecological Monitoring (NEM) for mammals, breeding birds, reptiles and butterflies. Yearly indices are derived with Poisson regression on the data.

From the measurements of a set of characteristic and target species, it appears that from 1994 the average quality of terrestrial nature in the Netherlands has decreased. In recent years, this decline has stagnated and the quality is even increasing again (Figure 3.2.3). This stagnation, and slight increase is mainly caused by the stagnation and slight increase in quality in marshes and semi-natural grasslands. In forests, heath land and dunes there is still a decline in quality (Figure 3.2.3).

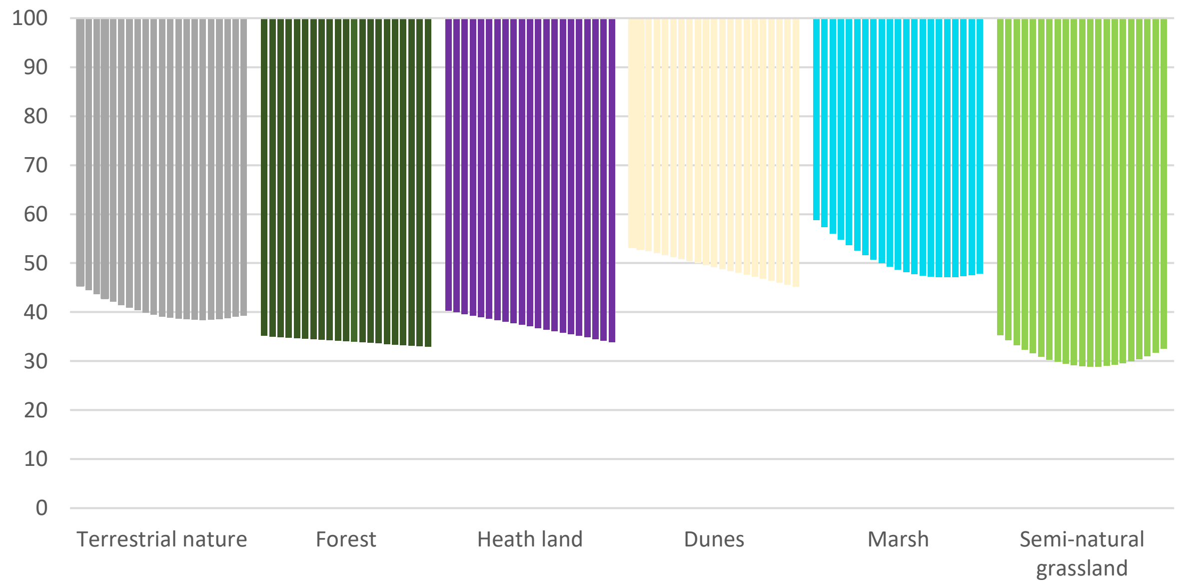


Figure 3.2.3 Indices of characteristic species and target species averaged per ecosystem. The quality of ecosystems is measured relative to an intact ecosystem (Index=100) (data: Statistics Netherlands et al., 2017 d). A higher value, depicted by a shorter bar, indicates a better quality.

Figure 3.2.3 shows that the ecosystem quality of terrestrial nature is lower than would be the case for an intact ecosystem (index = 100). An intact ecosystem is an ecosystem that is not affected by pressures such as eutrophication and fragmentation. The current mean ecosystem quality of terrestrial nature is approximately 40%.

3.2.4 Conservation status protected habitats

Article 17 of the Habitats Directive requires EU Member States to report the conservation status of habitat types and species every six years. For a habitat type to be considered to have a Favourable Conservation Status the directive requires its structure and functions to be favourable and its "typical species" to be at Favourable Conservation Status (ETC/BD, 2014). The method used to define indicators of structure and function and to score and combine these into a final assessment are left to the individual Member States. In the Netherlands, the conservation status is assessed using four parameters. For habitat types these are "range", |"area covered by habitat type within the range", specific structure and functions including typical species", and "future prospects". These parameters are combined into a final assessment of the conservation status of a particular habitat type for the relevant reporting period, using a traffic light system (Bijlsma and Janssen, 2014)
In the Netherlands, the conservation status of habitats is assessed as excellent ("A"), good ("B"), or average or reduced ("C"). Then, for each habitat, the surface areas assessed as "A", "B" and "C" are summed over the sites. In the Netherlands we use the following rules to assess the conservation status of the habitat as favourable (FV, green), unfavourable/inadequate (U1, orange), unfavourable/bad (U2, red) (see below).

	Excellent (A)	Good (B)	Average/reduced (C)
Favourable, FV	>75% A		<15% C
Unfavourable/bad, U2	A < (B + C)		>25% C
Unfavourable/inadequate, U1		Other combinations of A, B and C	

The conservation status of "typical species" of the habitats are assessed based on the Red List. The Dutch definitions (profiles) of habitat types make a distinction between exclusive and characteristic typical species on the one hand and constant typical species on the other. The former group comprises species whose ecological demands are met exclusively or mainly in the habitat type concerned, while constant typical species are not restricted to a particular habitat type, but are indicative of a favourable abiotic condition and biotic structure. All typical species were therefore used for the Article 17 reporting. The Dutch Red Lists distinguish six categories, based on combinations of rarity and trend: "Regionally extinct", "Critically endangered", "Endangered", "Vulnerable", "Near threatened" and"Least concern". The conservation status is linked to these categories for each typical species. The percentages of species that are indicative of FV (%FV), U1 (%U1) and U2 (%U2) for each habitat type have been used to assess the conservation status of typical species, using the same rules as for the assessment of structure and function (see below).

	'FV' "Least concern"	'U1' "Vulnerable" and "Near threatened"	'U2' "Regionally extinct", "Critically endangered" and "Endangered"
Favourable, FV	>75% '%FV'		<15% '%U2'
Unfavourable/bad, U2	'%FV' < ('%U1' + '%U2')		>25% '%U2'
Unfavourable/inadequate, U1		Other combinations of A, B and C	

The indicator for structure and function and the indicator for typical species are then combined in one indicator as shown on the next page.

	FV 'species'	U1 'species'	U2 'species'
FV 'structure and function'	F1	U1	U2
U1 'structure and function'	U1	U1	U2
U2 'structure and function'	U2	U2	U2

The structure and function of heath habitat types in the Netherlands is generally unfavourable/bad, U2 (Table 3.2.3). The only exception is habitat H2320 ("Binnenlandse kraaiheibegroeiingen") the structure and function of this habitat type is assessed at unfavourable/inadequate (U1). The structure and function of (semi) natural grasslands is also generally unfavourable/bad, except for habitat H6430 ("Ruigten en zomen").

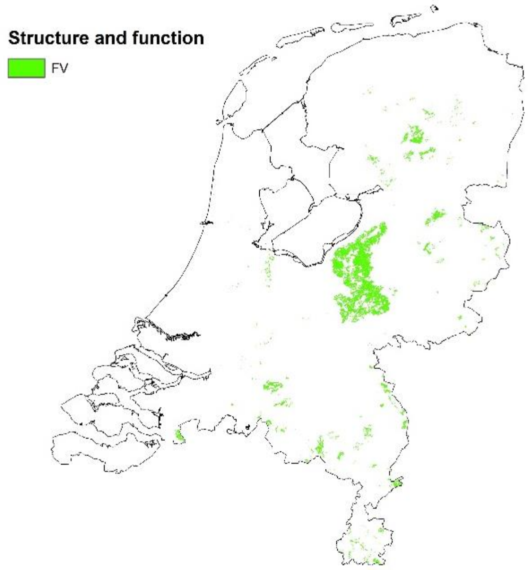
The structure and function of forests in the Netherlands is better, 87% of forests protected by the Habitat Directive is of good condition (Table 3.2.2) and is therefore assessed as unfavourable/inadequate (U1). Only habitats with >75% of the area in excellent condition are marked as favourable. Appendix 3.5.4 shows that the structure and function of habitats and the presence of typical species represent two different aspects of habitat condition and therefore not always show the same picture. Only when both aspects (structure and function, and typical species) are assessed at favourable (FV) the overall conservation status is favourable, this is only the case for habitats *Fagus* woodlands (H9120, "Beuken-eikenbossen met hulst) and old oak forests (H9190).

Table 3.2.2 Structure and function of protected forests, (semi)-natural grasslands and heath habitats in the Netherlands. Based on "structure and function" per habitat type 2013 (Bijlsma and Janssen, 2014). Percentage protected denotes which percentage of the total areal of the ecosystem type is protected by the Habitat Directive. The status of the remaining area is not reported.

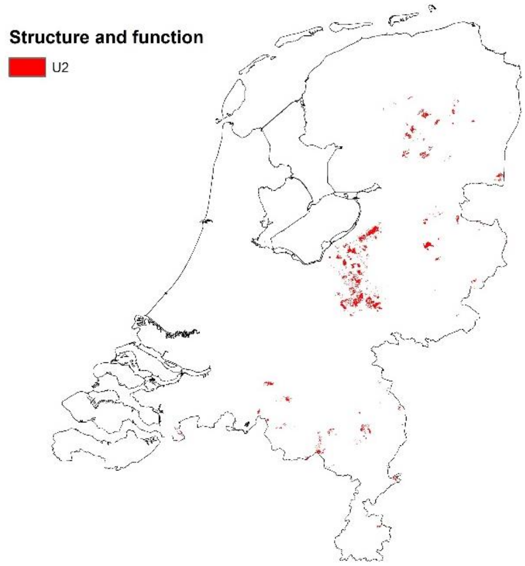
	Percentage protected	Habitat types	Excellent (ha)	Good (ha)	Average (ha)	Excelent (%)	Good (%)	Average (%)	Assessment structure and function
Forest	5.7	H9110, H9120, H9160, H9190, H91D0, H91E0, H91F0	12,138	1,771	2,228	75.2	11.0	13.8	FV
Semi-natural grassland	7.2	H6120, H6130, H6210, H6230, H6410, H6430, H6510	1,071	485	329	56.8	25.7	17.4	U1
Heath	12.8	H2310, H2320, H4010, H4030	5,515	2,375	13,386	25.9	11.2	62.9	U2
Fresh water wetlands	9.8	H7110, H7120, H7140, H7150, H7210, H7220, H7230	3,194	2,005	1,510	47.6	29.9	22.5	U1
Dunes	52.7	H2110, H2120, H2130, H2140, H2150, H2160, H2170, H2180, H2190	15,775	14,137	9,186	40.3	36.2	23.5	U1

Figure 3.2.4 (next page) Structure and function in protected Habitat Directive areas, per ecosystem type; a) forests, b) heathland, c) dunes, d) freshwater wetlands and e) semi-natural grasslands dunes, and f) for all above mentioned ecosystem types combined.

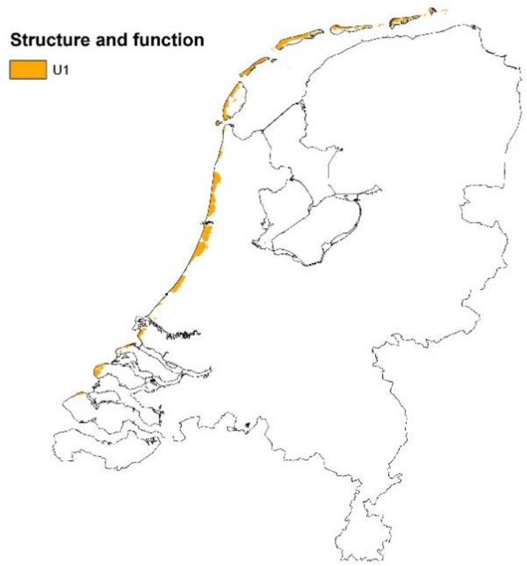
a) Forest



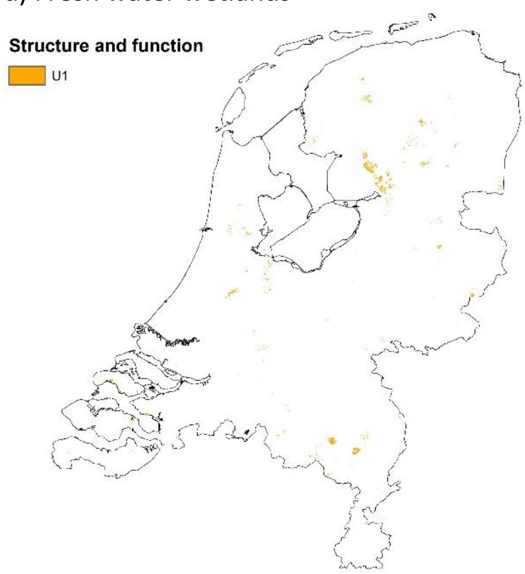
b) Heathland



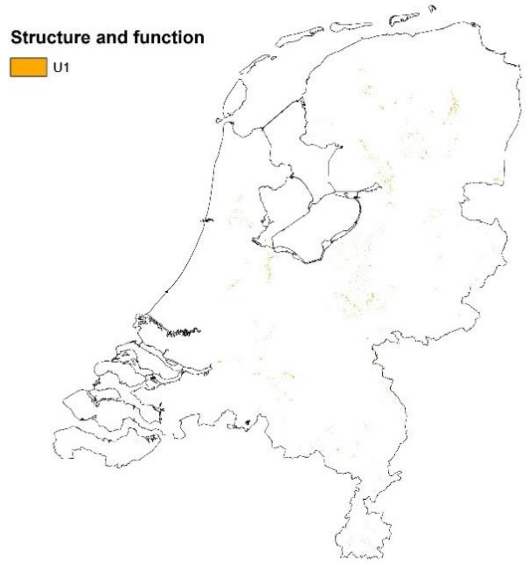
c) Dunes



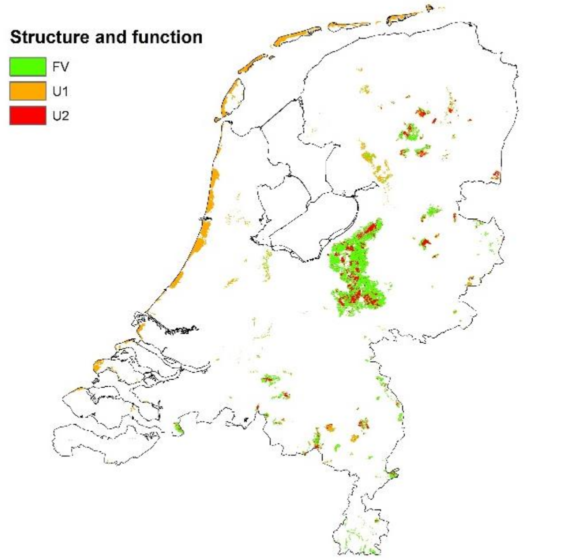
d) Fresh water wetlands



e) Semi-natural grasslands



f) Forest, heath, dunes, wetlands, SN grasslands



3.3 Soil

Soil quality can be defined as the continued capacity of the soil to function as a vital ecosystem that sustains plants, animals and humans. Soil quality is related to many ecosystem services, including provisioning services like agriculture and timber and regulating services like water filtering and carbon sequestration. Soil quality depends on both inherent and dynamic soil properties. Inherent soil properties include lithology, soil type and texture, and are static. They do provide the constraints and opportunities, but, because of its static nature, it is beyond reach for management. Therefore, inherent soil properties fall outside the scope for this ecosystem condition account. Dynamic soil properties include: physical properties (like water holding capacity, soil structure and crust formation); chemical properties (like pH, fertility and nutrient content); and biological properties (like organic matter content, earthworm activity and microbial activity). To characterize soil condition, we include the biological property soil organic matter, the physical property water holding capacity and the chemical property soil fertility.

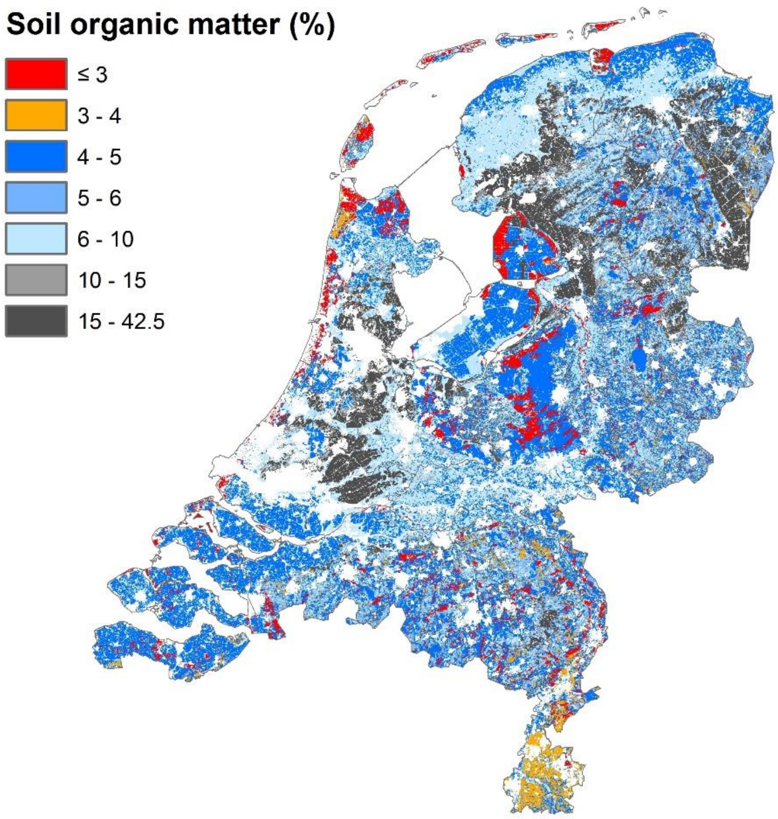


Figure 3.3.1 Soil organic matter content of the top 30 cm of the soil, in %. Based on Conijn and Lesschen (2015).

3.3.1 Soil Organic Matter

Soil organic matter (SOM) is the organic matter content of soil and consists, among others, of plant and animal material at various stages of decomposition. In general, SOM has a positive effect on soil fertility and plant productivity through the release of nutrients when SOM is decomposed and through the adsorption of nutrients which prevents leaching into surface and ground waters (Conijn and Lesschen, 2015). SOM also improves the soil structure and reduces soil loss by erosion. SOM increases water infiltration and water retention. The exact lower threshold for the positive effects of SOM is not known. It is assumed that SOM content higher 3% already has a positive effect on soil quality (Conijn and Lesschen, 2015). Approximately, 6 % of the soils in the Netherlands have a soil organic matter content less than 3 % (Figure 3.3.1). On the other hand, 44% of the soils in the Netherlands have a soil organic matter content higher than 6%.

Soil organic matter is mostly influenced by the soil type. Soil organic matter is highest in peat and peaty soils (Figure 3.3.2). In Chapter 6 the mean soil organic content per ecosystem is discussed.

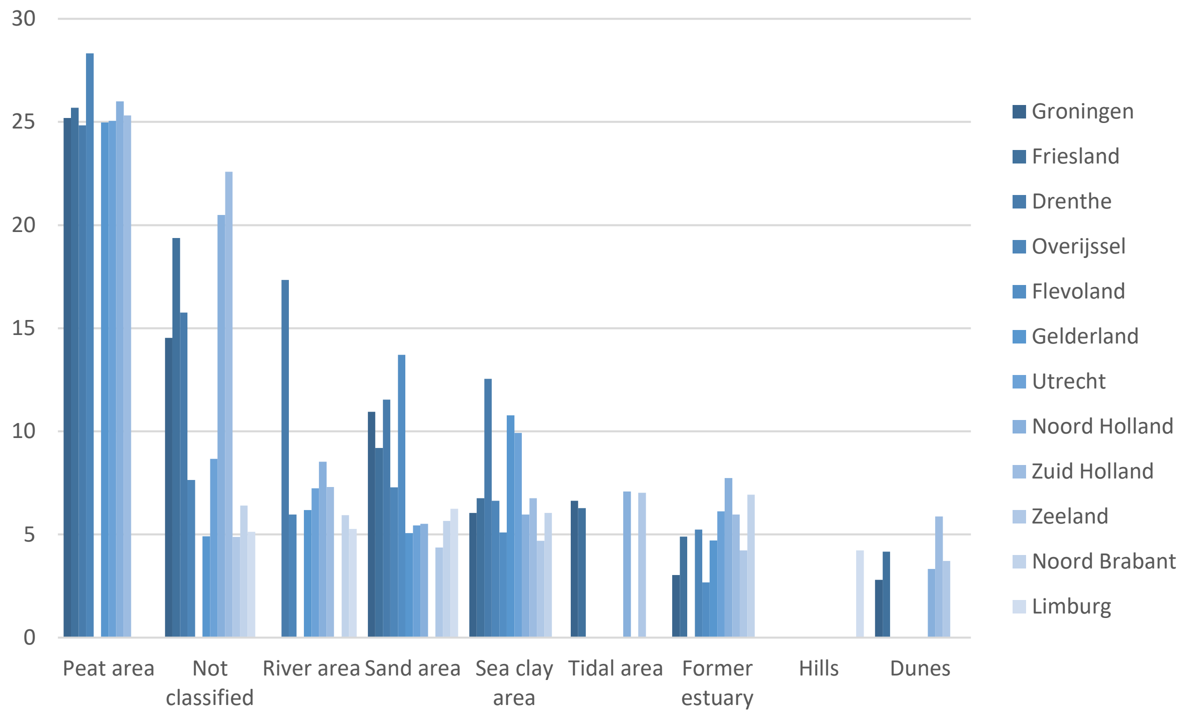


Figure 3.3.2 Soil organic matter content in %, depicted per province of the Netherlands and subdivided per physical geographic region.

3.4 Water

3.4.1 Water quality (Water Framework Directive)

The status of European surface water bodies and ground water bodies are assessed following the methodology of the European Water Framework Directive (EU, 2000). The two most important quality aspects are the ecological quality and the chemical quality. The chemical quality is determined based on 45 substances (of which 33 priority substances). The ecological quality is assessed based on four quality indicators that determine the biological quality and indicators for general physical-chemical quality and environmental quality (i.e. assessed based on river basin specific pollutants). To aggregate the indicators the European legislature chose to adopt the one-out, all-out rule whereby overall classification is defined by the lowest observed individual quality element.

The indicator biological quality is determined based on four metrics: one for phytoplankton, one for macro fauna, one for water plants and one for fish. In the Netherlands most water bodies are artificial or strongly altered. It was possible to set a lower goal for those water bodies (i.e. a Good Ecological Potential (GEP)). This is mostly done for the metrics macro fauna and fish, but less often for the metrics phytoplankton and water plants.

