MAIA

Mapping and Assessment for Integrated ecosystem Accounting

National Monitoring Data & Accounting for Biodiversity

Deliverable 4.4

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Contents

MAIA
Mapping and Assessment for Integrated ecosystem Accounting

EXECUTIVE SUMMARY

This report provides a synthesis of the experiences and lessons learned in using national biodiversity monitoring data for ecosystem accounting by MAIA countries. It provides a contribution from the MAIA project to the body of research in implementing the System of Environmental Economic Accounting Ecosystem Accounts (SEEA EA) framework for mainstreaming biodiversity into decision-making.

Target Audience

The report targets both ecosystem accounting practitioners and the potential users of these accounts. For producers, it summarises the technical approaches being applied by MAIA countries in 'Accounting for Biodiversity' using the SEEA EA so they may benefit from the experiences of others. For potential users, it illustrates the possibilities for generating key indicators and analyses that can help inform decision-making for better outcomes for biodiversity using the SEEA EA.

Context and Knowledge Gap

The SEEA EA describes thematic accounting for biodiversity as one of four themes in Chapter 13. Integrating national biodiversity monitoring data in the SEEA EA via thematic 'Accounting for Biodiversity' can support more coherent environmental-economic policy responses to addressing biodiversity loss. However, there are limited real world applications that demonstrate this in practice. This report has been produced to address this gap by providing a collated set of experiences from MAIA countries in the field of thematic accounting for biodiversity.

Research aim / questions

The report aims to answer the following research questions:

- How can existing national biodiversity monitoring processes (e.g., Norwegian Nature Index, Natura 2000 habitat type mapping database for Greece) be adapted for informing Accounting for Biodiversity and Ecosystem Condition Accounting?
- What specific biodiversity data items could be included in SEEA EA accounts (including Species) for better guiding decisions on biodiversity?

Methods

The report has been compiled based on case studies contributed by different MAIA country representatives and associated interviews. This was supported with literature research on any associated ecosystem accounts that have been published. The case studies summarised in the report relate to: Bulgaria; Finland; France; Germany; Greece; The Netherlands; Norway; and, Spain. This rich set of experiences was used to answer the research questions guiding the report.

Relevance of findings for mainstreaming NCA

With respect to Using National Biodiversity Monitoring, the report highlights the following:

- Established processes for organising monitoring data for reporting on the EU Nature Directives and National Biodiversity Indexes can support ecosystem accounting.
- National IUCN Red List type assessments can be used to compile 'Species Accounts'.
- Species abundance and richness accounts developed from national biodiversity monitoring data can inform ecosystem condition and cultural services accounts.
- Where spatial referencing for national biodiversity data is limited, information on species can be assigned to different broad ecosystem types based on species habitat preferences.
- Structured frameworks such as the Elite Index (Finland) and IBECA index (Norway) can be adapted to inform SEEA EA Ecosystem Condition Typology.

With respect to which biodiversity data items can be included in ecosystem accounts to better guide decisions on biodiversity, the report highlights the following:

- Integrating red list assessment data into ecosystem accounts can help inform a more integrated planning for achieving conservation objectives.
- Compositional state indicators need to be included in ecosystem condition accounts as other condition characteristics do not adequately reflect trends in species assemblages.
- Extended analyses carried out by France and Germany allow for a "Biodiversity Debt" to be estimated, which allows levels of underinvestment and budgetary investments to be determined.
- Integration of thematic 'Protected Area Accounts' into the SEEA EA will be helpful for decision-makers evaluating different land use and sustainable development options.
- Biodiversity trends presented in ecosystem accounts need reference thresholds, so that decision-makers realise what is in good or poor condition.
- Science based policy targets provide reference levels to track progress towards national biodiversity objectives.

Next steps and recommendations

The report highlights the need for further experimentation and development of extended applications of the SEEA EA for mainstreaming biodiversity into planning processes. In-depth discussions with a broad range of potential users of these accounting outputs should be prioritised to explore how they can best be developed to meet their needs. Where links can be made to policy targets and thresholds indicative of good condition for biodiversity, this will be particularly useful for guiding decision-makers. Collectively, this can help to deliver on the potential of the SEEA EA to guide sustainable development that delivers better outcomes for biodiversity and people.

1. INTRODUCTION

The importance of conserving and enhancing biodiversity for achieving sustainable development is well-established. The UN Agenda for Sustainable Development explicitly recognises that biodiversity losses are exacerbating the development challenges humanity faces (UN, 2015). The recent IPBES (2019) report identifies that declines in biodiversity undermine progress towards 80% of the SDG Targets. Reflecting the importance of biodiversity to development and well-being 'We need biodiversity in our lives' fronts the most recent EU Biodiversity Strategy to 2030 (EC, 2020) and is a stated priority of the European Green Deal (EC, 2019).

To help address biodiversity loss and stimulate biodiversity investment, IPBES (2019), the CBD (via Aichi Target 2), the SDGs (via SDG Target 15.9) and the EU Biodiversity Strategy (Section 3.3.3) all call for the mainstreaming of the values of biodiversity and ecosystem services into development planning. This is the stated context for the implementation of the System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA) framework, adopted as an official statistical standard in 2021 (UNSD, 2021). The SEEA EA provides a statistical framework for ongoing measurement of changes in the state of the environment and its relationship to economy and other human activity. This is central to ensure that biodiversity and ecosystems are mainstreamed in decision-making processes, particularly those concerning our economic and financial systems (UNSD, 2021).

There is now a growing group of countries producing SEEA Ecosystem Accounts for mainstreaming biodiversity into decision-making (Ruijs & Vardon, 2019). This includes the European Union (EU) via the KIP INCA project (UNEP-WCMC, 2017, 2019; Vallecillo et al., 2018), Uganda, Canberra in Australia and Peru (colectively reviewed in King et al., 2021), the Netherlands (Bogaart et al., 2020), Mexico (Schipper et al., 2017), the Southeast USA (Warnell et al., 2020), KwaZulu-Natal in South Africa (Driver et al., 2015) and the Great Barrier Reef in Australia (ABS, 2017). Through these and other efforts, the SEEA EA continues to gain recognition as an operational framework for integrating the values of biodiversity into decision-making (Burnett et al., 2020; Dasgupta., 2021; Nature, 2020).

1.1. Accounting for Biodiversity

The SEEA EA adopts the CBD definition of biodiversity: "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".[1] The core physical accounts of the SEEA EA organise information on ecosystem-level biodiversity, including on the extent and condition of ecosystems. The core physical and monetary

[1] https://www.cbd.int/doc/legal/cbd-en.pdf

ecosystem services accounts provide information on some of the values of biodiversity, although these should always be understood as partial, and underestimates of the full value of biodiversity.