The indicator for ecological quality is determined based on four indicators: the above-mentioned indicator for biological quality, an indicator for physical-chemical quality, an indicator for other relevant polluting substances and a fourth indicator for hydro morphology that is required for a “very good” condition. This last indicator is not used yet in the Netherlands, therefore, the best possible condition for the ecological quality is “good”. The ecological quality is primarily determined by the biological quality. If the biological quality is “good”, then the indicators for physicochemical quality and other polluting substances are considered to distinguish between a “good” or “moderate” ecological condition. The physicochemical indicator is determined based on the assessment of the parameters nitrogen, phosphor, temperature, oxygen, acidity and chloride. The other polluting substances consist of a group of approximately 100 substances, that are specific for a certain catchment area. The thresholds for most of these substances are never exceeded, only a few substances sometimes exceed the threshold.

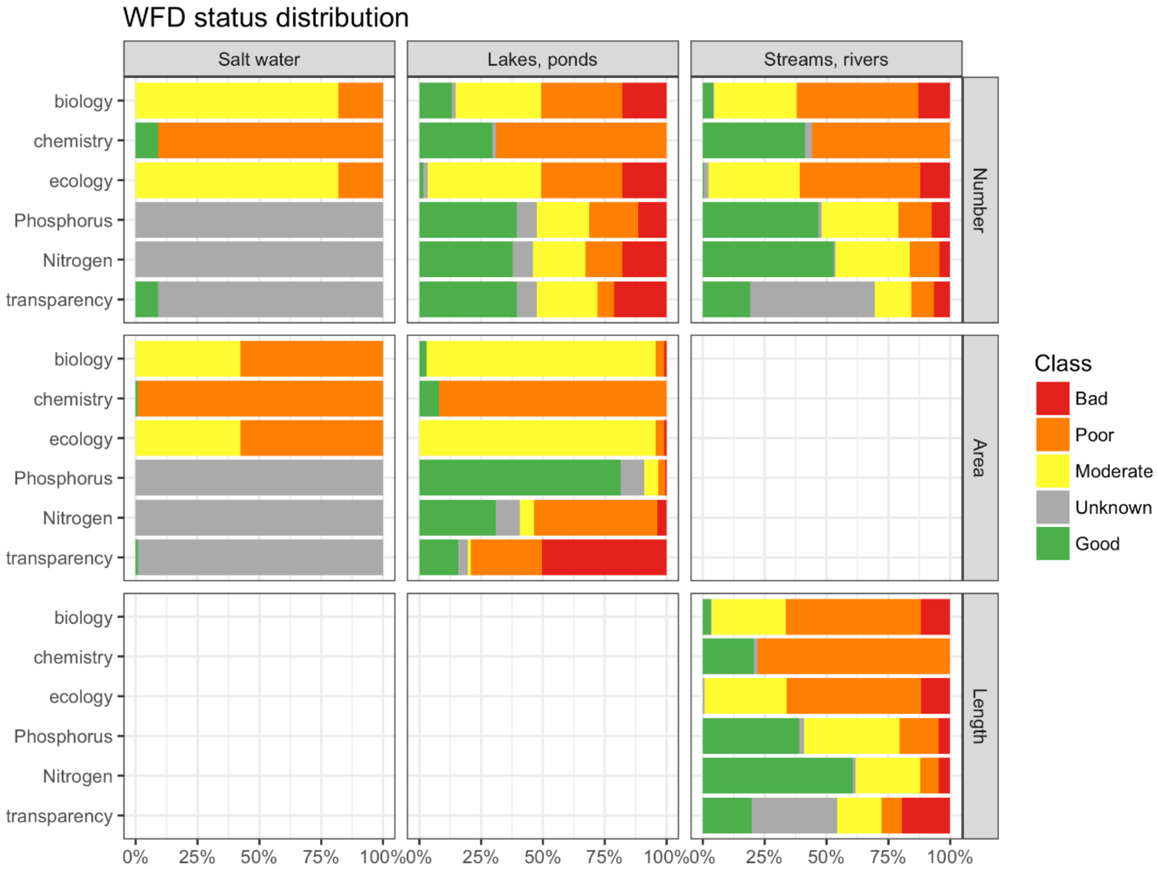


Figure 3.4.1 Percentage of area of open water bodies in the Netherlands with bad (red), poor (orange), moderate (yellow), good (green), very good (blue) biological status, chemical status and ecological status, and three parameters of the physicochemical status: total phosphorus, total nitrogen and transparency. Depicted per water body or water course (top row), based on area of the water bodies (middle row) and based on length of the water courses (bottom row).

The chemical quality is mostly poor (Figures 3.4.1 and 3.4.2). In about a quarter of the water bodies the concentrations of cadmium, mercury, tributyltin or polycyclic aromatic hydrocarbons is too high and in these water bodies the chemical quality does not suffice (van Puijenbroek, 2014).
The ecological quality is mainly determined by the biological quality. Mere 0.0% of area of water bodies and 0.1% of the length of water courses in the Netherlands have a good ecological condition (Figure 3.4.1). The remaining area are in moderate (61.6% of the area of water bodies, 33.2% of the length of water courses), poor (38.0 % of the area of water bodies, 54.6% of the length of water courses) or bad condition (0.4% of area of water bodies and 11.6% of the length of water courses).
The chemical quality is good in 3.5% of area of open water and in 20.6% of the length of the water courses in the Netherlands and poor in the remaining 96.5% area of the open water and 78.1% of the length of streams and rivers (Figure 3.4.1).

However, the total number of lakes and ponds with good status of total Phosphorus, total Nitrogen and transparency is approximately equal (about 37%). The total area of lakes and ponds with a good total Phosphorus status is much higher than the total area of lakes and ponds with a good status for transparency (about 85% versus about 15%). In general, the status of the three physicochemical parameters; total phosphorus, total nitrogen and transparency, is better than for ecology quality (which is based on a combination of biology, physicochemical and river basin specific pollutants).

3.5 Air

Clean air is a basic requirement of human health and well-being (WHO, 2006). Air pollution continues to pose a significant threat to health and the environment. Air quality affects people, that live, work, commute, recreate or otherwise spend time outside. In Europe, emissions of many air pollutants have decreased substantially over the past decades. However, air pollutant concentrations are still too high. Therefore, air quality problems persist, especially in cities where exceedances of air quality standards for ozone, nitrogen dioxide and particulate matter (PM) pollution pose serious health risks (EEA, 2008). Long-term and peak exposures to these pollutants range in severity of impact, from impairing the respiratory system to premature death (EEA, 2008). For example, fine particulate matter ($PM_{2.5}$) in air has been estimated to reduce life expectancy in the EU by more than eight months (EEA, 2008). European Union policy on air quality aims to develop and implement appropriate instruments to improve air quality with the goal to reduce the health impacts of air pollution in Europe (EU, 2008).

3.5.1 Air pollution

The EU Air Quality Directive (EU, 2008) has set limit values for air quality (Table 3.5.1). Under EU law a limit value is legally binding from the date it enters into force subject to any exceedances permitted by the legislation. To offer guidance in reducing health impacts of air pollution the World Health Organisation has provided air quality guidelines (WHO, 2006). In contrast to the limit values set by the EU, the WHO guidelines are not legally binding.

Figure 3.4.2 (next page) Water quality indicators Water Framework Directive for Dutch surface water in 2015. Top row: biological status, chemical status, and ecology status; bottom row three physicochemical indicators: transparency, total phosphorus and total nitrogen. Based on data provided by "Informatiehuis Water" and "de waterbeheerders van Nederland" (Waterkwaliteitsportaal, 2017)

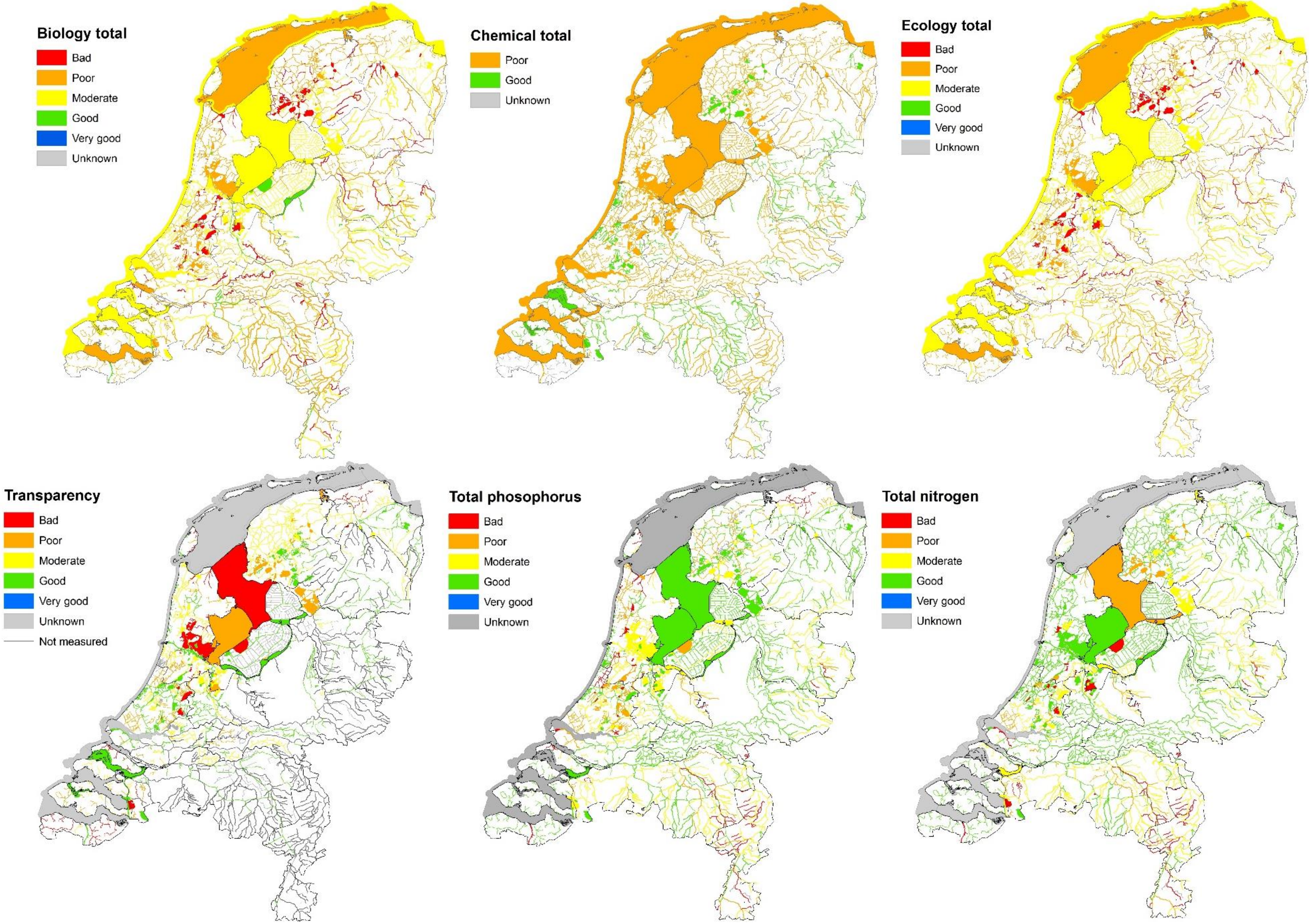

Biology total
Bad
Poor
Moderate
Good
Very good
Unknown
Chemical total
Poor
Good
Unknown
Ecology total
Bad
Poor
Moderate
Good
Very good
Unknown
Transparency
Bad
Poor
Moderate
Good
Very good
Unknown
Not measured
Total phosophorus
Bad
Poor
Moderate
Good
Very good
Unknown
Total nitrogen
Bad
Poor
Moderate
Good
Very good
Unknown

Table 3.5.1 Overview of EU and WHO air quality thresholds for $PM_{2.5}$, PM_{10} and NO_2

		EU Air Quality Directive		WHO Guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Permitted exceedances each year	Concentration	Comments
$PM_{2.5}$	24 hours			25 µg/m^3	99th percentile (3 days/year)
$PM_{2.5}$	1 year	Limit value, 25 µg/m^3	n/a	10 µg/m^3	
$PM_{2.5}$	3 years	Limit average exposure*, 20 µg/m^3	n/a		
PM_{10}	24 hours	Limit value, 50 µg/m^3	35		99th percentile (3 days/year)
PM_{10}	1 year	Limit value, 40 µg/m^3	n/a	20 µg/m^3	
NO_2	24 hours	Limit value, 200 µg/m^3	18	200 µg/m^3	
NO_2	1 year	Limit value, 40 µg/m^3	n/a	40 µg/m^3	

*Legally binding in 2015 (based on the years 2013, 2014 and 2015).

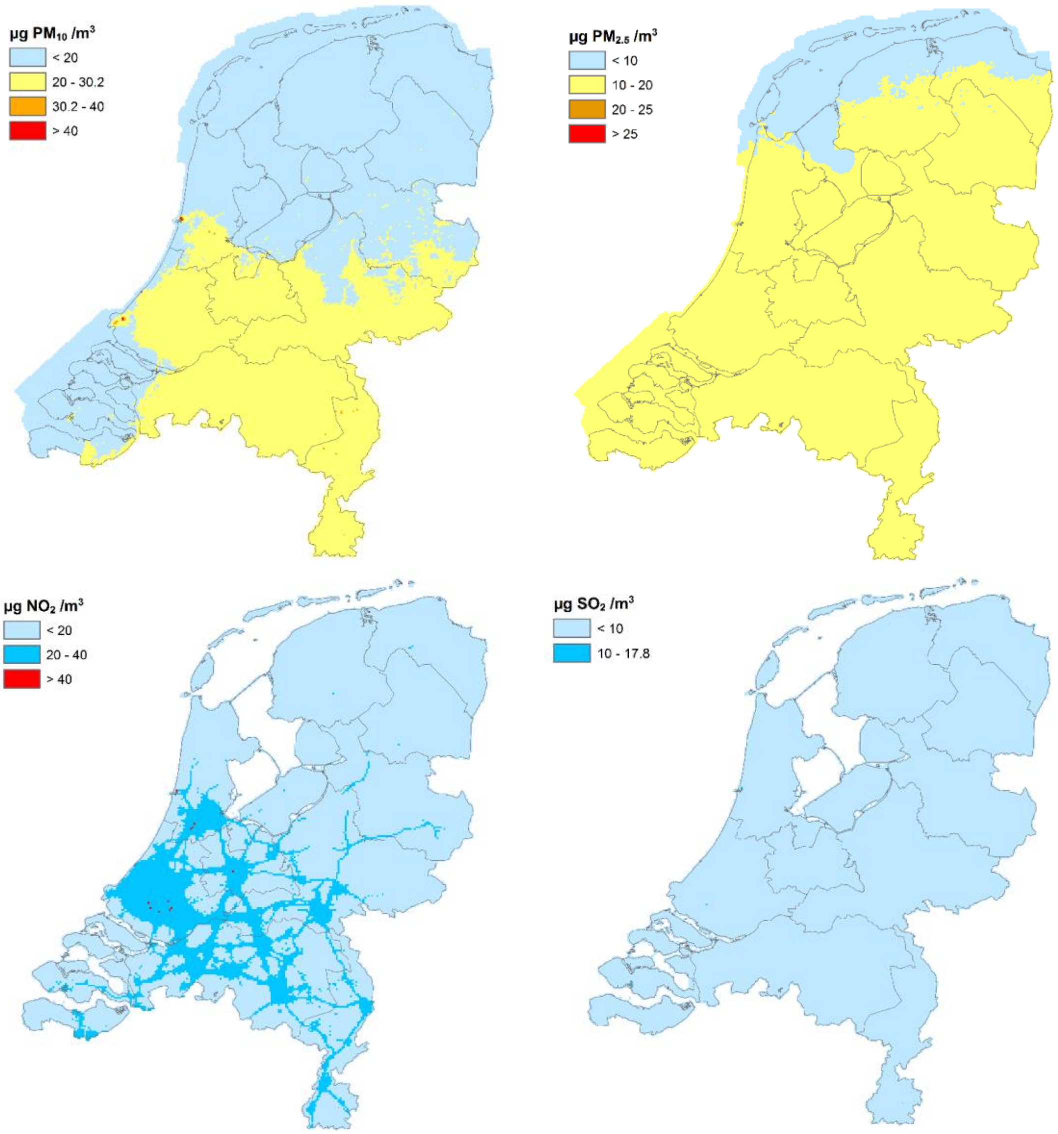


Figure 4.3.1 Yearly mean concentration in 2013 of a) PM10, b) PM2.5, c) NO2 and d) SO2 (data: RIVM, 2016 a). Blue indicates concentrations below WHO annual threshold value, red indicates concentrations above EU annual limit value. Yellow (and orange) are concentrations higher the WHO annual threshold but lower than the EU annual limit value.

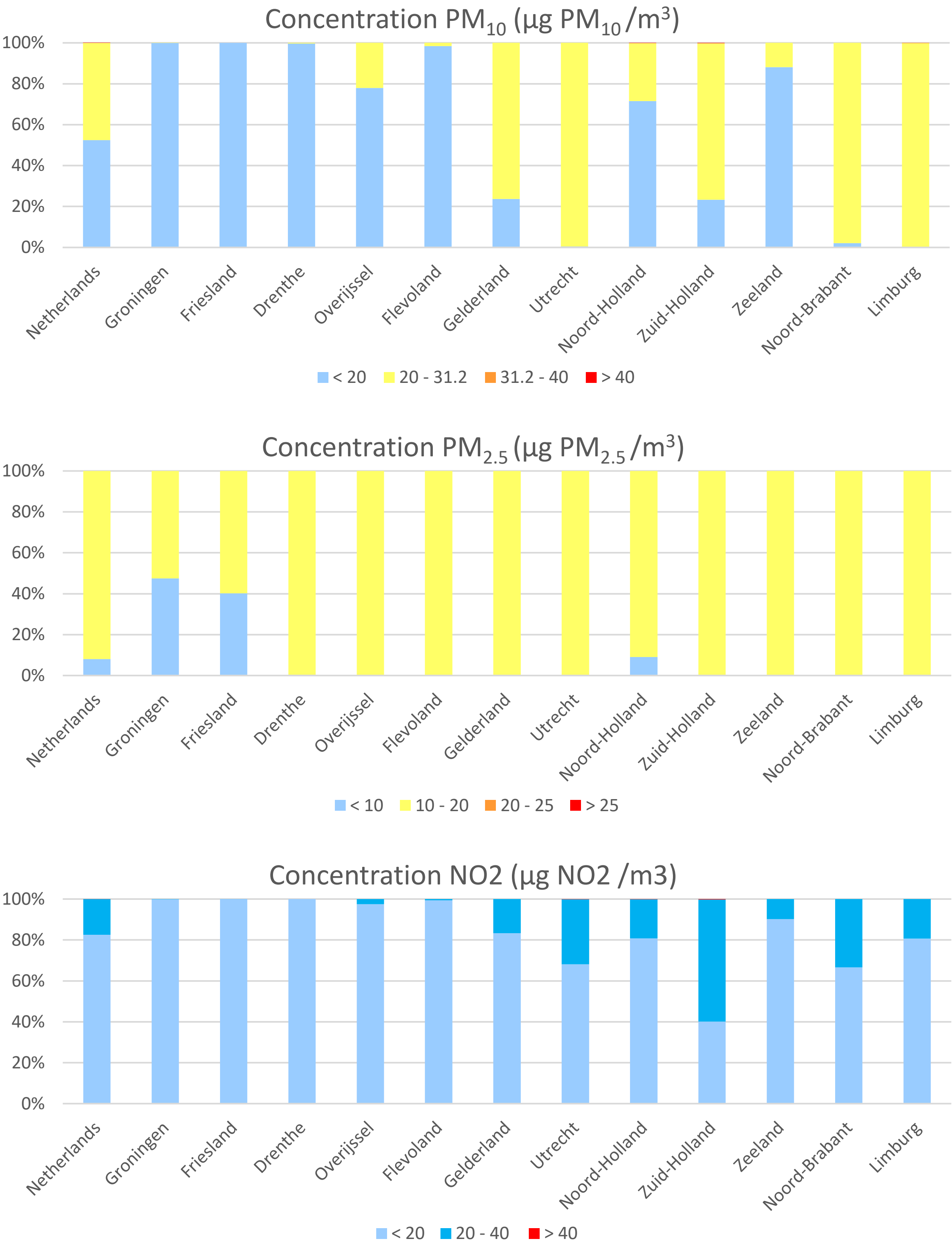
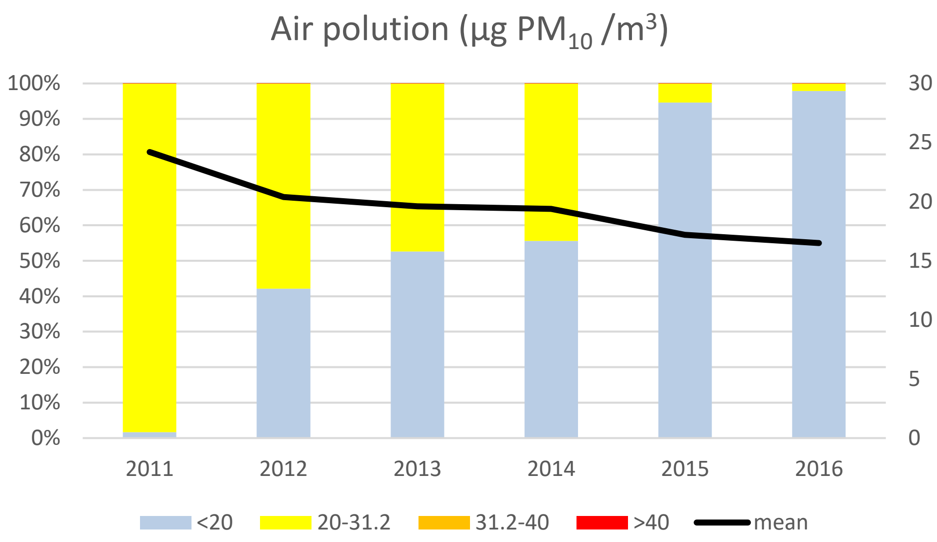


Figure 4.3.2 Yearly mean concentration in 2013 of a) PM10, b) PM2.5 and c) NO2 per province. Depicted is the percentage of area per range of concentrations. Ranges are based on threshold values from the EU and WHO. Blue indicates concentrations below WHO annual threshold value, red indicates concentrations above EU annual limit value. Yellow (and orange) are concentrations higher the WHO annual threshold but lower than the EU annual limit value.



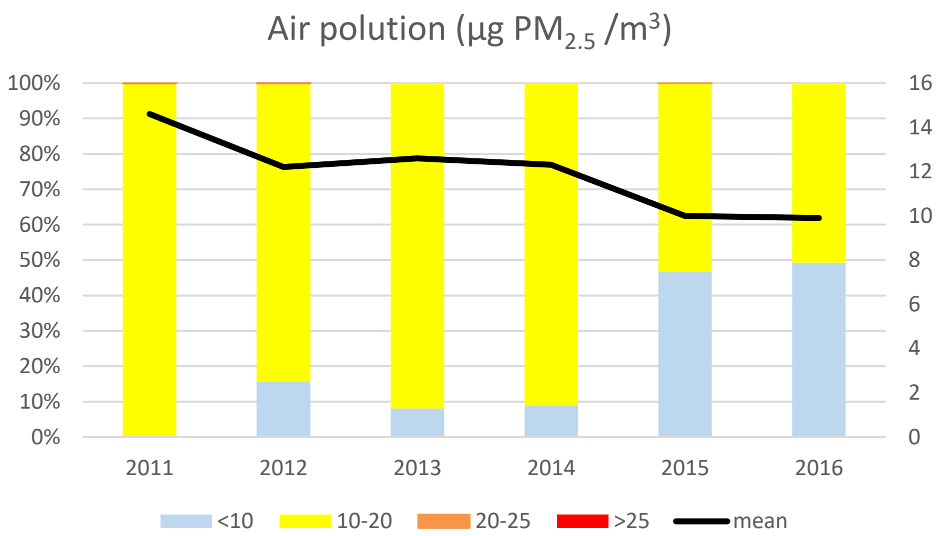


Figure 4.3.3 Trend in particulate matter concentration, a) PM_{10} and b) $PM_{2.5}$ in the air between 2011 and 2016 (based on data: RIVM, 2016 a). The bars depict the percentage of area per range of concentrations and the black line depicts the mean concentration (plotted at the axis at the right-hand side). Ranges are based on EU limit and WHO threshold values for PM_{10}, respectively $PM_{2.5}$ concentrations. Blue indicates concentrations below WHO annual threshold value, red indicates concentrations above EU annual limit value. Yellow (and orange) are concentrations higher the WHO annual threshold but lower than the EU annual limit value.

RIVM publishes annual mean values of among others $PM_{2.5}$, PM_{10}, NO_2 and SO_2. Therefore, we use the annual EU limit values and WHO thresholds. For PM_{10} we furthermore use 31.2 μg/m^3 as an annual threshold value that is calculated as a proxy for the daily limit value when translated into an annual mean (EEA, 2014; Statistics Netherlands et al, 2017 a,b,c).

The air pollution in 2013 was lower than the EU limit value for yearly average concentration in ≥99.9% of the area. However, in 2013 it is above the limit value for PM_{10} and NO_2 in a few locations in Zuid Holland, Noord Holland, Limburg and Utrecht (Figure 3.5.1). In 2013, the concentration of PM_{10} was lower than the stringent WHO threshold in 52.5% of the Dutch land area, while for $PM_{2.5}$ the WHO threshold was met in 8% of the land area (Figure 3.5.2). Between 2011 and 2016, the air has become cleaner, both the yearly mean PM_{10} and yearly mean $PM_{2.5}$ concentration reduced with 32%, from 24.2 to 16.5 µg PM_{10}/m^3, respectively from 14.6 to 9.9 µg $PM_{2.5}/m^3$ (Figure 3.5.3).

4 Pressure indicators

Ongoing human population growth, intensification of agricultural activities, economic growth, international traffic are drivers that exert pressure on the natural environment and climate. The state of the environment (e.g. ecosystem condition) is closely linked with the exerted pressures. There is, however, a conceptual difference between pressures and ecosystem condition. Indicators for ecosystem condition show whether there is something wrong with the quality of the environment , while pressure indicators show why something is wrong. An increase in pressure indicators is usually negatively related to ecosystem condition. For instance, eutrophication and acidification (by airborne pollutants emitted by industry, farms and traffic) affect nutrient availability and thereby can change species composition in favour of fast growing and at the expense of the characteristic species for poor soils, this results in a decrease in local biodiversity. This can potentially influence the ecosystem services provided. For instance, when a heathland is overgrown with fast growing grasses, it can be perceived less attractive for cultural services, like hiking, or biking.

Given the strong causal relation between pressures and ecosystem condition, pressures can be used as indicators to approximate condition in cases where indicators for ecosystem condition are not available. For instance, the pressure indicators eutrophication and acidification can give additional information on soil condition. However, not necessarily show the actual state of the soil, as ecosystem resilience or buffering capacities of the soil are not taken into account. Furthermore, ecosystems usually don’t react immediately to changes in pressures but can have quite a response time both to increase in pressures as to reduction in pressures. For instance, historical pollution or enrichment of soils can influence soil condition that can remain long after the pressure has ended.

In this chapter, indicators for pressures on ecosystems are presented.

4.1 Eutrophication

Nitrogen is an important nutrient for trees and plants. However, an excess of nitrogen has negative effects on species that are adapted to naturally poor soils (for instance heath). Plant species that thrive on poor soil are then outcompeted by fast-growing species that need more nitrogen, such as grasses and nettles. Change in soil condition thus can affect the natural species composition of the vegetation. Generally, a limited number of plant species increase at the expense of several others, as a result biodiversity decreases. Not only of the plant community, but also of the animal community that depend on these nature types. Most animals need a varied landscape, with suitable places for feeding, breeding, and sheltering. If variation in the landscape reduces because large areas are dominated by the same vegetation, the sensitive species can disappear. Furthermore, high nitrogen deposition can cause growth disturbances in trees and other plants because high nitrogen content in the soil can affect the absorption of other nutrients such as potassium and magnesium.
The law ammonia and animal husbandry (“*Wet Ammoniak en Veehouderij*”) uses the following definition for sensitivity of vegetation for eutrophication; based on three sensitivity classes of

vegetation for critical deposition levels of nitrogen (van Dobben and Hinsberg, 2008; van Dobben et al., 2012):

- Very sensitive vegetation: < 1400 mol N /ha/yr
- Sensitive vegetation: 1400 – 2400 mol N /ha/yr
- Less/not sensitive vegetation: > 2400 mol N /ha/yr

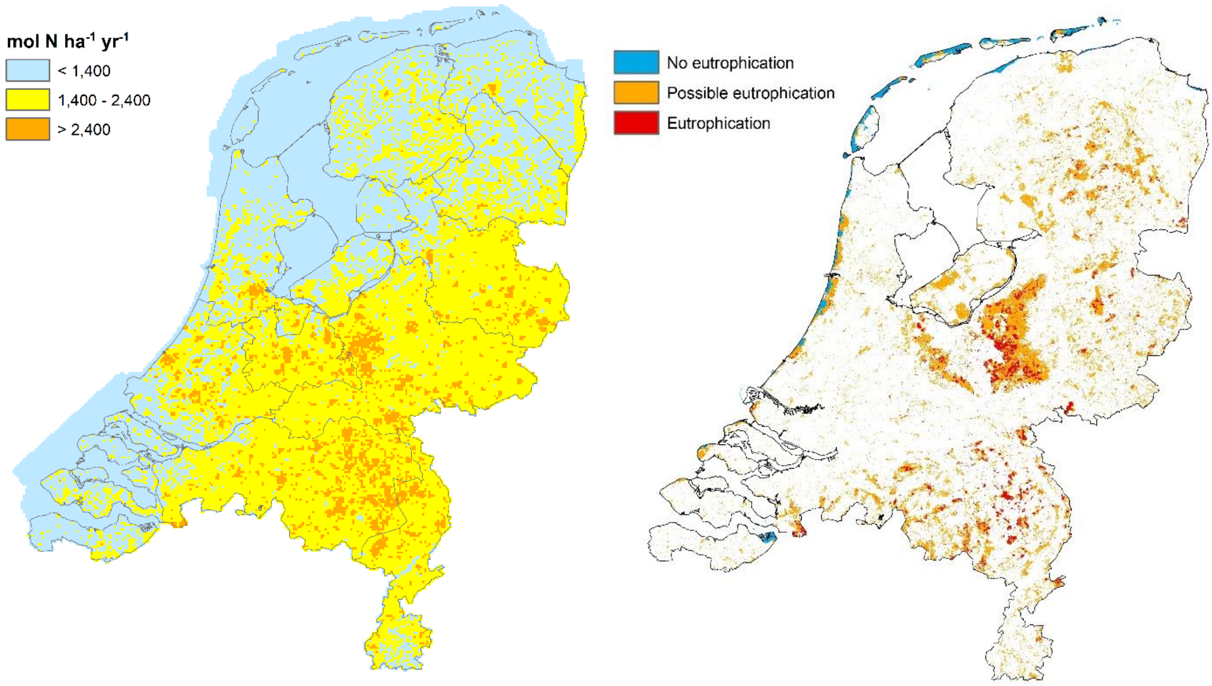
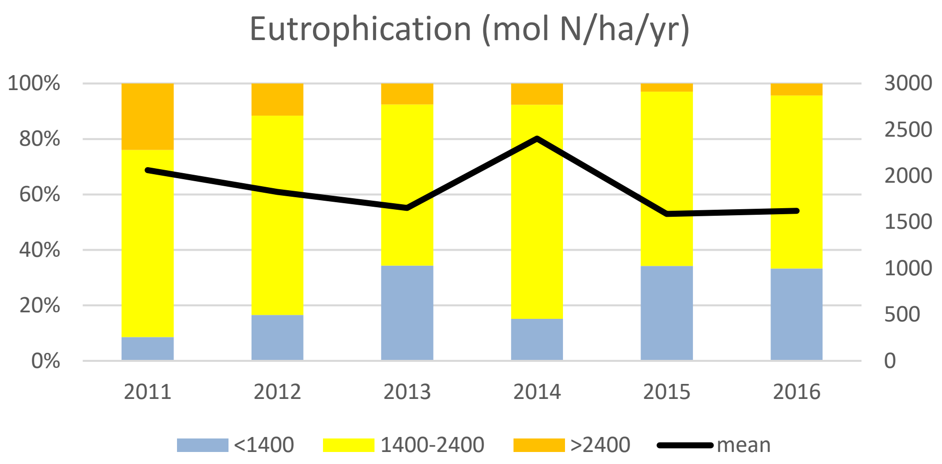


Figure 4.1.1 a) Nitrogen deposition in the Netherlands (data: RIVM, 2016a), b) possible eutrophication based on critical deposition in forests, dunes, heath, inland sand, freshwater wetlands, natural grasslands and salt marshes; "no effect" denotes areas with deposition lower than the lower threshold, "possible eutrophication" denote areas with deposition higher than the lower threshold, but lower than the upper threshold, "eutrophication" denotes areas with deposition higher than the upper threshold (see Table 4.1.1 for thresholds for eutrophication).

In 2013, the nitrogen deposition was higher than the lower critical deposition level in >99.5 % of the area of heath, sand, freshwater wetlands, and natural grasslands and in almost 70% of the vegetated dunes. Most of these are ecosystems situated on naturally poor soils. Eutrophication favors fast-growing at the expense of the characteristic species for poor soils, this result in a decrease in local biodiversity.

The Netherlands has committed itself to maintaining the biodiversity of designated natural areas (Natura 2000, Bird and Habitat Directive, VHR). Even though there is a reduction in nitrogen deposition between 2011 and 2016 (particularly in the period from 2011 to 2013 (Figure 4.1.2a)), nitrogen most likely will remain one of the most important limiting factor for biodiversity in the Netherlands for some time (WallisDeVries and Bobbink, 2017).



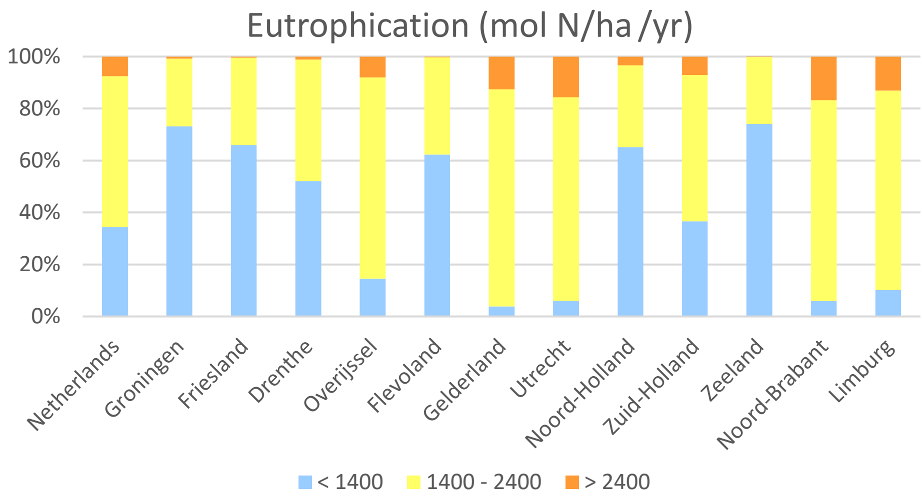


Figure 4.1.2 Nitrogen deposition in the Netherlands a) in the period 2011 – 2016, b) per province in 2013. Depicted is the percentage of area per range of deposition values. Ranges are based on the above mentioned broad three classes of critical deposition levels of vegetation types that differ in sensitivity to eutrophication.

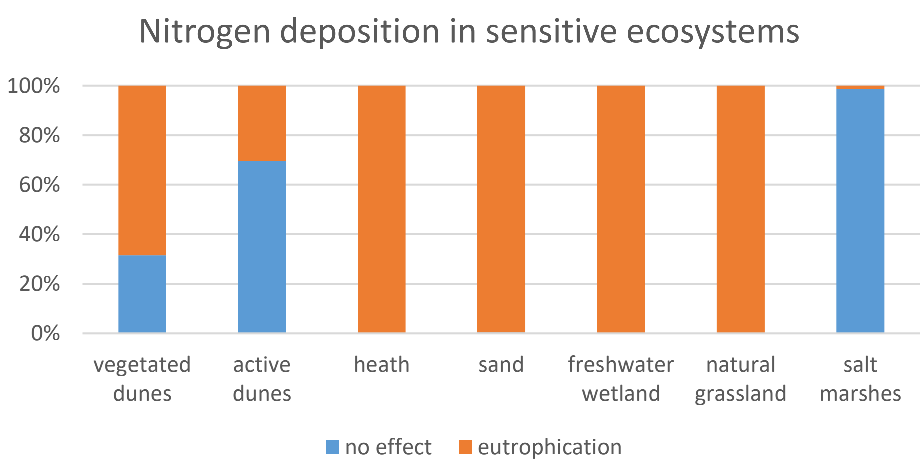


Figure 4.1.3 Nitrogen deposition in ecosystems that are (very) sensitive for eutrophication in 2013. Percentage of area with no-effect is based on the lowest critical deposition level for a subtype of the ecosystem (Table 4.1.1, based on van Dobben et al. (2012))

Table 4.1.1 Critical deposition levels for sensitive ecosystems in mol N /ha/yr. Based on subtypes of that ecosystems that are described in van Dobben et al. (2012)

Sensitive ecosystem type	Lower limit critical load	Upper limit critical load
Forest	1,071	2,429
Dunes with permanent vegetation	1,071	2,214
Active dunes	1,071	1,429
Heath	786	1,214
Inland sand	714	714
Freshwater wetland	500	1,571
Natural grassland	714	> 2,400
Salt marshes	1,571	1,643

4.2 Acidification

Acidification of soils and water is a result of emission of airborne pollutants by industry, farms, power plants and traffic. The emission is a mixture of sulfur dioxide (SO2), nitric oxide (NO), nitrogen dioxide (NO2), ammonia (NH3) and volatile organic compounds (VOC). These acidifying substances end up in the soil via air or water. Substances in the soil, like lime, specific minerals, humus, aluminum and iron oxide can buffer the effect of acids. This buffering capacity is very low in dry and low-lime areas, these are the areas where the vegetation is most vulnerable. In these areas excessive deposition of acid leads to a change in species composition in vegetation and a decline in biodiversity, since in general more sensitive species disappear than less sensitive species appear.
Also in soils with naturally high buffer capacity, there is a maximum. When that maximum is reached the soil acidifies. However, when the soil buffers the acid deposition, it releases toxic metals (like aluminum (Al)) and nitrate, that leak into ground water or open water. At the same time, also important nutrients like potassium, calcium, and magnesium leak away and are not available for trees and plants anymore. Shortage on important nutrients makes trees and plant more vulnerable for diseases, storm damage and drought. Furthermore, dissolved aluminum particles can damage the very fine roots of plants. In agriculture, the use of lime can mitigate the effects of acidifying deposition.
The risks and effects of acidification (and eutrophication) are assessed based on critical deposition levels or critical loads. This is the maximum permissible amount of atmospheric deposition whereby, according to current scientific knowledge, negative effects on the structure and functions of ecosystems do not occur (Statistics Netherlands et al., 2013). Below or at the critical deposition level it assumed that there is no damage at all. Critical deposition levels differ per ecosystem type. The critical deposition levels that are used by CLO are based on critical-load functions that translate no-effect levels for nitrogen to maximum permissible levels of sulfur and nitrogen deposition (van Dobben & Hinsberg, 2008). The following critical deposition levels were used (Statistics Netherlands et al., 2013):

- Critical deposition coniferous forest: 1650 (Al depletion), 1900 mol H^+/ha/yr
- Critical deposition broad-leafed forest: 1800 (Al depletion), 2450 mol H^+/ha/yr
- Critical deposition heath: 1100-1400 mol H^+/ha/ yr
- Critical deposition dune vegetation: 1000-1500 mol H^+/ha/yr

Supplemented with critical deposition levels for grasslands (Heij and Erisman, 1997):

- Critical deposition nutrient poor acidic grasslands: 1000 - 1500 mol H^+/ha/yr

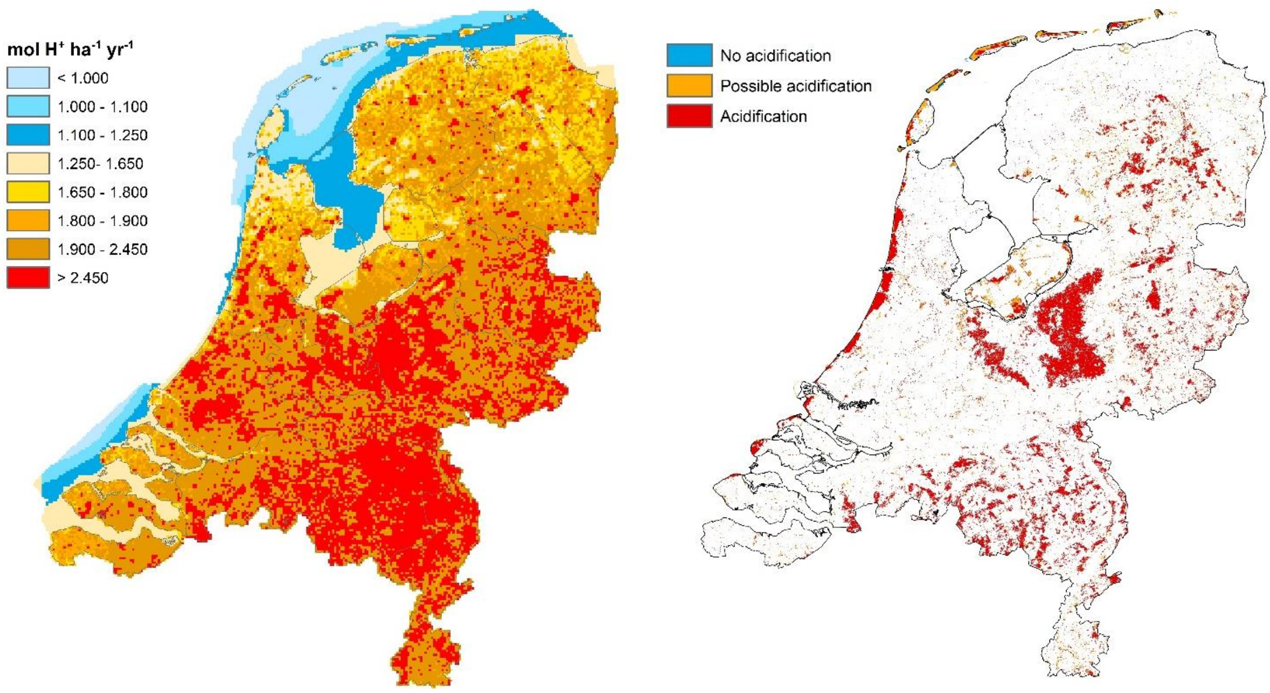


Figure 4.2.1 a) Potential acidifying deposition in the Netherlands in 2013 (data: RIVM, 2016 b) b) potential acidification in forest, heath, dunes and natural grasslands; “no effect” denotes areas with deposition lower than the lower threshold, “possible acidification” denote areas with deposition higher than the lower threshold, but lower than the upper threshold, “acidification” denotes areas with deposition higher than the upper threshold (see critical deposition levels above).

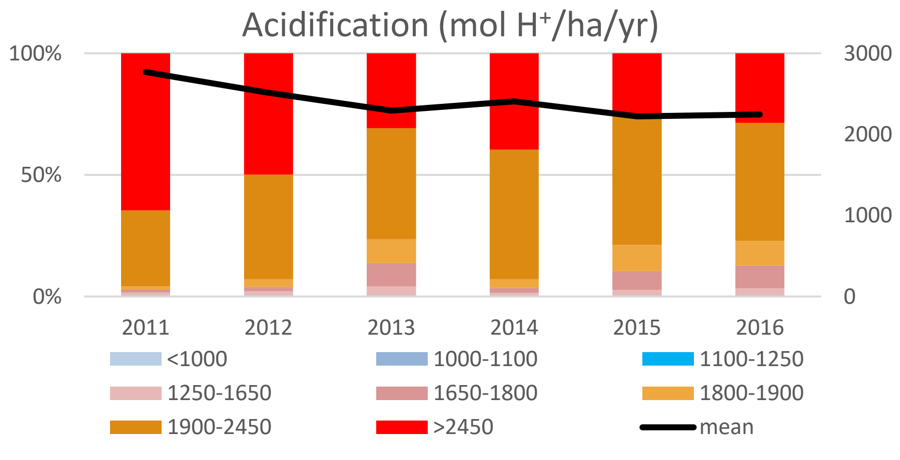


Figure 4.2.2 Trend in potential acidifying deposition in the Netherlands between 2011 and 2016. Depicted is the percentage of area per range of deposition values. Ranges are based on the critical deposition levels of the different ecosystems.

There has been reduction in the average acidifying deposition between 2011 and 2016 (Figure 4.2.2). In 2011, the acidifying deposition exceeds the upper critical deposition level (i.e. 2450 mol H^+/ha/yr for broad-leafed forests) in 65% of the total area. In 2016, this was reduced to exceedance in 29% of the area. Nevertheless, acidifying deposition is still too high for most natural ecosystems (Figure 4.2.1b), apart from broad-leafed forests. For sensitive ecosystems like heath and vegetated dunes the acidifying deposition is still well above the critical deposition level.