The core accounts of the SEEA EA allow for the broad measurement of ecosystem-level biodiversity and integration with standard economic information. However, the SEEA EA also describes thematic accounting for biodiversity, as one of four themes in Chapter 13. Thematic accounting using the SEEA EA recognises that policy and analysis about the environment, and its interactions with society and the economy, can be framed in different ways. The guiding principles for thematic accounting build directly from the SEEA EA. They require a geographical or ecosystem accounting area of focus, clearly defined entities that are the focus of accounting, and a set of accounts that are most relevant to the theme (i.e., from across the SEEA EA, SEEA Central Framework and SNA). The use of consistent measurement boundaries, concepts and classifications allows this information to be analysed in an integrated manner.

Thematic accounting opens up the potential for integrating information on the other levels of biodiversity (i.e., species and within species diversity), with information on ecosystems. This includes integrating information on accounts of species conservation status, abundance, distribution or suitable habitat, as described in the SEEA EA Subsection 13.3.3 and UNEP-WCMC (2016). Thematic accounting for the genetic level of biodiversity is also highlighted in the SEEA EA. However, further development of these types of accounts is required.

Unlike most other ecosystem attributes and values being assessed by accounts, spatial scaling of biodiversity is also strongly non-additive. This means that any assessment of biodiversity within a geographical or ecosystem accounting area needs to consider not only the variation within an ecosystem asset but also how species assemblages vary between ecosystem assets (King et al., 2021). The same applies to consideration of the effects of habitat configuration, especially connectedness / fragmentation and associated impacts on biodiversity. Larsen et al. (2021) provide a background paper to support Accounting for Biodiversity, which provides technical solutions for spatial aggregation and derivation of habitat-based biodiversity metrics via the SEEA EA.

1.2. Research questions

To achieve the best representation of biodiversity in ecosystem accounts, account compilers need data that accurately describes the distribution and condition of different components of biodiversity (e.g., ecosystems, species and within species diversity), as well as the ecosystem services that arise from biodiversity, the benefits these provide and who the associated beneficiaries are. Therefore, national biodiversity monitoring programmes that collate these types of data are essential sources of information for ecosystem accounting. Further, the integration of these data into national accounts is also essential if coherent environmental-economic policy responses are to be implemented.

This report aims to contribute to existing work on 'Accounting for Biodiversity' using the SEEA EA. It provides a synthesis of the experiences and lessons learned in using national biodiversity monitoring data for ecosystem accounting by participating countries in the MAIA project. Based on the review of associated accounting outputs and interviews with MAIA partners, it aims to answer the following research questions:

- How can existing national biodiversity monitoring processes (e.g., Norwegian Nature Index) be adapted for informing Accounting for Biodiversity and Ecosystem Condition Accounting?
- What specific biodiversity data items could be included in SEEA EA accounts (including Species) for better guiding decisions on biodiversity?

The remainder of the report is set out as follows. In Section 2 the experiences of MAIA countries in Accounting for Biodiversity are summarised. Section 3 then draws on this stock take to answer the research questions posed above. The conclusions to the work are presented in Section 4.

2. MAIA EXPERIENCES IN ACCOUNTING FOR BIODIVERSITY

As part of the MAIA project inception, factsheets were produced for each of the participating countries.[2] The factsheets provided a high-level overview of the ecosystem accounts under development by MAIA countries, including with respect to thematic 'Accounting for Biodiversity'. The factsheets described the development of thematic accounts for biodiversity via the MAIA project in the following countries: Belgium (Flanders); Bulgaria; Greece; Finland (Forests); Netherlands; Norway; and Spain. It was noted that there were no plans for thematic accounting for biodiversity to be completed in Czech Republic. In addition to the factsheets, the regular MAIA webinars on country experiences and progress provided an opportunity to understand where countries may be engaging in activities relevant to accounting for biodiversity. This highlighted further work by France and Germany on 'Accounting for Biodiversity'.

To establish a fuller understanding of countries activities based on the above, a series of interviews was completed in the year 2021 to establish progress in 'Accounting for Biodiversity' with MAIA countries and obtain associated research outputs. This informed a preliminary report that provided an overview of approaches for 'Accounting for Biodiversity' being implemented by MAIA countries and their progress at that stage. During Summer 2022, MAIA countries were engaged again to capture further progress made in the final stages of the project and inform this final report.

The purpose of this section is to summarise the work being undertaken in each of the MAIA countries engaged in 'Accounting for Biodiversity', as described above. This final report aims to provide a rich overview of a range of practical approaches for 'Accounting for Biodiversity' implemented by MAIA countries. It is hoped this will provide a valuable resource to support practitioners throughout Europe and beyond to better integrating information on biodiversity into ecosystem accounts.

2.1. Bulgaria

In Bulgaria, 92 different types of habitats are described, according to the EU Habitats Directive. These habitats provide a home to more than 700 species of national and European interest, which are part of the Bulgarian National Biodiversity Monitoring System. Thematic accounting for biodiversity under MAIA focuses on the calculation of accounting indices that show the status and trends in biodiversity

[2] Factsheets available here: https://maiaportal.eu/factsheets

changes over time. In particular, drawing on national bird monitoring data and on national Red List assessments for trends in threat status.

2.1.1. National biodiversity data used

There are established locations for the systematic monitoring of Bulgaria's biodiversity. At the national scale, the mid-winter bird census is the longest running monitoring scheme in Bulgaria running from 1976. Monitoring sites are established for different geographical areas, as well as protected areas, including Natura 2000 sites. More detailed information is also available for species of special conservation concern, including bear (*Ursus arctos*) and chamois (*Rupicapra rupicapra*). These data cover important habitat areas, such as mountain ranges, where these species occur.

The established monitoring of Bulgaria's biodiversity allows for a range of species trend metrics to be determined. These include trends in abundance based on counts of individuals, as well as relative trend indices. More detailed monitoring data, for example for bears, allows trends in populations age structures to be tracked over time.

A key reporting application of the monitoring data collected by Bulgaria is for the European Nature Directives. Specifically, with respect to Article 12 of the EU Birds Directive and Article 17 of the Habitats Directive. The organisation of monitoring data to support these reporting processes also helps to streamline the data organisation process for compiling the accounts and integrating it with information on ecosystem extent.

In addition to the systematic monitoring data on species described, two national IUCN Red List Assessments have been completed. The IUCN Red List assesses the extinction risk of species, with the intention to catalyse and inform action to address negative trends in the global distribution of that species. National Red Lists are led by national-level institutions, including government agencies, academic and non-governmental organisations. Two editions of The Red Data Book of Bulgaria (i.e., the national Red List Assessment) have been produced. The most recent was produced by the Bulgarian Academy of Sciences & Ministry of Environment and Water in 2015.[3] Prior to this, an earlier version was produced in 1984 for vascular plants and 1985 for vertebrate animals.

2.1.2. Compiling the Accounts

This section summarises the initial Species Accounts based on Article 12 and Article 17 reporting data and Red Data Books for Bulgaria. It also outlines plans to develop further species abundance accounts based on the mid-winter bird census.

2.1.2.1. Species Accounts using data for EU Nature Directives

[3] http://e-ecodb.bas.bg/rdb/en/

Bird species data for breeding and wintering birds in Bulgaria is available for the two most recent rounds of reporting under the Article 12 of the EU Birds Directive. Specifically, 2007 – 2012 (opening period) to 2013 – 2018 (closing period). A key feature of reporting data is the requirement for reporting on bird species distribution. This allows for spatial data to be presented using 10km x 10km grids of species distributions (see Figure 1). This can also help draw focus to those parts of the country that are particularly important for biodiversity (i.e., relatively higher bird species richness).

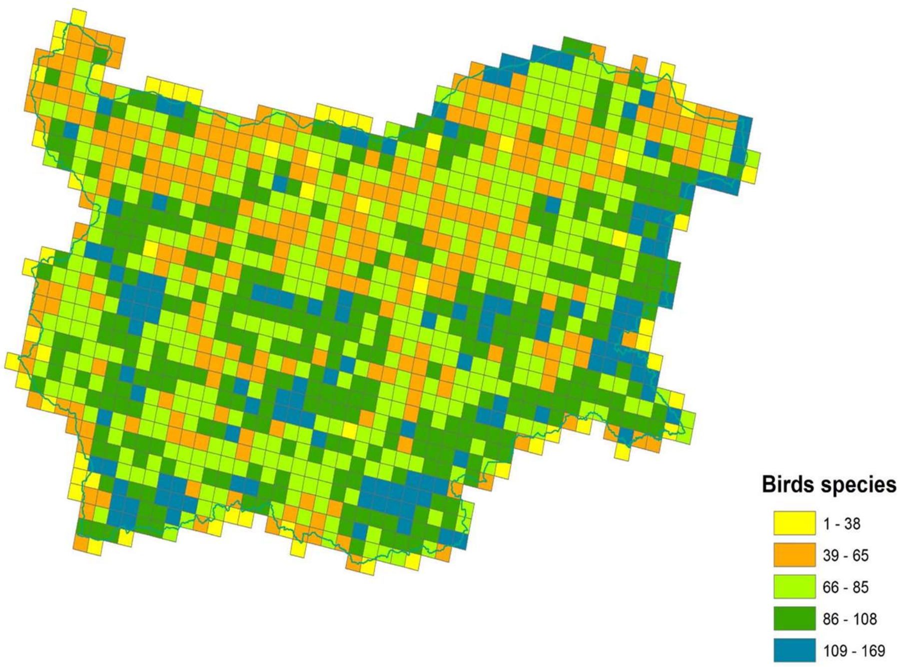

Figure 1: Bird Species Distribution under Article 12 Bird Directive Reporting Data using the ETRS 10 x 10 km Grid for 2013 – 2018

Whilst Figure 1 provides an opportunity to spatially align with coarse resolution information on ecosystem extent. However, on the ground, 10 km grids will contain multiple ecosystem types. As such, the approach used to align information on bird species with ecosystem extent is to use habitat preferences proposed by the European Environment Agency (EEA, 2015, as also adopted in the EU State of Nature Reporting). This broadly follows the approach of UNEP-WCMC (2017).

Following the approach described in UNEP-WCMC (2017), Table 1 presents bird species status accounts for Bulgaria based on Article 12 reporting data for 2007-2012 (opening period of the accounts) to 2013-2018 (closing period). The accounts make use of the European Red List of Birds Assessments completed in 2015 and 2021 (BirdLife International, 2015, 2021) and organise bird species monitoring data into threat status categories for the opening and closing periods in Table 1. The 'Aggregate index' in Table 1 aggregates information across the threat status category in the same way as the IUCN Red List Index, essentially summarising a distance to the desirable situation of all species being 'secure' (i.e., Index = 100).

Table 1: Bird Species Status Account for Bulgaria based on EU Species Threat Status

	Forest	Croplands	Wetlands	Rivers and lakes	Grasslands	Sparsely vegetated land	Heathlands and Shrubs	Urban	Marine	Total species
Opening (2007-2012)										
Secure	58	34	32	26	14	18	22	19	1	224
Not secure	14	14	5	7	7	9	5	10	1	72
Threatened	27	11	20	39	12	32	9	3	1	154
Unknown	3	1	4	4	2	3	0	1	0	18
Total species	**99**	**60**	**61**	**76**	**35**	**62**	**36**	**33**	**3**	**465**
Aggregate index 2007 – 2012	***65.65***	***75***	***63.11***	***44.07***	***55.71***	***63.7***	***68.05***	***75.75***	***50***	***59.13***
Closing (2013-2018)										
Secure	47	28	13	20	11	14	16	16	1	166
Not secure	13	17	5	5	8	9	6	8	1	72
Threatened	35	15	39	49	14	33	12	6	1	204
Unknown	1	2	2	2	1	1	1	1	0	11
Total species	**96**	**62**	**59**	**76**	**34**	**57**	**35**	**31**	**3**	**453**
Aggregate index 2013 - 2018	***56.32***	***60.83***	***27.19***	***30.41***	***45.45***	***30.04***	***55.88***	***66.67***	***50***	***47.01***
Net change										
Secure	-11	-6	-19	-6	-3	-4	-6	-3	0	-58
Not secure	-1	3	0	-2	1	0	1	-2	0	0
Threatened	8	4	19	10	2	1	3	3	0	50
Unknown	-2	1	-2	-2	-1	-2	1	0	0	-7
Total species	-3	2	-2	0	-1	-5	-1	-2	0	-12
Aggregate Index	***-9.33***	***-14.17***	***-35.92***	***-13.66***	***-10.26***	***-33.66***	***-12.17***	***-9.08***	***0***	***-12.12***

As Table 1 reveals, across all of Bulgaria's terrestrial ecosystem types, there is an increase in the number of threatened species (assessed at European scale) and aggregate threat status. This is particularly noticeable for wetlands (aggregate index change of -35.92) and sparsely vegetated land (-33.66) ecosystems in Bulgaria. The results reflect the increasing extinction risk to birds in Europe, as demonstrated via the most recent assessment (BirdLife International, 2021). Work is ongoing to develop the species status accounts in Table 1 to include national indices on bird species abundance. This will identify if bird species populations in Bulgaria are generally following the continental trend in these ecosystems, or if ecosystems in Bulgaria are proving better conditions that support European bird species populations and their recovery.