4.3 Drainage of organic soils

In their natural state, vegetation in peat lands capture carbon dioxide (CO_2) which is retained in the ecosystem because of a slow breakdown of organic matter. Whilst natural peat lands act as carbon sinks, agriculturally used peat lands commonly act as sources for carbon. This is related to drainage, which is required for agricultural activities. In the Netherlands, most peatlands are subject to various sorts of agricultural practices associated with drainage, resulting in oxidation of peat and release of CO_2 to the atmosphere. The degradation process reduces the thickness of peat layers. Finally, peat soils with a thin peat package can deform to another soil type. This shift of soil type has in recent decades with occurred in peatlands in the east of the Netherlands. In the period 2001-2003, Alterra checked around 103,000 ha peat soil on the status. This quick scan showed that 47% of the surface peat soils has deformed to a different soil type (Kuikman et al., 2005). Akker and co-workers (2010) calculated CO_2 emissions from subsidence of peat soils in the Netherlands based on a relationship between subsidence, ground water levels and ditch water levels. Where available we ditch water level was used as an indicator for drainage of organic soils (PBL, 2016). For the remaining areas, ground water tables were used as an indicator for drainage.

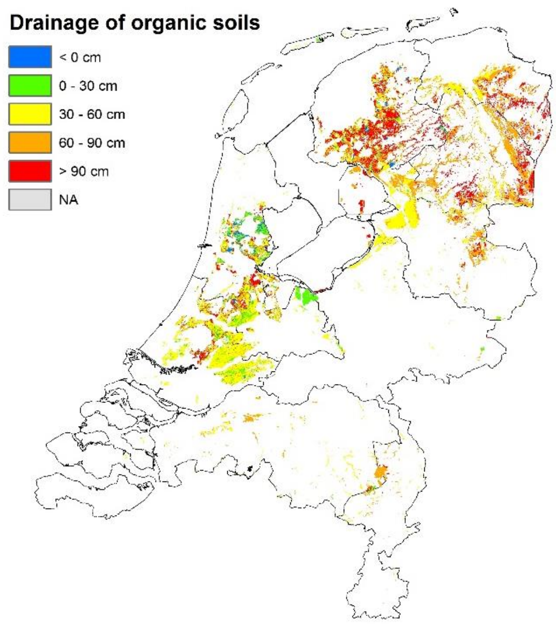
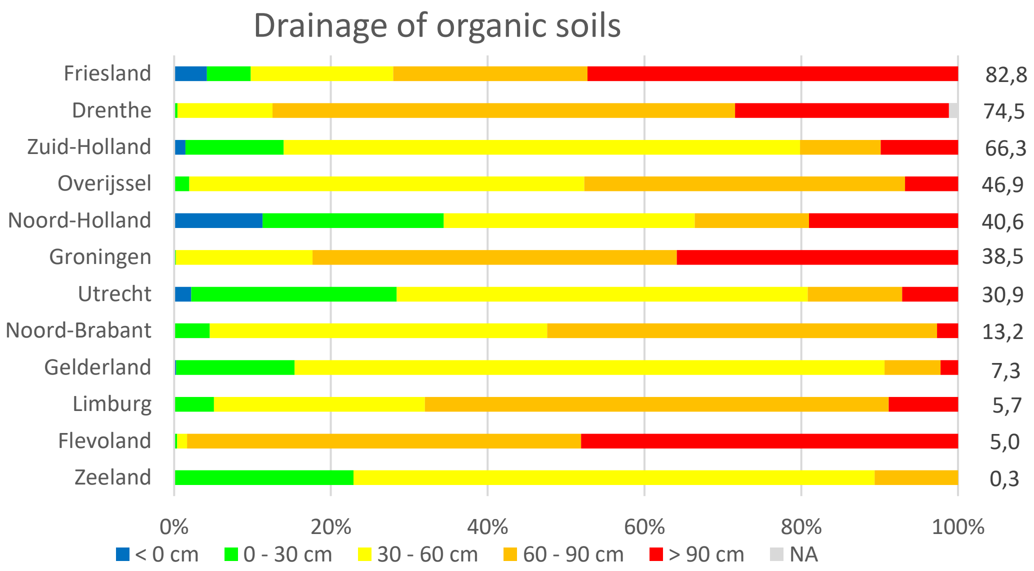


Figure 4.3.1 Drainage of organic (peat and peaty) soils in cm below ground level (Lof et al., 2017)

Friesland, Drenthe and Zuid Holland have the biggest area of organics soils, closely followed by Overijssel, Noord Holland, Groningen and Utrecht (Figures 4.3.1 and 4.3.2a). Drainage of organic soils is highest in Drenthe, Groningen and Friesland, with 86%, 82% respectively 72% of organic soils with more than 60 cm drainage (Figure 4.3.2a). In Utrecht, Zuid Holland and Noord Holland organic soils are less heavily drained, with 'only' 19%, 20% respectively 34% of the organic soils with more than 60 cm drainage (Figure 4.3.2a). Most of the organics soils are used for agricultural grassland (207,700 ha), annual crops (61,600 ha) and other unpaved terrain (29,600 ha). These soils are heavily drained, in annual crops 91 % of the organic soils are drained more than 60 cm, for other unpaved terrain and agricultural grassland 59% respectively 47% of the organic soils are drained more than 60 cm (Figure 4.3.2b). A smaller part of the organic soils is used for non-agricultural grasslands (13,400 ha), broad-leaved forests (11,300 ha) and buffer strips (10,600 ha). Organic soils that are used for non-agricultural grasslands and buffer strips are less heavily drained than grasslands with agricultural use (Figure 4.3.2b).



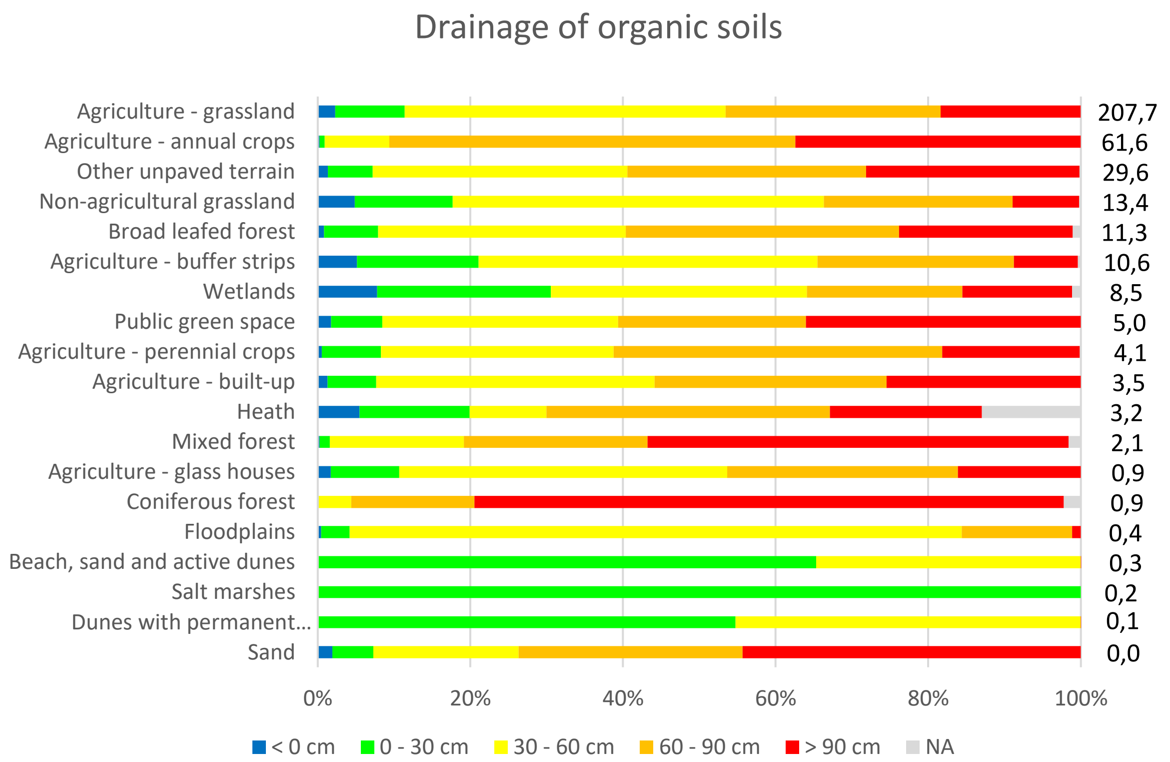


Figure 4.3.2 Drainage of organic soils in cm below ground level. Label on right hand side of the bars, indicate area of organic soil (in 1000 ha), sorted from large to small area. Bars depict the percentage of the area per drainage class; < 0cm (blue), 0-30cm (green), 30-60cm (yellow), 60-90cm (orange), >90cm (red) and not available (grey), a) per province, and b) per ecosystem type.

4.4 Urbanisation

Urban areas can have an influence on ecosystem services in semi-natural ecosystems that are situated near built-up areas. To assess urbanisation in the local landscape, we calculated the percentage paved area (urban areas, offices and business, infrastructure, greenhouses, farmyards and barns, and other paved surfaces) per square km. The value “% paved surface” is not an indicator for the percentage paved surfaces within the 10m grid of an ecosystem type, but for the local landscape in which it is situated. A high value for % paved surfaces indicates that a semi-natural ecosystem is generally situated close to paved surfaces, and thus can be expected to be influenced by urbanisation.A low value for % paved surfaces indicate that the semi-natural ecosystem is generally situated further away from built-up areas, and thus can be expected to be influenced less by urbanisation.

On average 16.5 % of the land area was covered by urban areas, offices and business, infrastructure and other paved surfaces in 2013, while this was 15.6% in 2006. Figure 4.4.2 shows that the mean percentage of paved surfaces in the local landscape of semi-natural ecosystem types generally varies between 5 and 10%. The mean percentage of paved surfaces is generally low for ecosystem types close to large open water, e.g. dunes and salt marshes. The mean percentage of paved surfaces is highest for public green spaces and other unpaved terrain. Both are ecosystem types that are closely linked to built-up areas. For instance, unpaved terrain is often situated close to roads. Figure 4.4.2 furthermore shows that heath is often situated further away from built-up areas. For almost all ecosystem types there has been an increase in the mean percentage of paved surfaces in the local landscape (Figure 4.4.2). This increase is highest for built-up areas approximately 1.2% to 1.5% (e.g. increase of paved area often takes place close to urban areas) and lowest for water bodies and courses. The strongest increase in paved surfaces was close to greenhouses (4.3% increase) (Figure 4.4.2).

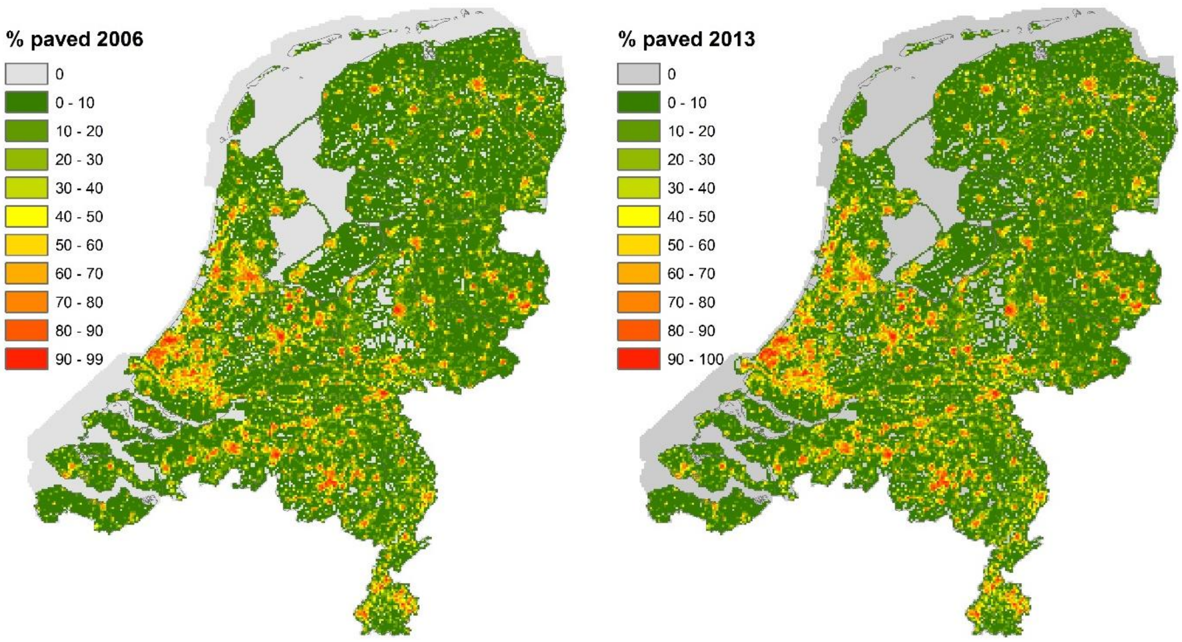


Figure 4.4.1 Percentage of paved area (i.e. residential area, offices and business, infrastructure, greenhouses, farmyards and barns, and other paved surfaces) per square kilometer in 2006 and 2013. Grey areas have no paved surfaces within the 1 km square.

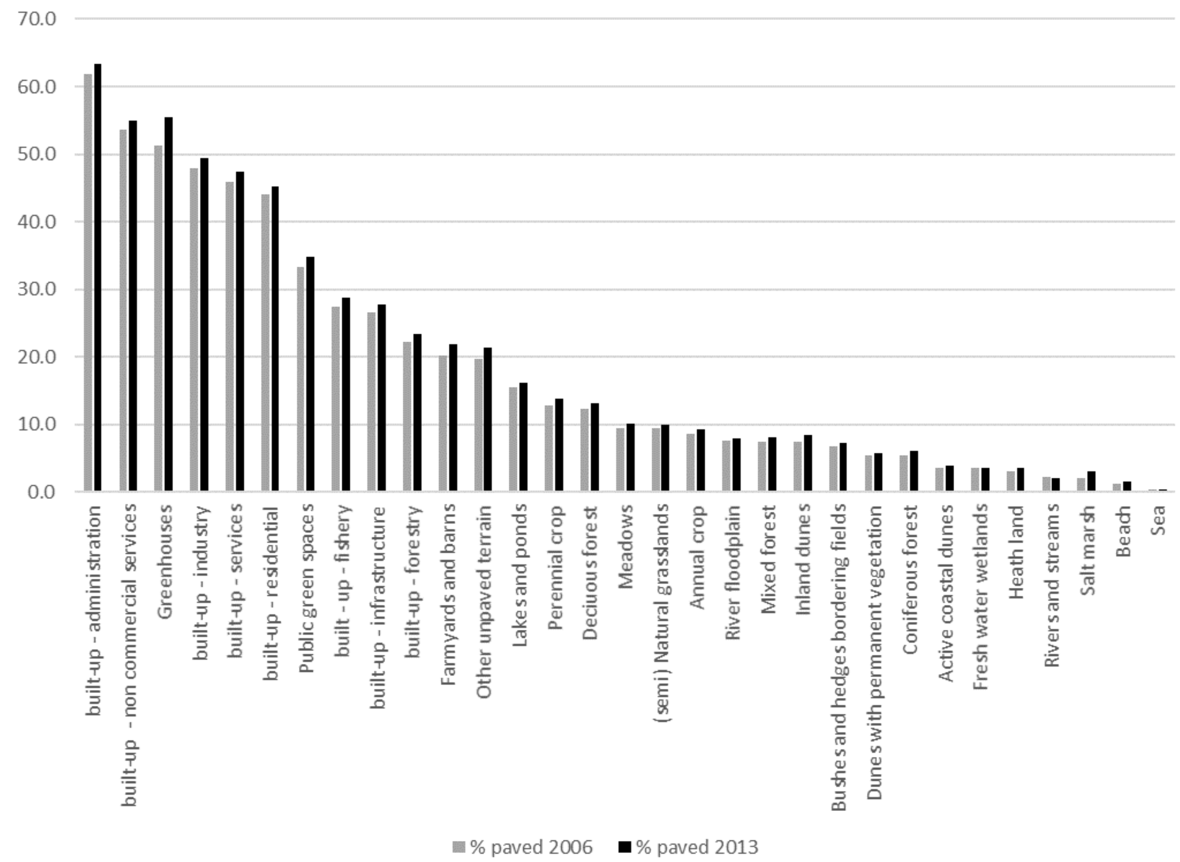
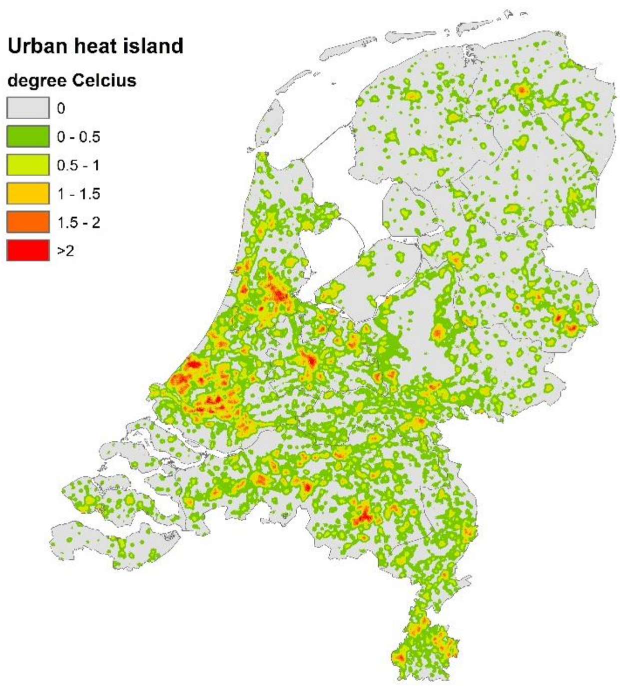


Figure 4.4.2 Mean percentage of paved surfaces per squared kilometer depicted per ecosystem type in 2006 (grey bars) and 2013 (black bars). Percentage of paved surface is based on the ecosystem type maps of 2006 and 2013, the show mean percentages are calculated based on the ecosystem types of 2006.



4.5 Urban Heat Island

During summer, temperatures in urban areas can be several degrees higher than in the rural surroundings. This phenomenon is known as the Urban Heat Island (UHI) effect. Additional heating occurs due to several factors. Urban areas contain more (dark) materials that have a higher absorption of sunlight, and a slower release of heat, such as asphalt and concrete. Furthermore, building reduce wind speeds, and soil sealing reduces natural evaporation of soils. UHIs can potentially increase the magnitude and duration of heat waves within cities. The elevated urban temperature can lead to additional heat stress or heat-related illness during hot days. Groups at risk include those suffering from cardiovascular disease, elderly people, children and pregnant women (Kovats and Hajat, 2008; Reid et al., 2009).

Public green areas can reduce the effect of urban heat islands, trees and water bodies cool down air temperature. Vegetation has a much lower heat storage capacity than stone, concrete and other building materials, which means it cannot capture as much heat during the day to release at night. Furthermore, vegetation evaporates water during photosynthesis, which increases the amount of energy going to latent heat instead of sensible heat (Oke, 1982). Trees in urban parks provide additional shading, decreasing the amount of radiation reaching the surface and lowering air and soil temperatures (Lin and Lin, 2010). In the Netherlands, a robust relation between urban greenness and reduction of the urban heat island, of about 0.6 °C for every 10% vegetated surface in the area around the measurement site, is found for various cities (Steeneveld et al., 2011; Heusinkveld et al., 2014).

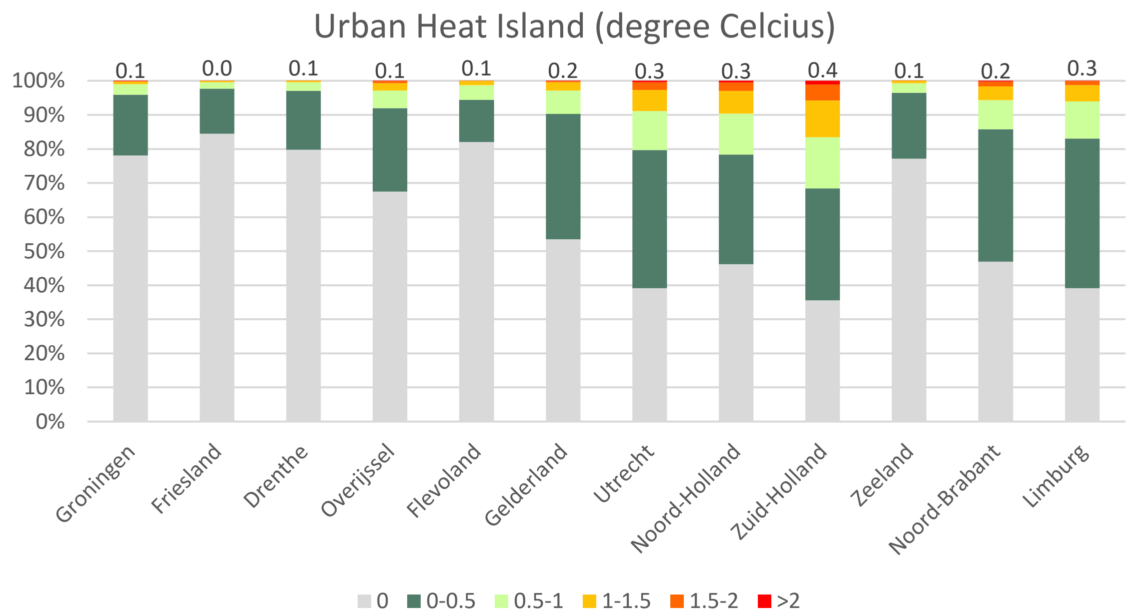


Figure 4.5.2 Urban Heat Island effect per province. Label on top of the bar denotes the mean temperature increase due to urban heat island per province (actual AHI, i.e. temperature includes effect of cooling by vegetation and water). Bars depict the percentage of the area per mean temperature increase due to UHI; 0 °C increase (grey), 0-0.5 °C increase (dark green), 0.5-1.0 °C increase (light green), 1.0-1.5 °C increase (orange), and >2 °C increase (red).

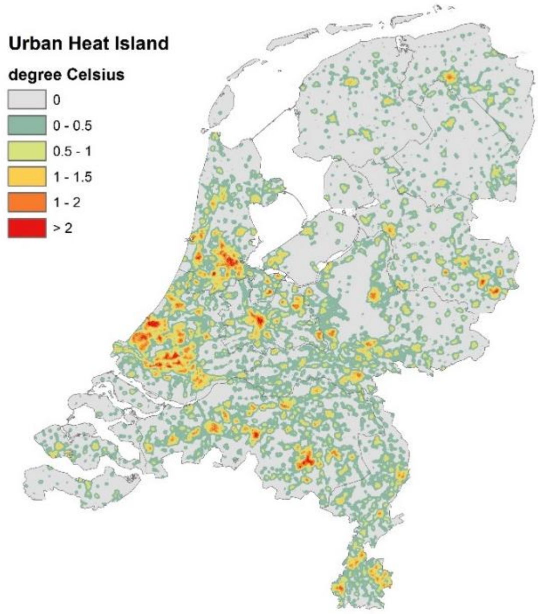


Figure 4.5.1 Urban Heat Island effect taking into account cooling by vegetation and water (Data: ANK, 2017 f).