In addition to making use of the Article 12 reporting data for the Birds Directive, species accounts are also being compiled for Bulgaria using Article 17 reporting data from the Habitats Directive. The species accounts will use information on changes in species conservation status reported in different biogeographical regions of Bulgaria under Article 17 of the Habitat directive for the 2007 to 2012 and 2012 to 2018 reporting periods. This will allow for aggregate indicators of conservation status and changes over the reporting periods to be determined. The Article 17 reporting requirements also allow for spatial data to be presented using 10km x 10km grids of species and habitats distributions (see Figure 2). However, given the coarseness of this data, species are assigned to different MAES ecosystem types on the basis of the preferences identified by the EEA (2015) (as per the Bird Species Accounts compiled using Article 12 data).

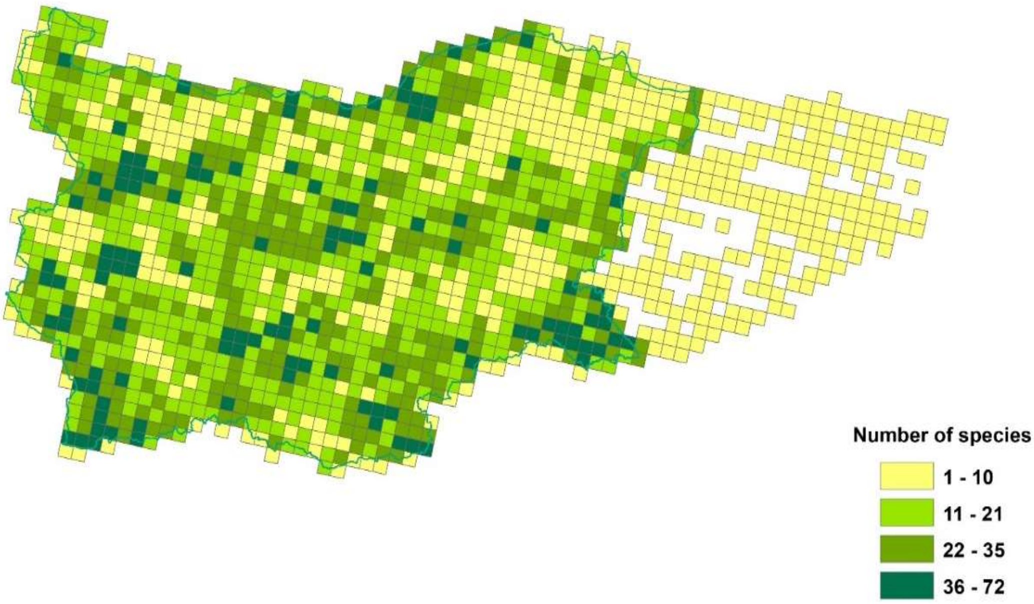

Figure 2: Species Distribution under Article 17 Habitats Directive Reporting Data using the ETRS 10 x 10 km Grid for 2013 – 2018

2.1.2.2. Threatened Species Accounts

Accounting for species threat status is recognised in the thematic accounting chapter of the SEEA EA framework. This type of approach, also highlighted by Table A4.1 of the SEEA-EEA (2012), suggests a supplementary account for threatened species (UN et al., 2014). A number of national and sub-national applications of threatened or endangered species accounts exist. Several such accounts have been compiled for sub-national areas in Australia. For instance, the Central Highlands of Australia (Keith et al., 2017). Elsewhere, via the EU Funded NCAVES project, threatened species accounts based on IUCN Threat Status Classes have been compiled for Brazil.[4]

For such accounts to be compiled, threat status assessments need to have been carried out for two or more time periods. This is the case with the two editions of the Red Data Book produced for Bulgaria. The first Red List was published in 1984 for vascular plants and in 1985 for vertebrates. In these lists, species are separated into three categories: Extinct; Endangered; and, Rare (see Table 2). The criteria by which the species are classified into the relevant categories do not fully follow the IUCN criteria but refer to parameters included in the IUCN criteria, such as population size, distribution and factors influencing their conservation status. In 2015, a second edition of the Red Book was published, in which species are described according to the IUCN criteria.

The assessment of conservation status and trends by biological group and species in both editions can only be made for those species presents in both Red Books. For these species, the Red List index is calculated by making following approximations using the crosswalk presented in Table 2.

Table 2: Crosswalk between 1984 and 2015 threat status categories

Red List Category=	**Red Book 1984 & 1985**	**Red Book 2015**
Extinct	Extinct	Extinct and Regionally extinct
Threatened	Endangered	Critically Endangered (CR) Endangered (EN) Vulnerable (VU)
Lower Risk	Rare	Near Threatened (NT) Conservation Dependent (CD) Least Concern (LC)

Table 3 presents the threatened species accounts for vascular plants and vertebrates in Bulgaria, based Red Data Books from the 1980s and 2015. The set of species included in Table 3 is consistent between 1985 and 2015. The accounts reveal a national reduction in extinct vascular plant species between 1985 and 2015 (-6) and an increase in nationally extinct vertebrates (+2). Across both vascular plants and vertebrates there is a large rise in in threatened species between 1985 and 2015

[4] In Portuguese: https://seea.un.org/sites/seea.un.org/files/images/Brazil/liv101754_folder_especies.pdf

(243 and 39, respectively). This is associated with commensurate decreases in the number of species at lower (threat) risk, indicative of species transitioning from low risk to threatened between 1985 and 2015.

Table 3: Threatened vascular plants and vertebrate species account (Bulgaria, 1985 to 2015)

	Vascular plants			Vertebrates		
	1985	2015	Net change	1985	2015	Net change
Extinct	18	12	-6	14	16	+2
Threatened	103	345	+243	79	118	+39
Lower risk	310	74	-236	42	1	-41
Total species	431	431	-	135	135	-
Red List Index	0.88	0.57	-0.31	0.7	0.44	-0.26

The finial row in Table 3 summarises changes in overall extinction risk using the same weighting procedure employed by IUCNs Red List Index (RLI) (e.g., see Bubb et al., 2009). Negative changes in the RLI for both vascular plants (-0.31) and vertebrates (-0.26) are observed, driven by the large number of increases in species assessed to be threatened between 1985 and 2015, and commensurate decrease in species assessed to be at lower risk.

2.1.2.3. Mid-Wintering Bird Species Accounts

In addition to the species accounts described above, accounts are being prepared for the period 1976 to 2021 using the mid-winter bird census monitoring data. These will include all wintering bird species and their wintering trends. The count data from the monitoring schemes will be analysed using the TRends and Indices for Monitoring data (TRIM) software package (Pannekoek & Van Strien, 2006). This will allow for yearly indices of wintering bird species to be determined from 1976 to 2021. It is anticipated the accounts will be compiled at the end of September 2022.