The Urban Heat Island effect is highest in Zuid Holland (with on average 0.4 °C increase, and 1.1% of the area with > 2°C increase relative to rural areas), followed by Noord Holland, Utrecht and Limburg, with on average over the whole province respectively 0.3 °C increase (Figures 4.5.1 and 4.5.2). In these provinces only 36 – 46% of the area is not affected by the UHI. The Urban Heat Island effect is lowest in Friesland and Flevoland, with respectively 84% and 82% of the area without an increase, and on average over the whole province 0.0 °C respectively 0.1 °C increase (Figure 4.5.1).

5 The condition account, 2013

In this chapter, the results of the condition and pressure indicators are presented together, integrated in one account. Following the SEEA-EEA technical recommendations (UN et al., 2017), ecosystem condition can be described at 5 different levels of aggregation, moving from individual indicators of specific characteristics to information on relative overall condition (relative to a reference condition). The first (basic) level shows characteristics that can be measured directly. The second level is based uppon characteristics that can be compared with a known baseline, threshold or limit. The third level composite indicator that is formed by several indicators (related to the same characteristic) that are weighted together. The fourth level comprises of a composite indicator that is formed by combining indicators (within a specific ecosystem type) by comparing the indicators to the same reference condition for that ecosystem. The fifth, most aggregated, level comprises of a composite indicator that is formed by combining composite indicators from level four for all ecosystems by comparing to a single reference condition. Most of the condition indicators and pressure indicators in the current condition account are at the first basic level, for instance there are no known threshold values to characterize the temperature increase in cities due to the Urban Heat Island effect or to characterize carbon stock in biomass. For some indicators the characteristics could be compared with known thresholds (level 2). For instance, to assess the air quality limit values for air pollutants were used, and to assess eutrophication critical loads per ecosystem type for nitrogen deposition were used. The indicators for open water developed for the Water Framework Directive are at the third level where several characteristics for the same ecosystem can be aggregated. Many of the indicators for biodiversity are at the fourth level. For instance, for ecosystem quality the presence of characteristic species is compared to a reference of an intact ecosystem.

Table 5.1 presents the condition account for the Netherlands for 2013 (or a period close to 2013). The table provides a comprehensive overview of the condition of ecosystems and the pressures on ecosystems per ecosystem types, for the Netherlands in the year 2013. For example, it shows that acidification and eutrophication are two pressures that negatively affect a large percentage of Dutch heath (100% of the area is exposed to acidification and eutrophication), natural grasslands (94.4% of the area is exposed to acidification, 99.9% of the area is exposed to eutrophication) and forests (76.8% of the forests are exposed to acidification, 99.9% of the forests are exposed to eutrophication). The effect of these pressures can also be seen in the ecosystem quality only in 33.9% of the forests, 34.1% of the heath and 18.3% of the natural grasslands have a (fairly) high quality, indicating that more than 50% of the qualifying species are present. In the remaining forests, heath and natural grasslands ecosystem quality is (fairly) low. It furthermore shows that air quality (PM_{10}) is above the WHO threshold in about two-third of the urban area. In this table ecosystem types have been aggregated to only 10 ecosystem types. As the ecosystem type (ET) map (formerly the LCEU map) contains a more detailed classification of ecosystem types, data form the condition account could in principle be further disaggregated. In annex I, the different ecosystems (and their disaggregated data) are discussed in more detail.

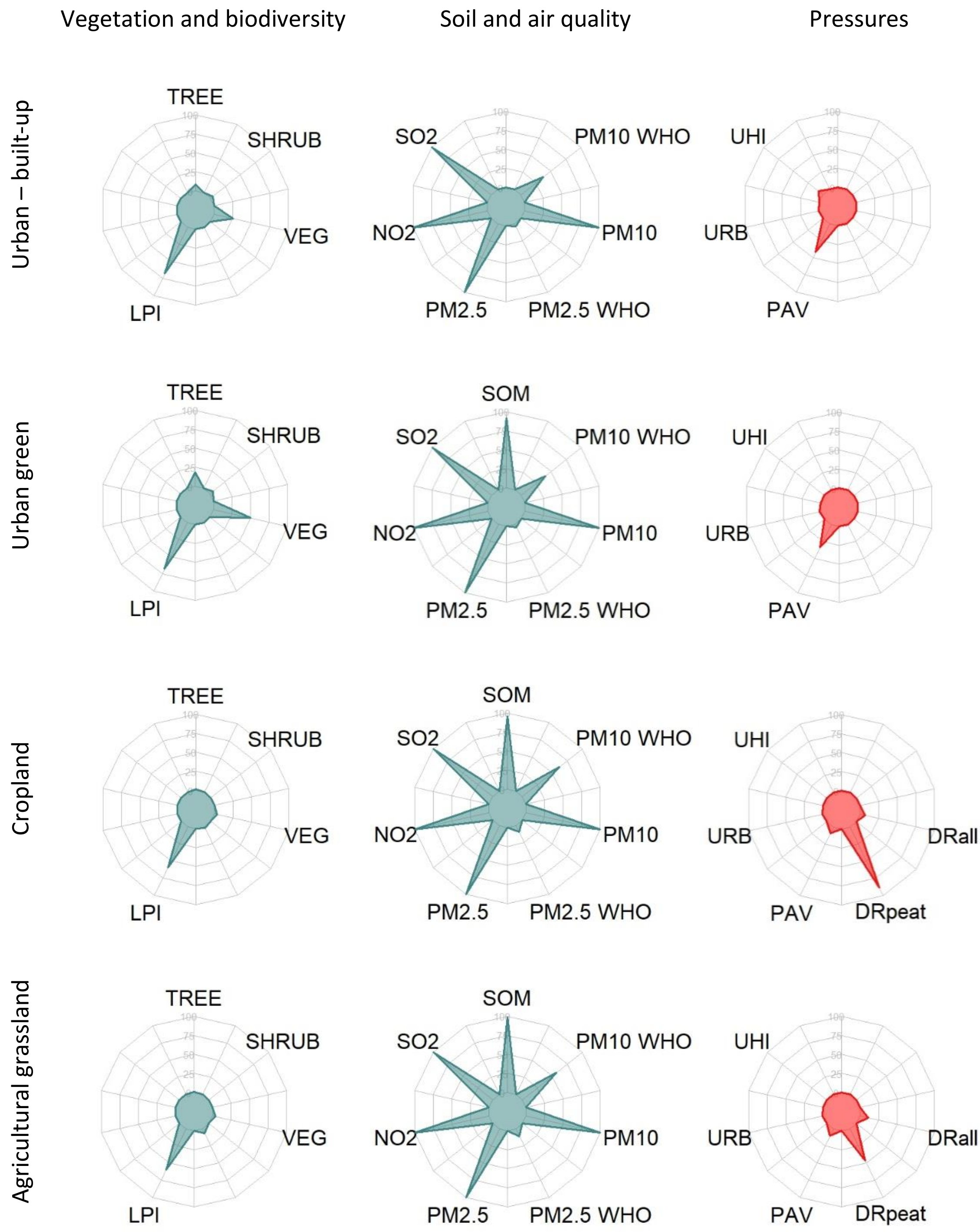
Table 5.1 The condition account for the Netherlands, 2013. In the last column, the first (or a single value) denotes the condition for terrestrial ecosystem types only, the second value denote the condition for all ET.

	Unit	Year	Urban		Agriculture			Water	Nature						TOTAL NL
			Built-up area	Urban green area	Crops	Grassland	Built-up	Sea/ Rivers/ Lakes	Forest	Heath	Semi-natural grasslands	Fresh water wetlands	Dunes and beaches	Other	
Extent															
Extent		2013	539,657	68,416	860,629	927,216	47,281	802,345	309,636	40,813	54,010	34,346	49,889	418,232	4,154,080
Extent (% of NL)		2013	13.0	1.6	20.7	22.3	1.1	19.3	7.5	1.0	1.3	0.8	1.2	10.1	100
Condition															
Vegetation															
Tree cover	%	*	9	19	2	1	6		60	7	8	4	11	9	10
Shrub cover	%	*	4	5	0	0	3		8	2	2	3	5	3	2
Low vegetation cover	%	*	26	50	3	4	23		25	62	44	59	40	33	17
Tree height	m	*	7.5	9.1	8.8	8.3	6.9		12.8	7.4	9.0	5.7	7.9	8.7	9.9
Carbon stock in above ground biomass	Mton C	2013	0	0.34	0.95	1.85	0		19.2	0.33	0.11	0.03	0.99	0.94	24.74
NPP	ton C / ha			4.6	4.9	4.1			4.4	3.2	4.7	4.0	3.5	3.4	4.3
Biodiversity															
% Protected areas - Natura2000 and EHS					2.0	6.7	0.3		32.1	76.0	46.7	73.5	96.1	20.6	12.0
LPI	Index (1990=100)	2013	68		60			Coast 98 Wadden118 Fresh 149	97	40		149	57		108.1
Characteristic species	Index (intact=100)	2013							33.1	34.2	31.8	47.6	46.0		
Structure and function (Habitat Directive)	% of HD area in excellent condition	2013							75.2	25.9	56.8	47.6	40.3		
Soil															
Soil organic matter	% of area with >3% SOM	1990 - 2000		92	96	99			76	80	97	91	35	94	93
Water															
Chemical quality (WFD)	% of area with good condition	2015						1.0/ 20.6/ 8.0							
Biological quality (WFD)	% of area with good condition	2015						0.0/ 3.2/ 2.8							
Ecological quality (WFD)	% of area with good condition	2015						0.0/ 0.1/ 0.0							
Transparency (WFD)	% of area with good condition	2015						1.0/ 19.8/ 15.7							

Total phosphorus (WFD)	% of area with good condition	2015						0.0/ 39.0/ 81.3							
Total nitrogen (WFD)	% of area with good condition	2015						0.0/ 60.6/ 30.9							
Air															
Air pollution – PM10	µg PM_{10} /m^3	2013	20.4	20.2	19.4	19.3	20.2	17.2	20.1	19.5	19.5	18.4	16.8	19.8	19.6 / 19.2
	% < WHO threshold	2013	37	40	62	57	41	89	47	64	55	74	99	45	60
	% < EU limit	2013	99.9	100	100	100	100	100	100	100	100	100	100	100	100
Air pollution – PM2.5	µg $PM_{2.5}$ /m^3	2013	13.2	13.1	12.3	12.3	13.0	10.8	12.9	12.5	12.5	11.7	10.5	12.8	12.6 / 12.2
	% < WHO threshold	2013	4.3	4.5	9.6	10.8	5.0	45.4	1.6	0.2	4.5	14.5	43.3	7.2	8.2 / 15.4
	% < EU limit	2013	100	100	100	100	100	100	100	100	100	100	100	100	100 / 100
Air pollution – NO2	µg NO_2 /m^3	2013	18.6	18.7	15.2	14.9	17.8	15.2	15.7	14.4	15.5	13.5	11.7	16.8	16.0 / 15.9
	% < EU limit	2013	99.9	99.9	100	100	100	100	100	100	100	100	100	99.9	100 / 100
Air pollution – SO2	µg SO_2 /m^3	2013	1.2	1.2	1.0	0.8	1.2	1.1	0.8	0.7	0.9	0.7	1.1	1.0	1.0 / 1.0
	% < EU limit	2013	100	100	100	100	100	100	100	100	100	100	100	100	100 / 100
Pressures															
Eutrophication – deposition	mol N/ha/ yr	2013	2,020	1,898	1,528	1,559	1,630	821	1,899	1,594	1,531	1,297	1,022	1,599	1,662 / 1,500
	% area with eutrophication	2013							99.6	100	99.9	100	42.6		
Acidification – deposition	mol H^+/ha/ yr	2013	2,706	2,592	2,140	2,169	2,277	1,415	2,575	2,242	2,171	1,919	1,645	2,250	2,300 / 2,129
	% area with acidification	2013							76.8	100	94.4		81.6		
Drainage organic soils	cm		66	71	81	61	75		82	64	52	49	26	63	66
Drainage organic soils	% area >60 cm (of peat soils)		68	60.6	88.8	46.5	54		65.0	70.0	33.7	35.9	0.0	52.3	56
Urbanisation – % paved surfaces	% paved surface in 1 km^2	2013	42	34	9	10	28	12	9	4	10	5	8	17	17 / 16
	% increase in paved surfaces	2006 - 2013	1.3	1.5	0.8	0.7	2.2	0.09	0.7	0.4	0.6	0.06	0.3	1.4	0.9 / 0.7
Urban Heat Island	°C increase	*	0.63	0.42	0.06	0.06	0.4		0.06	0.02	0.08	0.03	0.03	0.19	0.18
	% area > 1.5 °C increase	*	7.7	0.5	0.0	0	6.6		0.0	0	0	0	0.0	0.2	1.4

6 Ecosystem condition per ecosystem type

Although the condition account provides a comprehensive overview on the condition of and the pressures on ecosystems, at first glance it may be difficult to interpret the multiple data. Therefore we have used the data from the condition account to produce graphs to better visualise the results. Figure 6.1 shows two graphs of the condition of the ecosystems, for “vegetation and biomass”, and “soil and air quality” (here longer arms of the star represents better condition) and one graph for the pressures on ecosystems (here shorter arms represents less pressures).



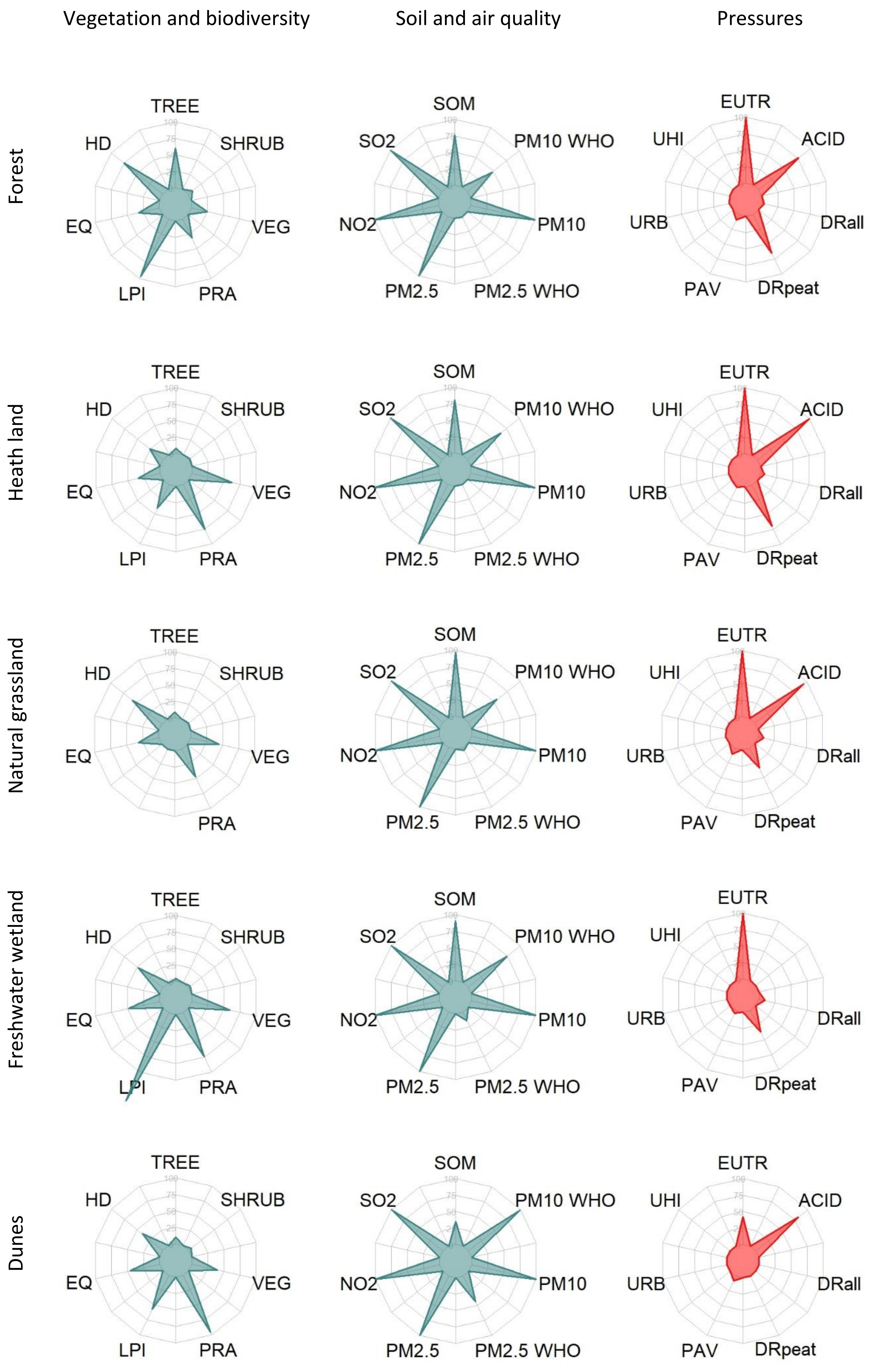

Vegetation and biodiversity
Soil and air quality
Pressures
Forest
Heath land
Natural grassland
Freshwater wetland
Dunes
TREE
SHRUB
VEG
PRA
LPI
EQ
HD
SOM
PM10 WHO
PM10
PM2.5 WHO
PM2.5
NO2
SO2
EUTR
ACID
DRall
DRpeat
PAV
URB
UHI

Figure 6.1 Ecosystem condition and pressures per ecosystem. The plots "vegetation and biodiversity" depict: TREE = tree cover (%), SHRUB = shrub cover (%), VEG = low vegetation cover (%, excluding agricultural low vegetation), PRA = % protected area, LPI = Living Planet Index (§3.2.2), EQ = Ecosystem quality (§3.2.3), HD = % of area protected by the Habitat Directive that is in excellent condition. The plots "soil and air quality" depict: SOM = area with soil organic matter > 3%, PM10 WHO and PM2.5 WHO depict % area with annual PM_{10}, respectively $PM_{2.5}$ concentration < WHO threshold, PM10, PM2.5, NO2 and SO2 depict % area with annual PM_{10}, respectively $PM_{2.5}$, NO_2 or SO_2 concentration < EU limit. The plots "pressures" depict: EUTR = % area with eutrophication, ACID = % area with acidification, DRall = % of all area with more than 60 cm drainage in peat and peaty soils, DRpeat = % of peat and peaty soils with more than 60 cm drainage, PAV = mean % paved surface in 1 km^2 surrounding the ecosystem type, URB = urbanisation, depicted as % increase in paved surfaces between 2006 and 2013 , UHI = % of area with more than 1.5 degree Celcius increase in temperature.

The indicators for soil and air quality show that the air quality meets the limits for the annual daily mean set by EU in more than 99.9% of the area. Nevertheless, in the majority of the area, the annual daily mean does exceed the more stringent threshold set by the WHO, especially for $PM_{2.5}$. For PM_{10}, the air quality exceeds the WHO threshold in a large fraction of the areal of most the ecosystems. The indicators for biodiversity show differences between ecosystem types, but also show differences between indicators within an ecosystem type (which can be explained by the different focus and methods of these indicators). The Living Planet Index reports a relatively higher condition as compared to the ecosystem quality, because it measures all monitored animals relative to their presence in 1990, while ecosystem quality measures only species that are characteristic for a certain ecosystem relative to an intact ecosystem (an ecosystem that is not influenced by pressures like eutrophication, acidification). These measures combined show that the biodiversity in freshwater wetlands has increased since 1990, but that the quality of the ecosystem has not reached an intact ecosystem yet. The graph of the pressures show that eutrophication and acidification affect almost the complete areal of (semi)natural ecosystems, except for the dunes, where the nitrogen deposition is lower and thus a relatively smaller areal of dunes is affected by eutrophication. More detail on ecosystem condition and pressures on ecosystem types can be found in Annex I.

7 Synthesis

Following the guidelines of the SEEA-EEA a condition account for the Netherlands was compiled. For the first time, information on ecosystem condition and pressure indicators were brought together in one consistent framework.

7.1 Data sources and limitations

For the condition account a large collection of available data about different aspects of the state of ecosystems and pressures in the Netherlands on ecosystem condition was used. Generally, aspects of air quality, like particulate matter concentration and pressures like acidifying deposition, are measured and reported yearly and have a good spatial coverage. Furthermore, critical deposition loads (for pressures) and limit values (for air quality) are available, so that these indicators can be compared to these criteria. Information about the state of vegetation, biodiversity and soil of ecosystems is less well available. If they are studied, the spatial coverage is low (i.e. only a few sample points) and they are not always repeated or repeated on a large time frame. This is a challenge for describing ecosystem condition, and especially when you would like to look at trends in time. The implication is that for soil only one indicator was included, and for biodiversity two non-spatial indicators, but that are measured on a yearly base, are included (e.g. LPI and ecosystem quality) and one indicator that is measured in only in a small fraction of the ecosystems (Structure and Function of areas protected by the Habitat Directive) and reported on a larger time scale. The indicators for vegetation are not reported on a regular time scale yet, but they are based on remote sensing data and thus repeated measures are possible.

7.2 Indicators – options for future expansion

In this report we made a first selection of condition and pressure indicators based on relevance and availability. There is however certainly room for improvement and expansion of the indicators. Below we discuss some options for improvement we have already identified.

7.2.1 Soil

The condition of soils is very important for the condition of terrestrial ecosystems. Pressures on soils can be monitored to predict change in condition, but not necessarily show the actual state of the soil. As historical pollution or enrichment of soils can influence soil condition that can remain long after the pressure has ended.

Soil organic matter (SOM) is the only soil related indicator included in the current condition account. It would be good to further include acidity of the soil (pH), the base saturation of the soil (ratio: (Ca+Mg+K+Na)/CEC) or the cation exchange capacity (CEC). These are indicators for aspects that affect nutrient availability for trees and plants (including crops). For arable lands base saturation should be 80-100%, in combination with a pH of 5.5 – 6 (Wim de Vries personal communication). The natural base saturation in forest soils is lower than 20%, here saturation with protons (H+ and Aluminium) is high, and the pH is usually less than 4.5 (Wim de Vries personal communication). Acidification of forest soils further reduces the base saturation to 5% (the practical minimum). This is a very slow process.

Another possible indicator for soil quality is the C/N ratio of soil, which is a state indicator with respect to the effects of eutrophication. Critical values for the C/N ratio in the soil are: 20-25, for both the mineral soil as the litter layer. Higher C/N ratios are good, at a C/N ratio larger than 30 there is hardly any leaching of nutrients (Wim de Vries personal communication).

7.2.2 Biodiversity

Two indicators for biodiversity have been included that can give a measure for the naturalness of ecosystems. However, these indicators are (at this moment) not spatially explicit. For the biodiversity account that is currently developed for the Netherlands, methods for including spatial information to biodiversity data are under development. However, these are not finalised yet, and only developed for a few species and thus cannot give the complete picture for the Netherlands yet. Spatial explicit biodiversity data would further improve the consistency of the condition account. Therefore, when the methods are finalised adding this data would be very valuable.