2.1.3. Key insights

The work reveals the following key insights for 'Accounting for Biodiversity':

- The organisation of reporting data for the EU Nature Directives provides a ready source of information that can support thematic accounting for biodiversity. These can also yield summary indicators for bird species diversity that can support ecosystem condition accounting.
- Where information on species status is collected, this can also be used to supplement the above and help inform planning for achieving conservation objectives and realising associated

ecosystem service benefits. For instance, comparative analysis of trends in member states and those for Europe as a whole can help identify countries whose ecosystems are in relatively better condition for different species groups.

- There is a lack of sufficient data on some biological groups or species specific to certain ecosystem types (e.g., data on agricultural and marine ecosystems).
- The Red Book based accounts show how data from national species assessment processes can inform thematic accounts for biodiversity.

2.2. Finland

As part of the MAIA project, Finland investigated the correlation between a composite structural ecosystem condition metric and species-level biodiversity metric (i.e., a composition indicator) in forest ecosystems. The study focused on protected areas because of greater data availability. The hypothesis tested is that forests that are of better quality and have more features of natural forest environment will maintain more diverse and abundant bird populations. The aim of the study was to understand whether monitoring schemes based solely on structural variables could alone provide enough information on the state of biodiversity (or condition with respect to compositional state) in the study areas, or if species level monitoring was also needed to complement the view.

The study also provided important insight into how biodiversity data from established monitoring programmes in Finland could be integrated into the SEEA EA ecosystem condition accounts and typology, as well as for the compilation of thematic “Species Accounts” as set out in Chapter 13 of the SEEA EA.

2.2.1. National biodiversity data used

The data used in the study is part of that collected by Metsähallitus, a state-owned enterprise that manages state owned lands in Finland. This includes management of Finland’s state-owned forests, parks and wildlife as a resource that can benefit all of the population. Metsähallitus has various objectives related to biodiversity conservation, public enjoyment of nature, cultural heritage and commercial activities, for which it needs biodiversity monitoring data.

In the study, the data describing the forest structural variables was the Protected Area Biotope Compartment Data produced by Metsähallitus.[5] The bird data was collected using the Finnish line transect census method (Järvinen & Väisänen, (1975), see Virkkala et al., (2020) for a recent description), which is mostly collected by Metsähallitus within protected areas. This Protected Area Biotope Compartment Data provides information on forest stands (on average 2ha in area). The data

[5] https://www.paikkatietohakemisto.fi/geonetwork/srv/eng/catalog.search#/metadata/e3aa7b2a-e6e2-45dc-a29a-b64bcf2aba9f

collected comprises delineation of the protected areas and several variables describing the structure of the forest stands in those areas, including ecosystem type, tree species abundance grouped into size classes and deadwood abundance. The data was used to further derive the variables needed to compute the so called 'ELITE index' for forests condition which is described in the next chapter. This spatially explicit and fine-scale data approach captures variation in habitat quality inside protected areas and enables estimating absolute and relative area of good quality habitat patches.

The Protected Area Bird Species Monitoring Data consists of species and overall pair density information from standardised 3-6km line transects (described in Järvinen & Väisänen, 1975; Virkkala et al., 2020). Sites used in the study consisted mainly of Natura 2000 sites. Protected forest areas of under 2ha or under 10% of total protected area were excluded because of uncertainties in estimated bird population density. Annual observations were aggregated on decades, ranging from 1980 to 2020 (temporal coverage differs between protected areas). Those that were temporally best matched with forest stand data described above were used in the study. Observations of bird species are also organised into a subset of FINIBA indicator species (i.e., indicators of good ecosystem condition of Finnish Important Bird Areas). These are species are those considered to be important for Finland in the IBA delineation process.

2.2.2. Compiling the Accounts

The study explores the potential to use the ELITE-index for measuring ecosystem condition in the SEEA EA. The ELITE method was developed by an expert group that was established to estimate condition of all ecosystems in Finland (Kotiaho et al., 2016; Kotiaho et al., 2015) and named based on the acronym of the group. For each broad ecosystem type in Finland, the expert group identified the most important variables describing its condition and a reference state that could be used for comparing the current state. The reference states were estimated based on scientific studies and expert knowledge. Considered features in boreal forests include number of large trunks, and amount of dead wood and broad-leaved trees. The variables were further weighted by their assumed importance for biodiversity and combined to a single index describing the naturalness of an area. Full ELITE process description and R script are available at GitHub.[6]

The method has been used before in broad national scale assessment and can be used to inform the ecosystem condition indicator account described in Table 5.3 of the SEEA EA and derive an associated sub-index for structural ecosystem condition. An example of this is presented in Table 4 for the forest protected areas in Southern Finland (Figure 3). The ecosystem condition indicator account in Table 4 reflects the state of structural ecosystem condition of forest protected areas based on data collected from 2000 and 2020. Further experimentation is required to fully evaluate the possibilities of generating condition indicators for different accounting periods.

[6] https://github.com/PKullberg/EEA_and_BD/tree/master/ELITE_index

Table 4: Forest Ecosystem Condition Indicator Account using ELITE Index for Forest Protected Areas in southern Finland (map). Area-weighted mean values for 2000-2020. [7]

SEEA ECT Class	Indicators	Variable values per ha	Natural reference level	Weights	Indicator values
Herb-rich forests	Large trunks (n)	13.32	30	0.4	0.44
	Dead wood (m^3)	12.80	100	0.4	0.13
	Broad leaved trees (m^3)	151.52	100	0.6	1.00
	ELITE-Index		1	-	0.35
Moist heath forests	Large trunks	1.76	20	0.4	0.08
	Dead wood	3.69	80	0.6	0.04
	Broad leaved trees	20.27	50	0.4	0.40
	ELITE-Index		1	-	0.18
Dry heath forests	Large trunks	0.19	10	0.62	0.02
	Dead wood	1.48	40	0.62	0.04
	Broad leaved trees	-	-	-	-
	ELITE-Index		1	-	0.16

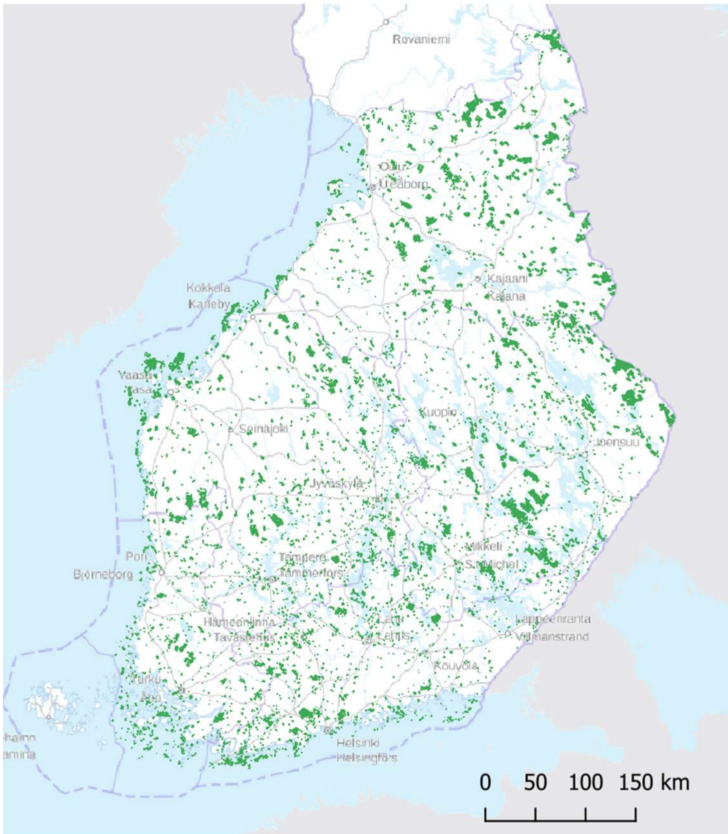

Figure 3: Forest Protected Area for which the ELITE Index has been estimated

[7] Note the forests in Lapland are excluded as Elite is sensitive to latitude (i.e., forests grow slower in the north). Therefore, the reference levels stated are not appropriate in this part of the country.

The bird species monitoring data essentially records the abundance of different breeding pairs of species in the forest protected areas. These data allow for a range of compositional state indicators to be derived for forests, such as bird species richness. Ideally, using species data should move beyond simple counts of the number of species and include information on the population sizes of each species (species abundance), as this provides more information on the status of biodiversity and is likely to be a more sensitive indicator of species-level biodiversity responses to declines in ecosystem condition and other pressures (UNEP-WCMC, 2016). Two such indicators that can be derived in this regard include the density of forest birds and the density of FINIBA birds for stands in forest protected areas. By being able to align the bird monitoring data to the extent of forest protected areas, these indicators can be readily determined. The correlation between these three compositional indicators and the ELITE-Index is evaluated in the following sub-section.

Another way to employ the bird species monitoring data would be in the compilation of 'Species Accounts', as described in Subsection 13.3 of the SEEA EA. The intention of these accounts is not necessarily to provide a complete inventory of species in an Ecosystem Accounting Area of interest (i.e., the forest protected areas). Rather, they could focus on species of conservation concern, social or cultural significance, important for ecosystem condition (e.g., FINIBA Species) or ecosystem services. With respect to this final focus, Table 5 presents a structure for organising information on the abundance of key bird species for recreation related ecosystem services. This includes for instance key bird species important for bird watching or hunting activities.

Table 5: Proposed Structure for Key Recreational Bird Species Account for Forest Protected Areas

	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7
Opening year (No. Breeding Pairs)							
Net Change							
Closing year (No. Breeding pairs)							

2.2.2.1. Modelling correlation between compositional and structural indicators

In total, observations for 539 forest stands in protected areas were available for which spatially explicit ELITE-indices could be calculated and reliable bird monitoring data was available. This spatially explicit and fine-scale approach captures the variation in habitat quality inside protected areas and enables estimating absolute and relative area of good quality habitat patches.

The correlation with the bird species compositional variables and ELITE-Index was studied in R by modelling bird overall density, density of different species groups, and species diversity using multivariate generalised linear models (GLM) and having log-transformed ELITE condition attributes as explaining variables. Latitude, decade of bird observation, forest area and amount of grove habitats in protected areas were used as supporting explaining variables in the models to control for their effect when interpreting the results.

As shown in Table 6, the models could explain variation in overall protected area forest bird density poorly (R^2 23.5, D2 34.4), and of this, only a small fraction was explained by the ELITE attributes. Most of the variation was caused by changes in latitude and other variables, which alone could explain as much (R^2 22.8) as models with ELITE. Models of FINIBA bird species density (being bird species representative forests) had slightly better performance (R^2 35.0, D2 48.2), but adding ELITE had the same, very modest, effect. However, the average ELITE of protected areas (mean_elite) performed better than quality patch attributes in explaining bird population density.

Species diversity models had better predictive performance than density models (R^2 34.9, D2 33.1), but in this case too, most of the variation remained unexplained. The effect of average ELITE of protected areas on species diversity was not significant (results are not presented in Table 6). However, quality patch ELITE attributes (eliteeq30_ha+1 and eliteeq30_%+1) did have a significant effect on species diversity. The best performing model was achieved with quality patch ELITE attributes and decade only, without any other variables (R^2 34.9, D2 33.1). Relative amount of quality patches (eliteeq30_%+1) was significant only with absolute quality area (eliteeq30_ha+1). This indicates that a significant proportion of good habitats in landscapes favours diversity, but only if the overall area is large enough.

Table 6: Example models, model fit, predictive performance and significance of variables. D2 value evaluates model fit as percentage of deviation explained.

Model	D2 %	r (obs, pred) %	R2 (obs, pred) %
Forest species richness ~			
latitude*** + log(forest_ha+1)*** + decade$^{(p=0.050)}$	32.2	55.7	31.0
log(eliteq30_ha + 1)*** + log(eliteq30_% + 1)*** + decade$^{(p=0.062)}$	33.1	59.1	34.9
Density of all forest species ~			
latitude*** + log(lehtohabitats_%+ 1)*** + decade$^{(0.044)}$	32.8	47.7	22.8
log(mean_elite)$^{(0.057)}$ + log(lehtohabitats_%+ 1)$^{(0.066)}$ + latitude** + decade$^{(0.059)}$	34.4	48.5	23.5
Density of FINIBA indicator species ~			
latitude*** + log(lehtohabitats_% +1)*** + decade*	45.8	58.5	34.2
log(mean_elite)** + log(lehtohabitats_% +1)* + latitude*** + decade$^{(0.080)}$	48.2	59.2	35.0

*Significance codes: 0 '***' 0.001+ '**' 0.01+ '*' 0.05+ '$^{(value)}$'. Predictive performance estimated from 100x repeated 70:30 random sampling. The first in group is the best model without elite variables, and the second with elite variables. FINIBA indicator species density model performed better than models for other forest bird groups and is the only group presented.*

2.2.3. Key insights

The work reveals the following key insights for 'Accounting for Biodiversity' in Finland:

- Potential for scaling up the ELITE Index nationally, to provide a solid conceptual basis for tracking structural ecosystem condition in forests.
    - This may be very relevant to ecosystem-level biodiversity and ecosystem services.

  - There is the potential to upscale the ELITE indicator to commercial and other forest areas using existing modelled spatial data on tree species composition and from National Forest Inventories. However, there is a lack of spatially explicit data on the amount of dead wood in forests, which is a constraint to modelling the ELITE in a spatially explicit fashion outside of protected areas.
  - ELITE provides limited explanatory power with respect to species-level biodiversity and associated composition indictors in forests.
  - A simple ecosystem condition index cannot be used to get any reliable estimates of bird population condition.
- The study underlines the importance and necessity of direct biodiversity monitoring as a base of environmental decision making. Separate species-level data is required to communicate on the compositional characteristics of forest ecological integrity and ecosystem condition. Current monitoring could support derivation of these indicators for forest protected areas in Finland.
- Species Accounts for key recreational species may provide a more nuanced insight into returns on ecological investment in forest ecosystems than summary metrics in the ecosystem condition accounts. It would also be useful to link these and other key species important recreational activities, such as bird watching and hunting.