Next to indicators for the biodiversity account, it would be interesting to develop an indicator for naturalness of forests based on other data that is spatial explicit, for instance age of the forest (if available), or tree height (if there is a relationship between (variation in) tree height and naturalness), possibly combined with knowledge on the protection status or owner category of a forest.

A third indicator for biodiversity "Extent of ecosystem quality" is not included yet as the procedure for this indicator has been developed but has not been used in practice thus far . The measure is based on Flora and Fauna data collected conform the "Werkwijze Monitoring en Beoordeling NatuurNetwerk – Natura 2000/PAS" (Approach Monitoring and Assessment of the Nature Network - Natura 2000 / PAS, further abbreviated as WMBM) (van Beek *et al.*, 2014). This network has been developed by the central government and the provinces, with the goal to set-up a coherent monitoring and assessment system that meets the requirements set by the European Commission to the national reports. Within the WMBM a method is developed to collect data on Flora and Fauna, Structure characteristics, abiotic factors that influence flora (moisture, nutrients, acidity, nitrogen deposition), size and spatial coherence and naturalness. These indicators combined assess ecosystem quality, measured in percentage of maximum possible qualifying species found per ecosystem (in % area) in Natura2000 areas and Nature Network Netherland areas (formerly known as EHS). The data will be reported once every six years. Not all data will be collected every six years. For instance, vegetation mapping (the basis to assess abiotic factors that affect flora) is done once every twelve years. The overall assessment is not available yet. However, it might be a suitable indicator to include in the future.

Indicators for habitat integrity have not been included in the current account. Important characteristics are the extent of areas and connectedness between areas with the same ecosystem (when described as a state) or habitat fragmentation (when described as a pressure). Construction of roads and buildings causes fragmentation of nature areas in the Netherlands. Roads and highways act as barriers for animals. When nature areas become small and less connected, this affects species survival. Population become smaller and more vulnerable to disturbance. Habitat connectedness and fragmentation is an important driver to presence of (characteristic) species. In general, sensitivity to fragmentation increases with body mass. The Ecological Network (Nature Network Netherlands, or formerly EHS) is an important part of nature policy in the Netherlands which is designed to connected nature areas to stabilize (and improve) biodiversity in the Netherlands. A possible indicator can be percentage of qualifying species for whom the area of the habitat is suitable (i.e. big enough for survival of the population) (Statistics Netherlands et al., 2016). Another, measure could be the sizes of the areas of ecosystems. We have not developed these indicators yet, therefore we did not include it. An indicator for fragmentation will be included in the update of the condition account.

7.2.3 Pressure indicators

There is an increase in the percentage of sealed area in cities, not only due to buildings but also due to paved private gardens. Currently, a map that quantifies changes in sealed areas in cities is being developed within the Natural Capital of the Netherlands project.

7.3 Linking ecosystem condition to ecosystem services

Ecosystem condition is closely linked with many ecosystem services (Table 7.2). Furthermore, the state of the environment (e.g. ecosystem condition) is closely linked with the exerted pressures. Recently, Maes et al. (2018), developed an analytical framework for assessing ecosystem condition. In this framework they also distinguish between indicators for ecosystem condition and indicators for pressures on ecosystem condition. The main distinction is that indicators for ecosystem condition show the state of the environment and pressures can be used to explain why an ecosystem is in a certain condition. Furthermore, pressures on ecosystems can have an effect on multiple aspects of ecosystem condition, and therefore affect multiple ecosystem services.

The optimal condition might differ between ecosystem services. There can be synergies between certain ecosystem services or trade-offs between other ecosystem services. For instance, to produce timber it is advantageous to have a production forest with trees of the same species and same age class close together. When these are fast growing species there is a synergy with carbon sequestration. However, there could be a trade-off with recreation, either because the forest is not accessible for recreation or because people prefer a forest with more diversity in species. Pressures on ecosystems indirectly affect ecosystem services via ecosystem condition. These pressures on ecosystems can have a long-lasting effect (e.g. historical nutrient enrichment can influence biodiversity long after the deposition of nutrients have ended).

Table 7.1 Linking effect of ecosystem condition to ecosystem services, pressure indicators affect ecosystems indirectly (marked by (x)) by affecting ecosystem condition.

Theme Indicator	Unit	Ecosystem service													
		Crop production	Fodder production	Wood production	Biomass for energy	Drinking water	Carbon sequestration	Air filtration	Pollination	Pest control	Erosion prevention	Protection against flooding	Nature recreation	Nature tourism	Amenity service
Vegetation															
Tree cover	%			x			x	x	x	x	x	x			
Shrub cover	%				x		x	x	x	x	x	x			
Grass cover	%				x		x	x	x	x	x	x			
Tree height	m			x			x	x							
Carbon stock	Mton C			x	x		x								
NPP	Ton C /ha	x	x	x	x		x								
Biodiversity															
% protected	% area								x	x			x	x	x
LPI	Index								x	x			x	x	x
Characteristic species	Index								x	x			x	x	x
Structure and Function	% area								x	x			x	x	x
Soil															
SOM > 3%	% area	x	x												
Water															
Chemical quality	% area					x							x	x	x
Biological quality	% area												x	x	x
Ecological quality	% area												x	x	x
Transparency	% area												x	x	x

Total P	% area					x									
Total N	% area					x									
Air															
PM_{10}	µg PM_{10} /m^3							x					x	x	x
$PM_{2.5}$	µg $PM_{2.5}$ /m^3							x					x	x	x
NO_2	µg NO_2 /m^3												x	x	x
SO_2	µg SO_2 /m^3												x	x	x
Pressure indicators															
Eutrophication	mol N/ ha/ yr			(x)	(x)		(x)	(x)	(x)	(x)			(x)	(x)	(x)
Acidification	mol H^+/ ha/ yr			(x)	(x)		(x)	(x)	(x)	(x)			(x)	(x)	(x)
Desiccation (peat soils)	cm drainage	(x)	(x)												
Urbanisation	% increase in paved surfaces	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)			(x)	(x)	(x)
UHI effect	°C increase														(x)

Further study is needed to establish how ecosystem condition (and the interplay of several ecosystem condition indicators) affect the ecosystem services delivered.

7.4 Applications of the condition account

Ecosystems provide multiple ecosystem services, which provide benefits and increase well-being. The extent to which ecosystems can provide these services depends on the condition of the ecosystem. Furthermore, the intrinsic value of ecosystem can be related to specific characteristics of ecosystems such as its quality as a habitat for native and/or protected species. Specific condition indicators, such as those reflecting air quality, are crucial to human health. Finally, by European and national law specific ecosystem condition indicators need to be monitored and reported upon on a regular basis. The condition account brings these indicators together in a comprehensive overview of the status of the Netherlands' ecosystems. By bringing together information sets that have, to date, been reported separately a more informed picture can be given of where there are critical trends in ecosystems, and which parts of ecosystem condition are most relevant for policy makers to focus on.

The account clearly shows which aspects of ecosystem condition are of priority for further policy action, and which are relevant to be monitored but do not require immediate action. For instance, acidification and eutrophication still negatively affect a very large percentage of Dutch heath, natural grasslands and forests: 100% of heath, 99.9% of natural grasslands and 98% of coniferous and mixed forests are exposed to acidification, and 100% of heath, 99.9% of natural grasslands, 99% of forests are exposed to eutrophication. Eutrophication can affect the competition between plant species and therefore alter species composition and generally reduces biodiversity in these ecosystems. For instance, in heath land, increased nutrient availability favors fast growing grasses over slow growing heath vegetation. This potentially also affects the ecosystem services that these ecosystems can provide – the cultural and recreational value of heathlands is generally associated with the characteristic heath species not with the (*Molinia* and other) grass species that replace them under eutrophic conditions.

7.5 Recommendations for future work

The development of the Condition Account for the Netherlands revealed some important aspects for future work.

Develop time series. An important part of the policy applications stem from having the condition account for multiple years, however for some of the indicators only one year was available for this account. Repeating the work for multiple years, would further improve the strength of having all data presented in one consistent framework.

Review and expand indicators. As mentioned in the Introduction of this report, further work is needed to evaluate which indicators are most useful for the account, which could be deleted in future accounts, and which indicators are still missing. Recently, Maes et al. (2018) published an analytical framework for mapping and assessing ecosystem condition in Europe. For several ecosystem types they propose a set of (key) indicators "which are able to capture physical, chemical and biological quality of the different ecosystem types while also integrating existing definitions of condition as implemented by European environmental legislation" (Maes et al., 2018). Most of the indicators currently included in the condition account are considered key parameters in this framework. Consultation with users of the data and comparison with the framework of Maes et al. could provide information on which indicators for ecosystem condition and indicators on ecosystem pressures can further be included.

Work on reference conditions to develop composite indicators. Currently composite indicators are only available for biodiversity indicators, for instance the Living Planet Index and conservation status for the Habitats Directive and for indicators for the Water Framework Directive like the ecological quality of water. The other indicators are mostly individual metrics. Reference conditions can be used to easily compare metrics for ecosystem condition. The development of composite indicators on ecosystem condition need involvement of data users and stakeholders to warrant proper weighting of individual metrics and to warrant relevance for policy uses. Setting reference conditions is not a trivial task, differences in reference condition between for instance the Living Planet index (a specific year) and the index for ecosystem quality (an intact ecosystem) show different trends. The optimal reference might differ for different policy goals.

Analyse link with ecosystem services. Ecosystem extent and ecosystem condition define the total capacity to deliver ecosystem services. In table 7.2 an overview of the possible links between indicators for ecosystem condition and ecosystem services are given. Further analysis is needed to link ecosystem condition to the capacity to provide ecosystem services.

Further develop visualizations. Many of the current indicators are presented as individual metrics, as a result the condition account is a large table with many measures. In Chapter 6 spider plots are used to visualize the results to improve the usability for policy applications. Visualization of the results could be further developed to bridge the gap between a big table with a lot of data and the key aspects that policymakers need to know. A GIS-tool that enables downloading area specific ecosystem condition could further enhance the application of the data.

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I. Annex - Ecosystem condition in detail

a. Forest

Forests provide a wide range of ecosystem services including provisioning, regulating, and cultural ecosystem services. For instance, forests provide timber, but can also provide berries or game. Furthermore, trees store carbon, capture air pollution. In addition, forests are a favorite environment for hiking, running and biking. This is just a small selection of the services that they provide. The condition of forests influences to what extend forest can provide these services. Furthermore, there might be trade-offs; a forest that is most suitable for timber production, might not be the most desirable forest for recreation. This paragraph gives an overview of the condition of Dutch forests.

Table I.1 Ecosystem condition of forests in the Netherlands, 2013

	Deciduous forest	Coniferous forest	Mixed forest
Extent			
Extent (ha)	109,142	81,923	118,571
Condition			
Tree cover (%)	54 (29)	64 (24)	64 (25)
Shrub cover (%)	10 (8)	6 (5)	7 (6)
Low vegetation cover (%)	28 (26)	24 (21)	23 (21)
Carbon stock in biomass (Mton C)	6.8	5.1	7.4
Protected areas (Natura2000, EHS) (% of area)	16	44	38
Living Planet Index (Index 2000=100)	102		
Characteristic species (Index intact=100)	33.1		
Ecosystem quality (% of area with ≥50% of qualifying species)	33.9		
Habitat structure and function (% of area in excellent condition)	75.2		
Soil organic matter (% of area with <3% SOM)	17	34	24
Air pollution – PM10	19.9 (2.2)	20.2 (1.8)	20.1 (1.8)
Air pollution – PM2.5	12.8 (1.7)	13.0 (1.4)	12.9 (1.4)
Air pollution – NO2	16.0 (4.5)	15.7 (3.3)	15.5 (3.4)
Air Pollution – SO2	0.9 (0.4)	0.8 (0.3)	0.8 (0.3)
Pressures			
Urbanisation – % paved surface	13 (15)	6 (9)	8 (11)
Urban Heat Island (°C increase)	0.10	0.02	0.05
Acidification – mean deposition	2368 (403)	2724 (410)	2663 (382)
Eutrophication – deposition	1713 (369)	2025 (368)	1982 (347)
Drainage organic soils (cm)	67	97	85

Vegetation. Dutch forests have on average 54 to 65 % tree cover, 6 to 10% shrub cover and 23 to 28% low vegetation cover. Deciduous, coniferous and mixed forest store in total 19.2 Mton carbon. This is 78% of the total above ground biomass stock in the Netherlands.

Biodiversity. About 31% of all forest area in the Netherlands is protected within Natura2000. About 14% of the deciduous forests, 44% of the coniferous forests and 38% of the mixed forests is designated as Natura2000 area. Only a small percentage, less than 2%, is protected within the Nature Network Netherlands (NNN (EHS)). The indicator, “characteristic species” calculates indices of characteristic species per ecosystem. Where an intact ecosystem equals 100. The index of the characteristic species of forest gradually reduced in time from 35 in 1994 to 33 in 2014 (Figure 3.2.2). In 2013, the index for characteristic species was 33.1 for forests. Furthermore, forest habitats were assessed based on their structure and function for the Habitat directive, of the protected forest types 75.2% of the area was in excellent condition, (Table I.1).

Soil. The mean SOM is slightly higher in broad-leafed forests than in coniferous forests and mixed forest. Compared to the other forest types, broad-leafed forests are situated more often on organic soils. Furthermore, there is less area of broad-leaf forest with very low soil organic matter content (Figure I.1). Soil organic matter content in dunes with permanent vegetation is very low, 92% of the area has a SOM of less than 3 %.

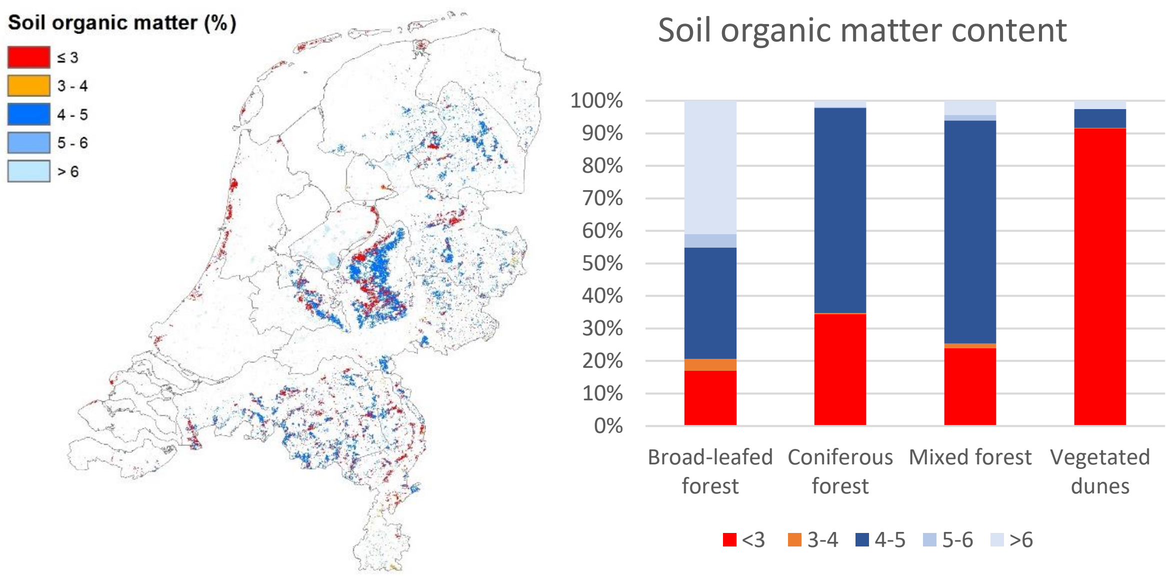


Figure I.1 Soil organic matter content in forest soils a) depicted for the Netherlands and b) depicted per forest type based on SOM data from Conijn and Lesschen (2015) and the LCEU map from 2013.

Air. The air quality for all four measure pollutants is better in forests than in urban areas (Table 5.1). The air is cleaner than the most stringent threshold for particulate matter in almost 50% of the forest area.

Pressures. The potentially acidifying deposition is above the critical deposition threshold in 99 to 100% of the coniferous and (subsequently, by definition) mixed forests. The critical deposition threshold of broad-leafed forests is higher, therefore, with a similar deposition as in coniferous forests and mixed forests, the threshold for acidification is reached in a smaller area (37% of the area in 2013) and there are some areas with potential acidifying deposition lower than the lower limit for acidification (4.7% in 2013). Between 2011 and 2016, the fraction of broad-leafed forests above the acidification threshold has reduced from 78% to about 37%, more forests are now in the range where Aluminum depletion still occurs, but where the pH of the soils remains stable because of the buffering properties of the soil. There is thus a positive trend where the acidification is reduced, but potential acidifying deposition remains to negatively affect forest soils.

Percentage of area with no-effect of eutrophication is based on the lowest critical deposition level for a subtype of the forest type, for broad-leafed forests this was set at the level for old oak forests, for coniferous and mixed forests this was set at the level for forests on nutrient-poor sandy soils, both have no effect below 1,071 mol N /ha/yr (based on van Dobben et al. (2012)). At this level, more than 99% of the forest area undergo eutrophication, and less than 1% of the forests do not experience eutrophication at the nitrogen deposition level of 2013. When 1,429 mol N /ha/yr is taken as the level of no-effect (based on several other forest types), 19.4% of the broad-leafed forest, 2.5% of the coniferous forests and 3.4% of the mixed forests are not affected by eutrophication.

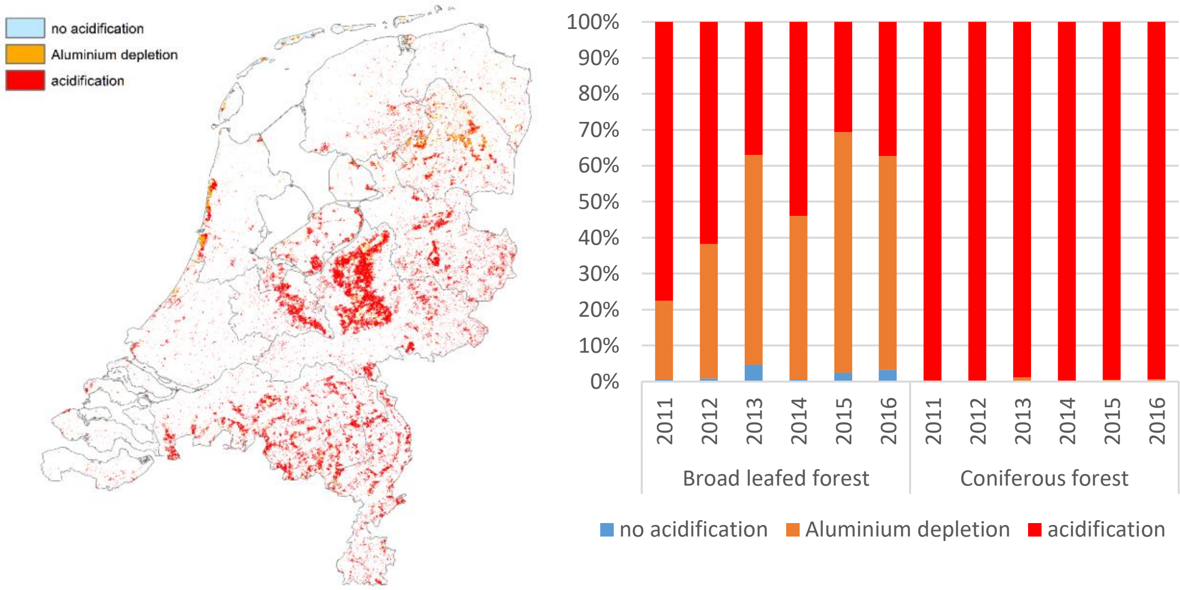


Figure I.2 Acidification status in forests a) depicted for the Netherlands in 2013 and b) depicted per forest type from 2011 to 2016. Classes based on critical deposition values for broad-leaved forests and coniferous forests. Critical deposition coniferous forest 1650 mol H^+ ha^{-1} yr^{-1} for Aluminum depletion, and 1900 mol H^+ ha^{-1} yr^{-1} for acidification. Critical deposition broad-leaved forest 1800 mol H^+ ha^{-1} yr^{-1} for Aluminum depletion, and 2450 mol H^+ ha^{-1} yr^{-1} for acidification. For mixed forest (result not shown) the values for coniferous forests were used, as they show the same trend.

b. Grasslands

Agricultural grasslands produce fodder, due to their extent they also play an important role in carbon sequestration and water retention. Carbon is also stored in natural grasslands. Furthermore, natural grasslands also play an important role in the intermediate service pollination, as they can provide alternative food sources for pollinators and are more suitable for nesting as they are less disturbed than agricultural grasslands. The next paragraphs show an overview of the condition of grasslands in the Netherlands.

Vegetation. Semi-natural grasslands are primarily covered by low vegetation (on average 44%) and some trees (8%) and shrubs (2%) (Table I.2). Due to its extent, agricultural grasslands store in total 1.85 Mton carbon, while semi-natural grasslands store 0.11 Mton carbon.

Table I.2 Ecosystem condition of grasslands and heath (see next paragraph) in the Netherlands

	Agricultural grasslands	(semi)-natural grasslands	Heath
Extent			
Extent (ha)	927,216	54,010	40,813
Condition			
Tree cover (%)	1 (8)	8 (20)	8 (18)
Shrub cover (%)	0 (2)	2 (6)	2 (6)
Low vegetation cover (%)	5 (18)	44 (42)	44(35)
Carbon stock in biomass (Mton C)	1.85	0.11	0.33
Protected areas (Natura2000, EHS) (% of area)	7	47	76
Living Planet Index (Index 2000=100)	-		
Characteristic species (Index intact=100)	-	31.8	34.2
Ecosystem quality (% of area with ≥50% of qualifying species)	-	18.3	34.1
Habitat structure and function (% of area in excellent condition)	-	56.8	25.9
Soil organic matter (% of area with <3% SOM)	1	3	20
Air pollution – PM10	19.3 (2.3)	19.5 (2.1)	19.5 (1.7)
Air pollution – PM2.5	12.3 (1.8)	12.5 (1.7)	12.5 (1.4)
Air pollution – NO2	14.9 (4.2)	15.5 (4.3)	14.4 (3.2)
Air Pollution – SO2	0.8 (0.4)	0.9 (0.4)	0.7 (0.3)
Pressures			
Urbanisation – % paved surface	10 (10)	10 (12)	4 (7)
Urban Heat Island (°C increase)	0.06	0.08	0.02
Acidification – mean deposition	2169 (376)	2171 (409)	2242 (403)
Eutrophication – deposition	1559 (414)	1531 (368)	1594 (358)
Drainage organic soils (cm)	61	52	64

Biodiversity. A small percentage of the agricultural grasslands (2.4%) are situated within a Natura2000 area and outside this area, 4.2% is situated within the Nature Network Netherlands (NNN (EHS)). Almost 50% of the semi natural grasslands are designated as Natura2000 area (23.7%) or are otherwise situated within the NNN (23.0%).
For the nature value of (semi)natural grasslands a measures was used that shows the condition of grasslands based on the presence of characteristic species of semi-natural grasslands. This index first gradually reduced between 1994 and 2005 from 35 to 29 (where an intact ecosystem equals 100), after that there was a gradual increase up to 33 in 2014 (Figure 3.2.2). In 2013, the index for characteristic species was 31.8 for (semi)natural grasslands. Furthermore, grassland habitats were assessed based on their structure and function for the Habitat directive, of the protected grassland types 56.8% of the area was in excellent condition (Table I.2).