2.3. France

France is concentrating on the development of marine ecosystem accounts under the MAIA project. As part of this work, Comte et al., (2020) have produced a framing of ecosystem condition accounting to support the transition to sustainable societies. This has been developed in response to the SEEA EEA Technical Recommendations (UN et al., 2017) call for determining an appropriate set of characteristics and associated indicators for testing in ecosystem condition accounting.

Comte et al., (2020) highlight that the aim of the first SEEA EEA framework (UN et al., 2014) was to present a systems-based approach to record the relationship between ecosystems, the economy and society that is useful for policy-making and environmental management. As such, they proposed to measure ecosystem condition through a set of biophysical indicators organised into the following management objectives and categories (in brackets):

- Maintenance of ecosystem functions (“functionality”)
- Conservation of features or elements of ecosystems (“conservation”)
- Capacity of ecosystems to sustainably supply goods and services (“ES capacity”)

MAIA
Mapping and Assessment for Integrated ecosystem Accounting

2.3.1. National biodiversity data used

Comte et al., (2020) illustrate how descriptors of the European Marine Strategy Framework Directive (MFSD) can be aligned to the proposed ecosystem functionality, conservation and ES capacity categories. Thereby, providing a point of entry for biodiversity data for reporting on the MSFD and other national, regional and international reporting obligations. These include reporting obligations for the EU Birds and Habitats Directives, OSPAR regulations and France's own Biodiversity Strategy.

Within the experimentation for marine ecosystem condition accounting, monitoring datasets have been made available by the French Biodiversity Office. Complementary datasets that are publicly available have been collected from Ifremer[8]. Collectively, these comprised heterogeneous collection of datasets to inform ecosystem condition accounting. Some of these data are organised in Table 7, alongside the different ecosystem condition categories proposed.

Table 7: Time series datasets organised by marine ecosystem condition category

Dataset	Condition category
Birds	Conservation
Marine Mammals	Conservation
Marine mammal stranding	Conservation
Protected areas	Conservation
Floating waste	Functionality
Waste on seabed	Functionality
Risk of cumulative effects on Benthic Habitats	Functionality
Eutrophication	Functionality
Fish stocks	ES Capacity

In addition to the datasets highlighted in Table 7, the development of conservation indicators based on IUCN Red List status and maps of abundances of marine mammals provided by the French Biodiversity Office is being explored.

2.3.2. Compiling the Accounts

The structure of the ecosystem accounts proposed in Comte et al., (2020) is presented in Figure 4. The green shaded area reflects the core physical and monetary accounts of the SEEA EA. As can be appreciated from Table 7, national biodiversity monitoring data will feed into the ecosystem condition accounts and inform the associated functionality, conservation and capacity indicators. A key additional feature for informing ecosystem management for better outcomes for biodiversity, are the supplementary accounts (orange shaded area). It is highlighted that work is still ongoing with respect to compiling the actual accounts set out in Figure 4.

[8] https://sextant.ifremer.fr/

The supplementary analysis to calculate 'required costs' requires distance from biophysical targets to be established. This may be determined on the basis of distance to a scientifically defined limit or reference level. Comte et al., (2020) also argue that science based environmental standards that better accommodate social preferences and the consideration of costs and other trade-offs are also appropriate. In the context of the marine environment in France, the *environmental targets* resulting from the second implementation cycle of the Marine strategy framework directive are highly relevant examples of such standards. As set out in Figure 4, these types of targets are clearly relevant when an analytical objective is to understand 'Required costs' to meet them.

The 'Required costs' in Figure 4 are derived from cost estimates by the French Biodiversity Office to reach the objectives of the EU MSFD, the French Biodiversity Strategy and the 30% target for Marine Protected Areas based on the existing state of biodiversity, a state that could also be communicated via the ecosystem condition accounts. Once these 'Required costs' are estimated, comparisons with existing levels of environmental expenditure ('Observed costs') can be made. The shortfall is then estimated in terms of 'Unpaid ecological costs' in Figure 4.