Soil. Compared to (semi-)natural ecosystems, the soil organic matter content in agricultural grasslands and non-agricultural grasslands is quite high. More than 70% of the grasslands has a SOM content greater than 6% SOM, and less than 1% of the agricultural grasslands, respectively 3% of the non-agricultural grasslands, has a very low content of less than 3% SOM (Figure I.3). These soils (with SOM less than 3%) can have a reduced soil fertility and can potentially have a lower water retention capacity.

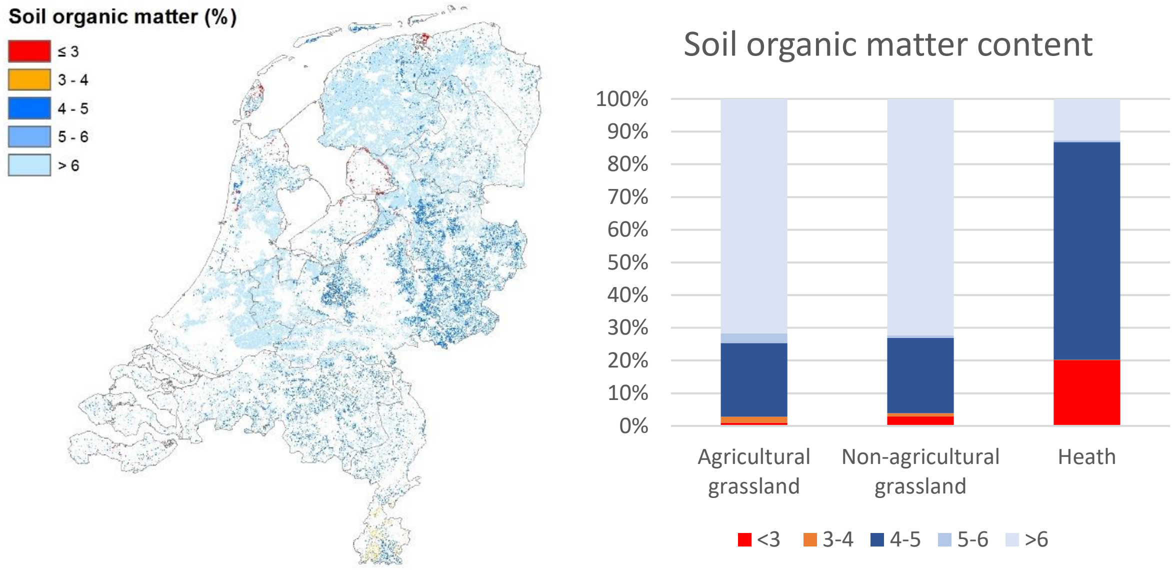


Figure I.3 Soil organic matter content in soils from grasslands and heath a) depicted for agricultural grasslands and non-agricultural grasslands the Netherlands and b) depicted type for agricultural grasslands, non-agricultural grasslands and heathland, based on SOM data from Conijn and Lesschen (2015) and the LCEU map from 2013.

Pressures. The condition of, and pressures on agricultural grasslands and non-agricultural grasslands are fairly similar in the sense of deposition of substances that can potential cause acidification or eutrophication. However, the effect of these pressures on agricultural and non-agricultural is different. Both acidification and eutrophication has a more severe effect on non-agricultural grasslands, as many natural grassland types can only exist in relatively poor soils. The mean deposition of potential acid is 2171 mol H^+/ha/yr, while the critical deposition level of nutrient poor acidic grasslands is between 1000 – 1500 mol H^+ /ha/yr. In 2011 this threshold was exceeded in more than 99% of the area with non-agricultural grassland (Figure I.3). There has been a reduction in the deposition of potential acid between 2011 and 2016, however, the deposition of potential acid is still too high to maintain nutrient poor acidic grasslands. To counteract the effect of deposition of acid, it is common practice in agricultural grasslands to use lime to keep the pH of the soil at the desirable level. Not only the potential acidifying deposition is too high to maintain nutrient poor acidic grasslands, also the total nitrogen deposition that can cause eutrophication is too high in 99.9% of the natural grasslands in 2013.

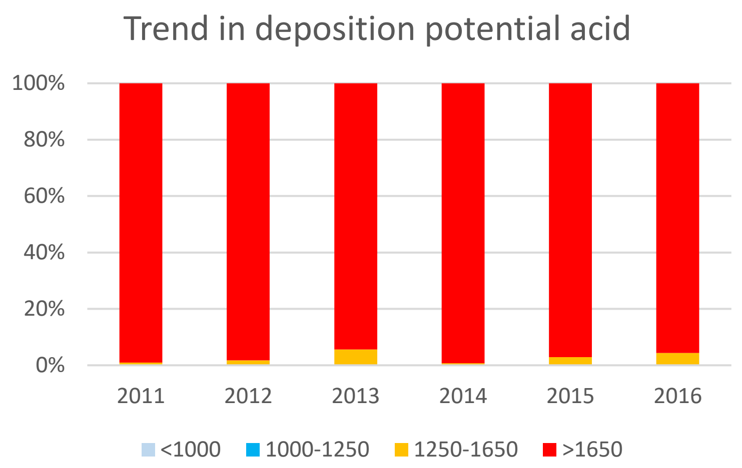


Figure I.4 Trend in acidification status in non-agricultural grasslands from 2011 to 2016. Classes based on critical deposition values for nutrient poor acidic grasslands.

The average drainage of agricultural grasslands is deeper in agricultural grasslands than in natural grasslands (Table I.2). The main difference is that a higher percentage of the agricultural grassland are deeply drained (i.e. > 90 cm); namely in 18.4% of the agricultural grasslands, versus 8.7% of the natural grasslands. On the other hand, natural grasslands are more often superficially drained (i.e. < 30 cm); namely in 17.7% of the natural grasslands, versus 11.4% of the agricultural grasslands (Figure I.5).

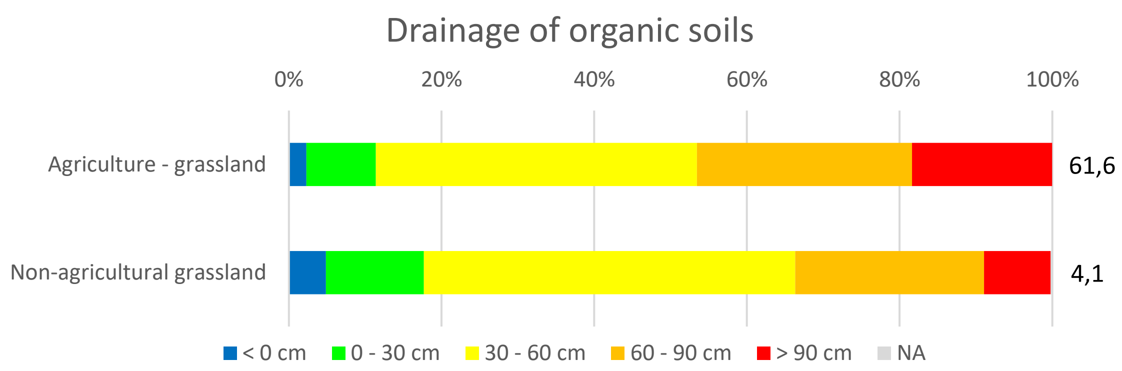


Figure I.5 Drainage of organic soils in cm below ground level. Label on right hand side of the bars, indicate area of forest on organic soils (in 1000 ha). Bars depict the percentage of the area per drainage class; < 0cm (blue), 0-30cm (green), 30-60cm (yellow), 60-90cm (orange), >90cm (red) and not available (grey) per grassland type

c. Heath

Heath mainly provides regulating, and cultural ecosystem services. Like forests, heath is a favorite environment for recreation. Heath stores carbon and captures air pollution. The condition of heath influences to what extend heath can provide these services. Heath is an ecosystem that is found on nutrient poor soils, mostly younger cover sand areas. It is vulnerable for acidification and eutrophication. The next paragraphs give an overview of the condition of heath in the Netherlands.

Vegetation. Heath is mainly covered by low vegetation, on average 44%, and sparsely covered by shrubs (2%) and trees (8%) (Table I.2). In total, 0.33 Mton carbon is stored in the above ground biomass of heath in the Netherlands.

Biodiversity. About 75% of Heath area is designated as Natura2000 area and is protected by the EU Habitat Directive and EU Bird Directive. For the nature value of heath, a measure was used that show the condition of heath based on the number and presence of qualifying species (butterflies, plants and birds). The index of the characteristic species of heath gradually reduced in time from 40.3 in 1994 to 33.9 in 2014 (where an intact ecosystem equals 100). In 2013, the index for characteristic species was 34.2 for heath (Table I.2). Furthermore, structure and function of heath habitats were assessed for the Habitat directive, of the protected heath types 25.9% of the area was in excellent condition.

Soil. The soil organic matter content in heath is substantially lower in heath than in natural grasslands (Table I.2). Similar to forests, in 20%of the acreage of heath the soil organic matter content is less than 3%.

Air. Recreation is an important ecosystem service of heath. The air quality in heath is on average better than in urban areas and forests. The concentration of PM_{10} is lower than the most stringent WHO threshold in 64% of the heath area, while for forests this is below this threshold in less than 50% of the forest area and for residential areas this is below the threshold only in 37.5% of the area (Table I.2, Figure I.9). One possible explanation for the difference in air quality with forests can be that heath tends to be further away from urban areas, industry and roads, as indicated by the lower mean percentage of paved surfaces in the local landscape (Tables I.*2*).

Pressures. Heath is adapted to grow on nutrient poor soils. When soils become more nutrient rich, heath is outcompeted by species that grow faster and the ecosystem transforms from domination by dwarf shrubs to domination by grasses and eventually trees. Even though, both the deposition of potential acid and of nitrogen has reduced between 2011 and 2016, the deposition of potential acid and total nitrogen deposition is too high to maintain heath in 100% of the heath in the Netherlands (Figure 4.2.3). The mean deposition of potential acid and the total nitrogen deposition is equal to approximately twice the lower critical deposition level for heath (Table I.2).

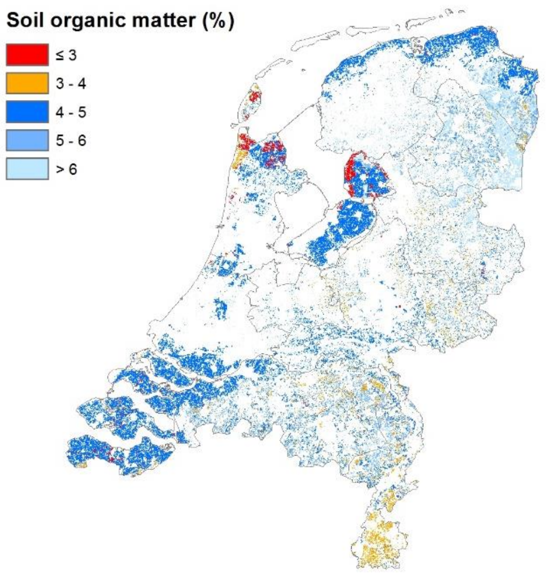
d. Agriculture (cropland)

Crop production is the predominant ecosystem service in annual and perennial crops. However, annual and perennial crops also contribute to air filtration, furthermore perennial crops also contribute to carbon sequestration.

Vegetation. The cover with vegetation, other than crops, in annual crops is low, on average only 1% of the area is covered by trees and only 2% of the area is covered by short vegetation (Table 5.4.1). In perennial crops, this coverage is slightly higher.

Table I.3 Ecosystem condition of annual and perennial crops in the Netherlands

	Annual crops	Perennial crops
Extent		
Extent (ha)	781,401	79,228
Condition		
Tree cover (%)	1 (7)	8 (25)
Shrub cover (%)	0 (2)	3 (7)
Low vegetation cover (%)	2 (12)	9 (23)
Carbon stock in biomass (Mton C)	0.00	0.95
Protected areas (Natura2000, EHS) (% of area)	2	4
Soil organic matter (% of area with <3% SOM)	3	11
Air pollution – PM10	19.3 (2.4)	20.0 (2.4)
Air pollution – PM2.5	12.3 (1.8)	12.9 (1.8)
Air pollution – NO2	15.1 (4.1)	16.0 (4.1)
Air Pollution – SO2	1.0 (0.5)	1.0 (0.4)
Pressures		
Urbanisation – % paved surface	9 (10)	12 (12)
Urban Heat Island (°C increase)	0.06	0.09
Acidification – mean deposition	2130 (414)	2235 (451)
Eutrophication – deposition	1521 (382)	1595 (414)
Drainage organic soils (cm)	83	66



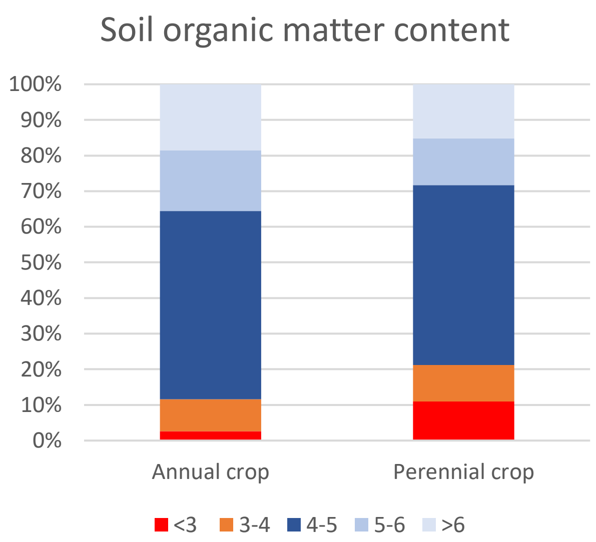


Figure I.6 Soil organic matter content in soils from annual and perennial crops a) depicted for the Netherlands and b) depicted for annual and perennial crops, based on SOM data from Conijn and Lesschen (2015) and the LCEU map from 2013.

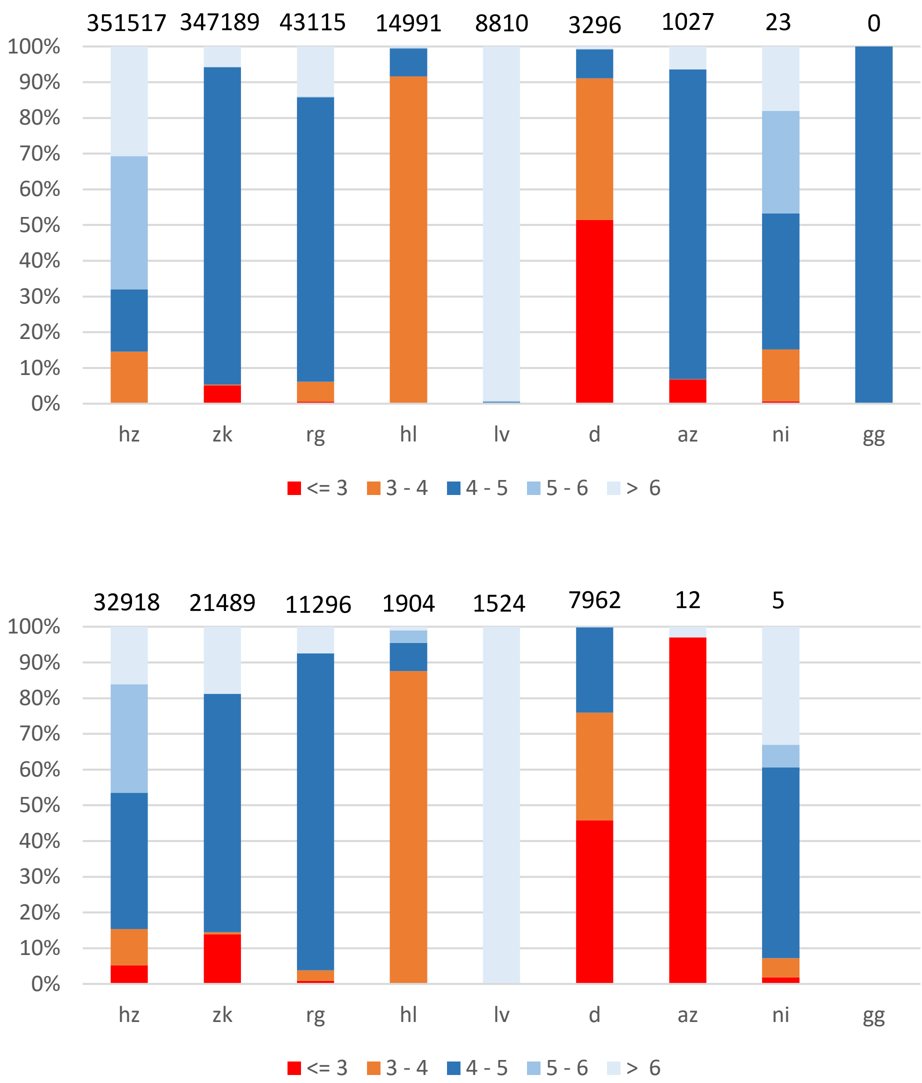


Figure I.7 Soil organic matter content in agricultural area per physical geographic region for a) annual crops and b) perennial crops. Bars depict the % of agricultural area with <3 % SOM (red), 3 -4% SOM (orange), 4 - 5% SOM (blue), 5 - 6% SOM (light blue), > 6% SOM (lightest blue). Depicted per physical geographic region (hz= "sandy area", zk=sea clay area, rg=river plain area, hl="hilly landscape", lv=low moorland, d=dunes, az=enclosed see arm, ni=not classified, gg=tidal area). Label on top of the bar is total area of annual, respectively perennial, crops in the specific physical geographic region in the Netherlands in hectare. Based on SOM data from Conijn and Lesschen (2015) and the LCEU map from 2013.

Biodiversity. A small fraction of agricultural fields are situated within (or bordering) a Natura2000 area (0.5% of the annual crop area and 3% of the perennial crop area) or are situated within the Ecological Network (about 1% of the annual and perennial crop area). The Natura2000 areas are mainly protected by the EU Habitat Directive or by both the EU Habitat Directive and the EU Bird Directive, which means that these habitats need to be conserved.
There has been a moderate reduction in the Living Planet Index of agricultural habitat (Figure 3.2.2). Population sizes of many typical animal species of the agricultural habitat decline. . This reduction is mainly due to the decline in characteristic breeding birds and butterflies in agricultural habitats,

while most species of mammals persist or increase (http://www.clo.nl/indicatoren/nl1580-trend-fauna-agrarisch).

Soil. About 3% of the annual crop area and 11% of the perennial crop area has a low soil organic matter content (<3% SOM, Table I.3, Figure I.6). In annual crops, 5% of the sea clay areas have low SOM, furthermore 51% of the annual crop area in dunes and 7% of the annual crop area also have a SOM less than 3% (but the total area of these is smaller than in sea clay) (Figure I.7). In perennial crops, low soil organic matter content is mostly found in dunes (3663 ha) and sea clay areas (3008 ha).

Pressures. There has been a reduction in the deposition of potential acid between 2011 and 2016, however, the mean deposition of potential acid is still high, 2130 and 2235 mol H^+/ha/yr in annual, respectively perennial, crops. To counteract the effect of deposition of acid, it is common practice in agricultural crops to use lime to keep the pH of the soil at the desirable level.

e. Urban areas

In this paragraph, we show the results for all paved areas that are classified as residential areas (also in rural areas), all infrastructure (i.e. roads, train tracks, runways and parking lots), other paved areas (mainly offices and buildings) and all urban green areas.

Table I.4 Ecosystem condition of urban areas in the Netherlands

	Residential area	Infrastructure	Other paved	Urban green
Extent				
Extent (ha)	250,417	111,811	177,429	68,416
Condition				
Tree cover (%)	9 (20)	12 (23)	6	20 (28)
Shrub cover (%)	4 (6)	3 (5)	2	5 (7)
Low vegetation cover (%)	29 (28)	29 (26)	20	50 (34)
Air pollution – PM10	20.3 (2.1)	20.2 (2.3)	20.6	20.2 (2.1)
Air pollution – PM2.5	13.1 (1.7)	13.0 (6.0)	13.3	13.1 (1.7)
Air pollution – NO2	18.1 (5.0)	18.2 (6.0)	19.6	18.7 (5.8)
Air Pollution – SO2	1.1 (0.6)	1.1 (0.7)	1.3	1.2 (0.6)
Pressures				
Urbanisation – % paved surface	45 (27)	27 (25)	48	34 (25)
Urban Heat Island (°C increase)	0.7(0.5)	0.4 (0.4)	0.8	0.4 (0.4)

Vegetation. Vegetation plays an important role in, among others, regulating temperature and air quality in urban areas. Vegetated areas in cities also play an important role in the capture of rain water, and thus in the reduction of nuisance of rain water. The presence of vegetation in large cities often shows a spatial pattern, with little vegetation in the city centres and more vegetation towards the city's boundaries (Figure I.8). About 42% of the residential areas are vegetated (Table I.4). Low vegetation, like grass and flowers, is the most prevalent vegetation in residential areas (on average 29% of the area), followed by trees (on average 9% of the area) and shrubs (on average 4% of the area). In urban green areas, the mean vegetation cover is higher, this is mainly due to a higher prevalence of low vegetation and trees, on average 50%, respectively 20% of the area.

Biodiversity. Although there is increasing attention for the city as a biotope and for greenery in the city, the species do not yet benefit. An important cause of this is the progressive compaction of the buildings and the replacement of vegetation by tiles in gardens, which means that potential habitats disappear. Thus, even though the total urban area has increased, there has been a reduction in fauna in the urban area between 1990 and 2014 (figure 3.2.2, www.clo.nl/nl158501). This is mainly due to a decline in butterflies. The situation for breeding birds in urban areas has remained stable.

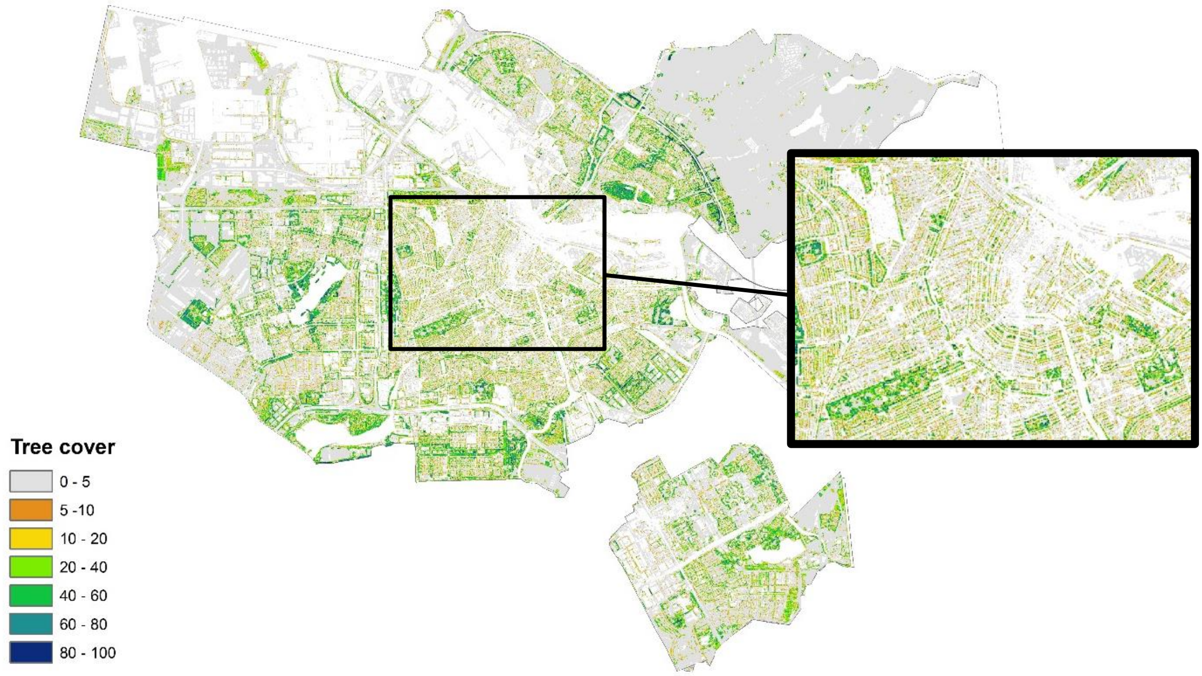


Figure I.8 Tree cover and grass cover (%) in an urban area, depicted for municipality Amsterdam the Netherlands.

Air. Air pollution has drastically decreased in urban areas over the recent years. The mean particulate matter concentration in the Netherlands is generally below the EU threshold for yearly mean concentration. Nevertheless, the mean particulate matter concentration in residential areas, business areas and even in urban green areas is still above the more stringent threshold that is advised by the WHO in 62% of the residential areas, 60% of the urban green areas, and 68% of the other paved surfaces (Figure I.9).

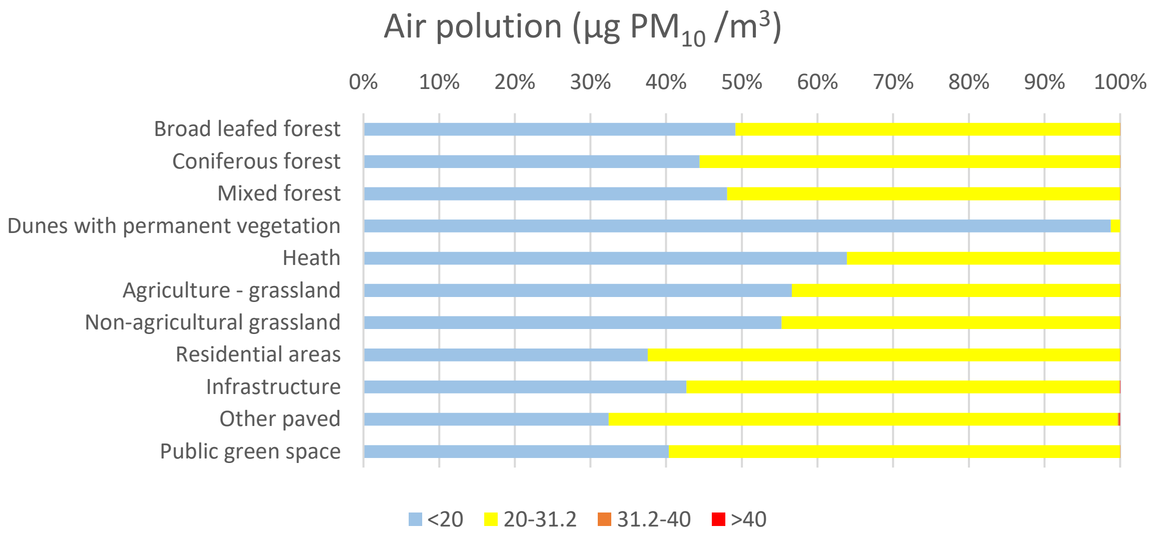


Figure I.9 Yearly mean concentration of PM10 in 2013 in forests, grasslands, heath, and urban areas. Depicted is the percentage of area per range of concentrations. Ranges are based on threshold values from the EU and WHO.

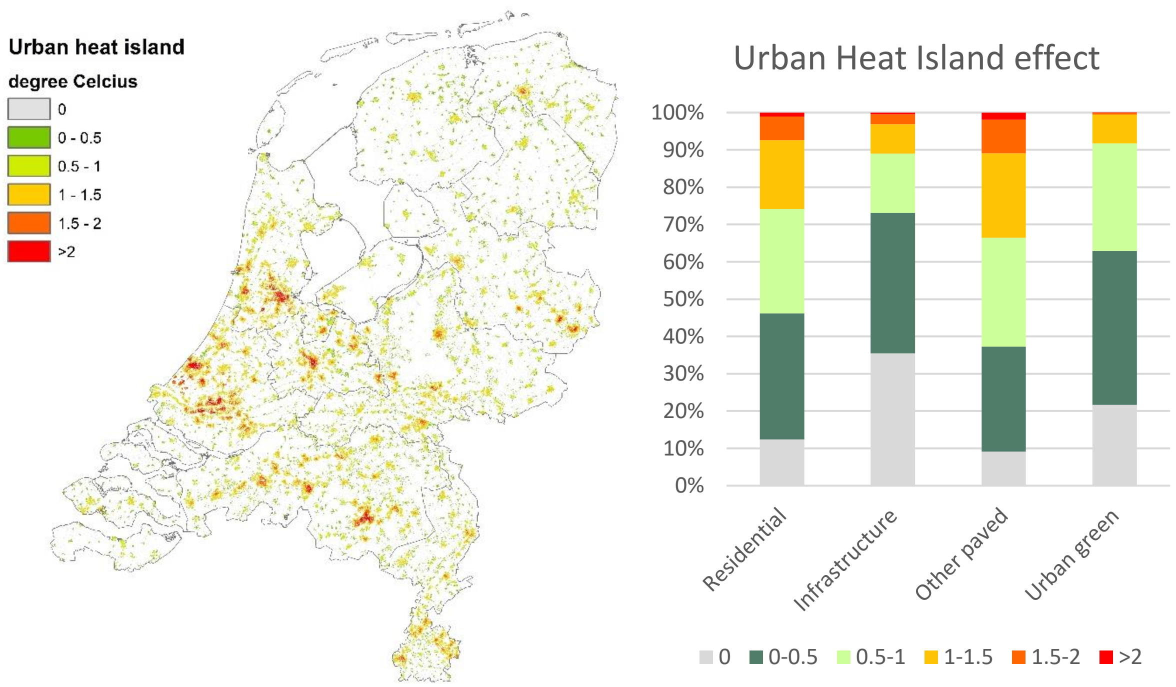


Figure I.10 Urban heat island effect (increased temperature in °C as compared to rural areas) depicted for a) cities in the Netherlands and b) per urban land use type. Here, other paved includes all business areas and other paved areas.

Pressures. Urban areas are warmer than rural areas. Residential areas and other paved areas (business and industry) are on average 0.7 °C, respectively 0.8 °C warmer than rural areas (Table I.4). The urban heat island effect is lower in urban green areas (urban parks), but these are still on average 0.4 °C warmer than rural areas. Residential areas and other paved areas have a higher percentage of area with more than 1.5 °C increase (7.4% respectively 10.9%) as compared to urban green areas where these temperatures are reached in less than 0.01% of the area (Figure I.10).

f. Open water

Open waters provide multiple ecosystem services. A few examples are drinking water from rivers and provisioning of fish for human consumption. Open water also provides opportunities for recreational activities such as water sport, like sailing, canoeing, angling or swimming. To align with international guidelines, the condition of water bodies in the Netherlands was based on data collected for the EU Water Framework Directive (see paragraph 3.6).

Mere 0.0% of area of water bodies and 0.1% of the length of water courses in the Netherlands have a good ecological condition (Figure I.11). The remaining area are in moderate (61.6% of the area of water bodies, 33.2% of the length of water courses), poor (38.0 % of the area of water bodies, 54.6% of the length of water courses) or bad condition (0.4% of area of water bodies and 11.6% of the length of water courses). The chemical quality is good in 3.5% of area of open water and in 20.6% of the length of the water courses in the Netherlands and poor in the remaining 96.5% area of the open water and 78.1% of the length of streams and rivers (Figure I.11).

Even though, the total number of lakes and ponds with good status of total phosporus, total nitrogen and transparency is approximately equal (about 37%). The total area of lakes and ponds with a good total phosphorus status is much higher than the total area of lakes and ponds with a good status for transparency (about 85% versus about 15%). In general, the status of the three physicochemical parameters; total phosphorus, total pitrogen and transparency, is better than for ecology (which is based on a combination of biology, physicochemical and river basin specific pollutants).

The generally poor quality of the Dutch water bodies has various causes. The main causes of the poor quality are design and management of Dutch surface water, and eutrophication.

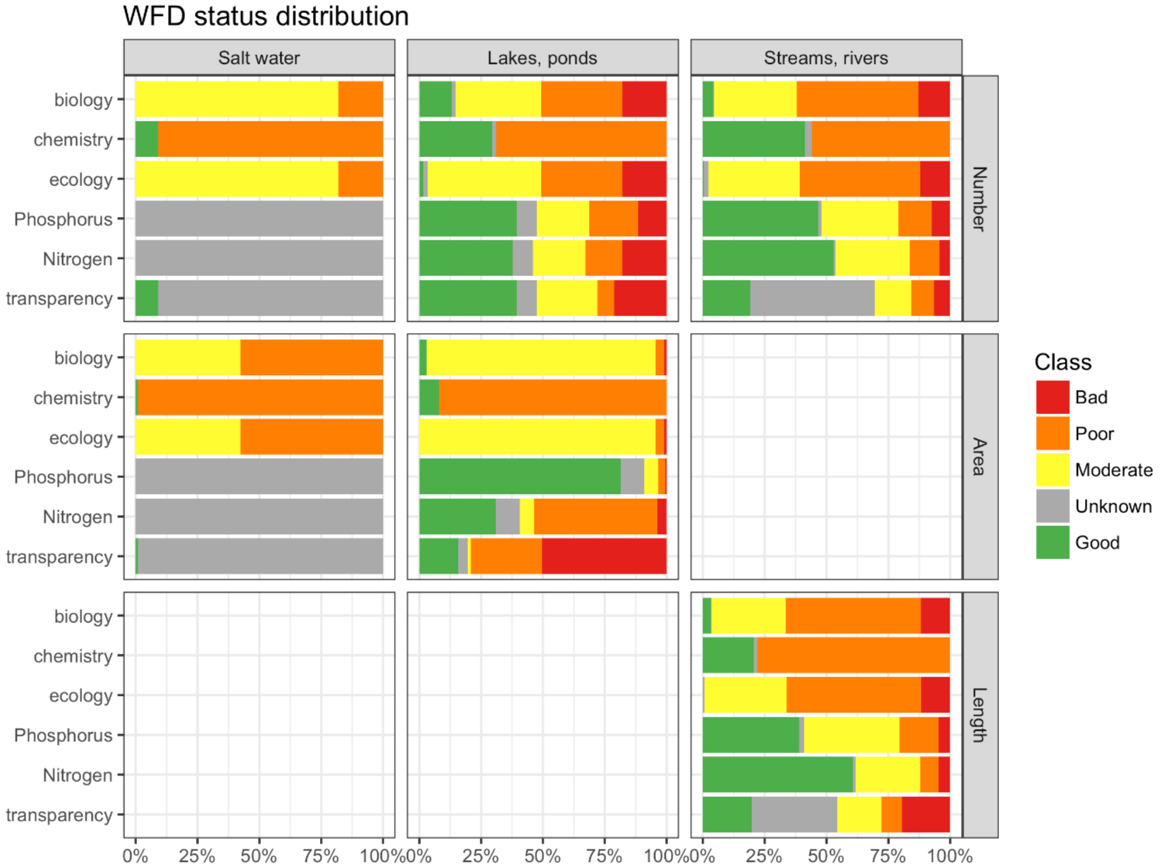


Figure I.11 Percentage of area of open water bodies in the Netherlands with bad (red), poor (orange), moderate (yellow), good (green), very good (blue) biological quality, chemistry, ecological quality, total P, total N and transparency. Depicted per water body or water course (top row), based on area of the water bodies (middle row) and based on length of the water courses (bottom row).

II. Annex – additional data

Table II.1 provides the raw data used to produce Figure 3.2.3 (CBS et al., 2017 d).

Table II.1 Ecosystem quality - Indices of characteristic species per ecosystem. Intact ecosystem=100.

	Marsh	Dunes	Heath land	Forest	Semi-natural grassland	Terrestrial nature
1994	58.8	53.3	40.3	35.2	35.3	45.4
1995	57.4	52.9	40.0	35.1	34.2	44.5
1996	56.1	52.5	39.6	34.9	33.3	43.6
1997	54.8	52.1	39.3	34.8	32.4	42.9
1998	53.7	51.7	39.0	34.7	31.6	42.1
1999	52.6	51.3	38.7	34.6	30.9	41.5
2000	51.6	50.9	38.4	34.5	30.3	40.9
2001	50.8	50.5	38.0	34.4	29.9	40.3
2002	50.0	50.0	37.7	34.3	29.5	39.9
2003	49.3	49.6	37.4	34.2	29.2	39.5
2004	48.7	49.2	37.1	34.1	29.0	39.1
2005	48.2	48.8	36.8	34.0	28.9	38.9
2006	47.8	48.4	36.5	33.8	28.9	38.7
2007	47.5	48.0	36.1	33.7	29.0	38.5
2008	47.3	47.6	35.8	33.6	29.2	38.4
2009	47.1	47.2	35.5	33.5	29.5	38.4
2010	47.1	46.8	35.2	33.4	30.0	38.5
2011	47.2	46.4	34.9	33.3	30.5	38.6
2012	47.3	46.0	34.5	33.2	31.1	38.8
2013	47.6	45.6	34.2	33.1	31.8	39.0
2014	47.9	45.2	33.9	33.0	32.6	39.3

Table II.2 combines data from “structure and function” and “typical species” from Bijlsma, and Janssen (2014). We used the assessment rules from Bijlsma and Janssen (2014) to calculate the overall assessment per Habitat type (Table II.2).

Table II.2 Assessment "structure and function" and "typical species" per habitat type 2013. Data from: Bijlsma and Janssen (2014).

Habitat Code	Habitat name (Dutch)	sum ha	% unknown	% excellent	% good	% average/ reduced	Assessment structure and function 2013	Total number of typical species	Number regionally extinct	Number favourable condition	Number unfavourable /inadequate	Number unfavourable /bad	Assessment typical species	Overall assessment
H1310	Zilte pionierbegroeiingen	2298.79	0	72.32	6.47	21.21	U1	12	0	8	3	1	U1	U1
H1320	Slijkgrasvelden	746.72	0	77.06	22.67	0.26	FV	1	1	0	0	0	U2	U2
H1330_A	Schorren en zilte graslanden (buitendijks)	9747.05	0	6.7	92.8	0.5	U1							
H1330_B	Schorren en zilte graslanden (binnendijks)	626.71	0	1.51	25.23	73.26	U2							
H1330_tot	Schorren en zilte graslanden	10373.76	0	6.38	88.72	4.9	U1	28	0	9	15	4	U1	U1
H2110	Embryonale duinen	645.98	0	87.59	1.55	10.86	FV	1	0	0	0	1	U2	U2
H2120	Witte duinen	1916.71	0	45.11	31.26	23.62	U1	12	0	7	3	2	U1	U1
H2130_A	Grijze duinen (kalkrijk)	7123.66	0	16.78	64.22	19	U1							
H2130_B	Grijze duinen (kalkarm)	8279.26	0	17.4	44.74	37.85	U2							
H2130_C	Grijze duinen (heischraal)	245.42	12.13	27.71	2.85	57.31	U2							
H2130_tot	Grijze duinen	15648.34	0	17.28	52.95	29.58	U2	51	0	23	13	15	U2	U2
H2140	Duinheiden met kraaihei	2487.09	0	27.6	70.32	2.07	U1	2	0	1	1	0	U1	U1
H2150	Duinheiden met struikhei	400.26	0	67.09	32.51	0.4	U1	3	0	3	0	0	FV	U1
H2160	Duindoornstruwelen	7746.52	0	90.31	5.79	3.9	FV	2	0	1	1	0	U1	U1
H2170	Kruipwilgstruwelen	886.11	0	72.86	9.75	17.38	U1	2	0	0	1	1	U2	U2
H2180	Duinbossen	7272.44	0	35.01	16.93	48.05	U2	5	0	5	0	0	FV	U2
H2190	Vochtige_duinvalleien	2126.16	0	23.44	75.1	1.46	U1	27	0	7	8	12	U2	U2
H2310	Stuifzandheiden met struikhei	2305.42	0	59.07	12.27	28.66	U1	26	0	8	7	11	U2	U2
H2320	Binnenlandse kraaiheibegroeiingen	792.41	0	99.92	0	0.08	FV	5	0	3	2		U1	U1
H2330	Zandverstuivingen *	3148.88	0	30.56	37.99	31.44	U2	16	0	9	2	5	U1	U2
H3110	Zeer zwakgebufferde vennen	30.43	0	0	88.6	11.4	U1	6	0	2	1	3	U2	U2
H3130	Zwakgebufferde vennen	336.17	0	53.15	33	13.85	U1	22	2	8	7	5	U2	U2
H3140	Kranswierwateren	8255.05	0	55.57	44.37	0.06	U1	13	0	5	5	3	U1	U1

H3150	Meren met krabbenscheer en fonteinkruiden	2923.99	0	47.51	35.89	16.6	U1	18	0	9	5	4	U1	U1
H3160	Zure vennen	663.1	1.05	65.96	18.25	14.74	U1	11	1	3	5	2	U2	U2
H3260	Beken en rivieren met waterplanten	90.06	0	55.45	39.34	5.21	U1	17	0	5	6	6	U2	U2
H3270	Slikkige rivieroevers	190.32	0	78.99	0	21.01	U1	8	0	7	1	0	FV	U1
H4010_A	Vochtige heiden (hogere zandgronden)	2043.35	0	41.71	33.32	24.97	U1							
H4010_B	Vochtige heiden (laagveengebied)	167.94	0	91.64	7.77	0.59	FV							
H4010_tot	Vochtige heiden	2211.29	0	45.5	31.38	23.12	U1	14	0	3	9	2	U1	U1
H4030	Droge heiden	15966.92	0	14.75	8.76	76.49	U2	26	1	8	9	8	U2	U2
H5130	Jeneverbesstruwelen	389.64	0	24.27	73.98	1.76	U1	2	0	1	0	1	U1	U1
H6110	Pionierbegroeiingen op rotsbodem	3.77	0	28.91	0	71.09	U2	7	0	2	2	3	U2	U2
H6120	Stroomdalgraslanden	240.15	0	60.3	2.04	37.66	U1	16	0	6	7	3	U1	U1
H6130	Zinkweiden	0.58	0	0	0	100	U2	3	0	0	1	2	U2	U2
H6210	Kalkgraslanden	49.62	0	90.53	8.79	0.69	FV	24	1	4	12	7	U2	U2
H6230	Heischrale graslanden	541.65	0	49.17	29.76	21.07	U1	14	1	2	5	6	U2	U2
H6410	Blauwgraslanden	338.63	0	0	77.63	22.37	U1	13	1	1	4	7	U2	U2
H6430	Ruigten en zomen	1890.72	100	0	0	0	U1	23	1	11	8	3	U1	U1
H6510	Glanshaver- en vossenstaarthooilanden	715.72	0	85.95	7.28	6.68	FV	18	0	9	6	3	U1	U1
H7110_tot	Actieve hoogvenen	193.16	0	34.98	57.8	7.23	U1	23	1	2	10	10	U2	U2
H7120	Herstellende hoogvenen	4796.68	0.02	55.19	31.08	13.71	U1	21	1	2	8	10	U2	U2
H7140_tot	Overgangs- en trilvenen	1387.21	0	25.5	20.06	54.46	U2	22	0	2	6	14	U2	U2
H7150	Pioniervegetaties met snavelbiezen	233.09	0	49.2	29.25	21.55	U1	3	0	3	0	0	FV	U1
H7210	Galigaanmoerassen	92.08	0	10.38	58.59	31.03	U2	1	0	1	0	0	FV	U2
H7220	Kalktufbronnen	0.24	0	66.67	20.83	12.5	U1	6	0	1	3	2	U2	U2
H7230	Kalkmoerassen	8.16	0	12.5	31.5	56	U2	6	0	0	3	3	U2	U2
H9110	Veldbies-beukenbossen	492.09	0	100	0	0	FV	14	0	10	4	0	U1	U1
H9120	Beuken-eikenbossen met hulst	7274.67	0	94	0	6	FV	8	0	8	0	0	FV	FV

H9160_A	Eiken-haagbeukenbossen (hogere zandgronden)	173.3	0	6.98	6.87	86.15	U2							
H9160_B	Eiken-haagbeukenbossen (heuvelland)	767.37	0	86.75	13.05	0.2	FV							
H9160_tot	Eiken-haagbeukenbossen	940.67	0	72.05	11.91	16.04	U1	39	1	18	9	11	U2	U2
H9190	Oude eikenbossen	2343.26	0	91.85	3.59	4.56	FV	9	0	7	2	0	FV	FV
H91D0	Hoogveenbossen	655.09	0	20.34	18.14	61.53	U2	5	0	2	3	0	U1	U2
H91E0_A	Vochtige alluviale bossen (zachthoutooibossen)	3252.1	0	53.86	26.78	19.36	U1							
H91E0_B	Vochtige alluviale bossen (essen-iepenbossen)	111.29	0	0	67.02	32.98	U2							
H91E0_A+ B		3363.39	0	52.08	28.11	19.81	U1							
H91E0_C	Vochtige alluviale bossen (beekbegeleidende bossen)	1025.51	0	9.1	46.74	44.16	U2							
H91E0_tot	Vochtige alluviale bossen	4388.9	0	42.03	32.46	25.5	U2	37	2	16	14	5	U1	U2
H91F0	Droge hardhoutooibossen	62.28	30.56	0	50.46	18.98	U1	4	0	3	1	0	FV	U1