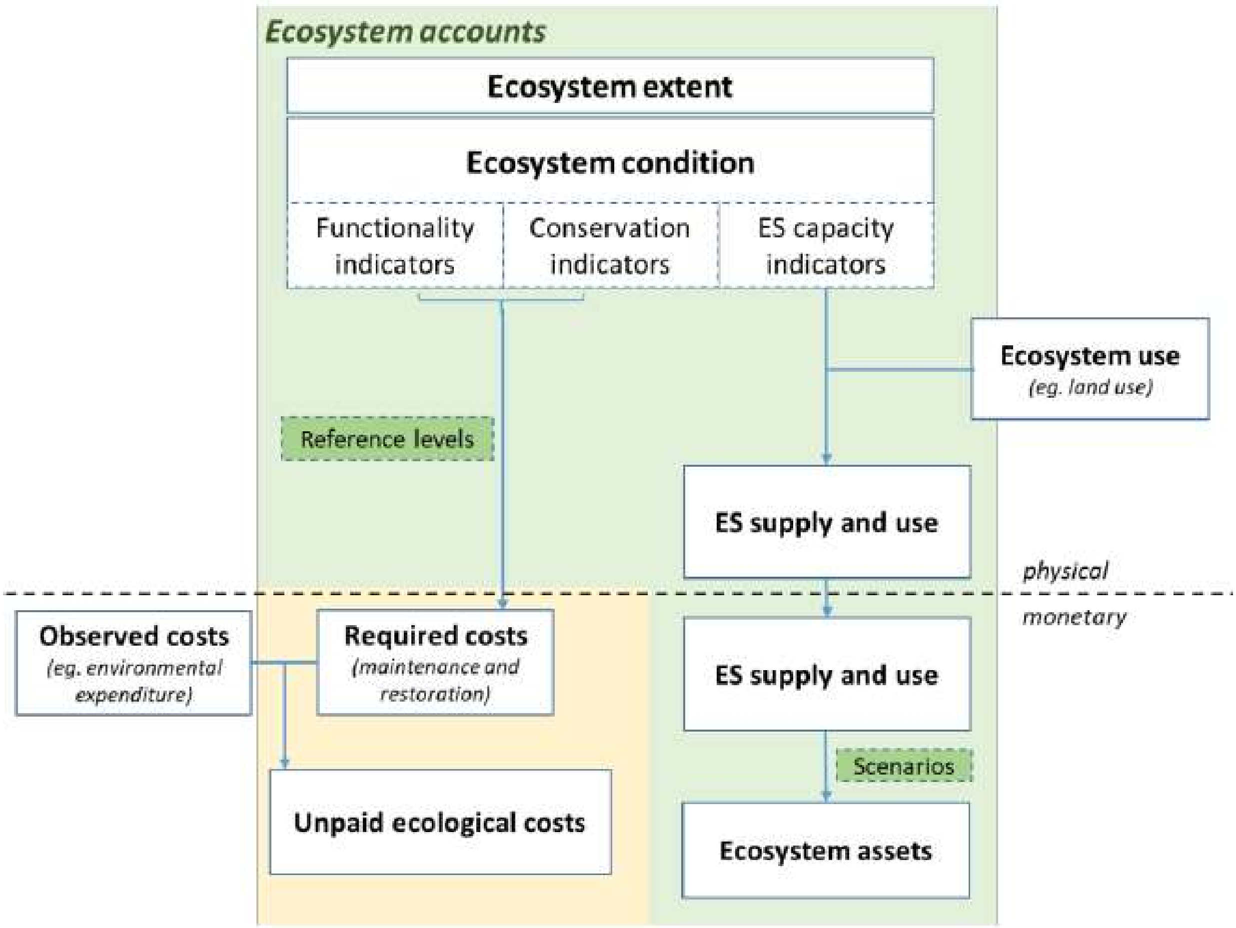

Figure 4: Structure of ecosystem accounts discussed in Comte et al., (2020)

2.3.3. Key insights

The work reveals the following key insights for 'Accounting for Biodiversity':

- Whilst the finalised marine ecosystem accounts are still being compiled, the approach illustrates the ability to integrate multiple biodiversity monitoring data into an ecosystem condition account that is directly relevant to identified marine ecosystem policy and management concerns.
- The extended analytical framework presented can directly inform policy makers on budgetary requirements for achieving agreed objectives for biodiversity.
- It provides relevant information on distance to policy targets and can hold policy-makers, implementing agencies and ecosystem managers to account.
- It fosters strategic biodiversity data collection and ecosystem condition accounting in response to national biodiversity objectives.
- This experimentation has shed light on the need to harmonise and systematise data collection on key marine biodiversity indicators, as the existing datasets are often only available for a limited geographic zone and for a limited number of years.

2.4. Germany

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) together with the Federal Agency for Nature Conservation (BfN) have initiated the pilot project "Integration of ecosystems and ecosystem services (ES) into the Environmental-Economic Accounting". The accounts compiled via the pilot comprise ecosystem extent and ecosystem services accounts for: Biomass provisioning services; Global climate regulation services; Local (micro and meso) climate regulation services; Water erosion control services; Pollination services (by wild bees); Visual amenity services; and, Appreciation of ecosystem and species services (Grunewald et al., 2021). In another project, nationwide visit frequency and visit distance were modelled using representative data on recreation behaviour as the basis for a physical and monetary recreation-related services account (Hermes et al., 2021).

The methodology for calculating the 'Appreciation of ecosystem and species service' is based on the use of "biotope points". In German nature conservation law, there is a provision where the impact of land development and land use change on nature must be compensated, as far as possible, by the creation or enhancement of other ecosystems with similar, or at least equivalent, functions. Biotope point values have been developed to help determine compensatory measures and achieve no-net loss under the nature conservation law in Germany (Grunewald et al., 2021).

Schweppe-Kraft & Ekinci (2021) describe the methodological approach for estimating the 'Ecosystem and species appreciations' service included in the SEEA EA reference list based on changes in Biotope point values. This is based on linking marginal changes in physical Biotope points to associated and amortized habitat restoration costs. This method provides an approach to integrate national biodiversity data into the monetary ecosystem services accounts of the SEEA EA. This provides a slightly different perspective on 'Accounting for Biodiversity'.

2.4.1. National biodiversity data used

Biotope points take into account ecosystem characteristics such as naturalness, age, the occurrence of threatened species or the degree of threat to an ecosystem type itself. The criteria employed for assessing the threat to the ecosystem type itself follows the IUCN Red List of Ecosystems approach, as described in Heinze et al., (2020). A Biotope list has been compiled for the Federal Compensation Ordinance in Germany, as described in Mengel et al., (2018). The Biotope list defines average biotope points for about 500 different ecosystem types. The assessments range from 0 (pavements) to 24 (healthy bogs, old (semi-) natural forests). The average biotope point can be increased or decreased by a maximum of three points to reflect different levels of ecosystem condition (Schweppe-Kraft & Ekinci, 2021).

Various data sources have been used to delineate areas into different ecosystem types and ecosystem condition classes for the entire territory of Germany. These include: Satellite based data (German Land Cover Model LBM-DE); Land use data from the federal statistical office; Cadastral data for linear features (e.g., for hedgerows, tree rows, streams); and, Federal Forest Inventory and Monitoring of High-Nature-Value farmland. Additional national biodiversity data is included in the form of reporting data to the EU Habitats, Water Framework and Marine Framework Strategy Directives to provide more thematic resolution with respect to the condition of ecosystems. Overall, areas were defined for approximately 300 different ecosystem types and condition classes. A biotope point value per hectare could then be assigned to each ecosystem type and condition class based on Mengel et al., (2018).

2.4.2. Compiling the Accounts

Once biotope points are assigned to each ecosystem type area, they can be summed to provide a physical measure for Germany's wealth (stock) of biodiversity in an accounting year (Schweppe-Kraft & Ekinci, 2021). Between 2012 and 2018, this measure decreased from 420.1 million points in 2012 to 415.6 million points in 2015, stabilising at 415.7 million points in 2018. Improved methods for extrapolating High Nature Value farmland and assessing Natura 2000 habitat condition may change the values slightly. For this physical assessment, only data that can be linked to biotope restoration costs was used. Future ecosystem condition and biodiversity accounts are envisaged that will directly include species-related and other biodiversity related data items (Schweppe-Kraft & Ekinci, 2021).

To assign a monetary value to the biodiversity 'stock' measured using biotope points, average costs for the production of a biotope point were estimated. These were based on the estimated costs of habitat restoration that will be required in the coming years to meet the obligations of the EU Habitats Directive. Consequently, the science-policy targets of this directive represent a 'reference level' against which 'biodiversity' is compared in the pilot. The method takes into account the time needed for each ecosystem to reach this targeted condition (or reference level), assuming a linear recovery of the ecosystem over this time. Costs are then discounted using a discount rate of 3% to calculate an average net present value of €3,634 per each additional biotope point. Schweppe-Kraft & Ekinci (2021) note that two contingent valuation studies in Germany estimate willingness to pay for conservation programmes that exceed this cost value per biotope value point by approximately a factor of two.

Applying the average cost per additional biotope point to the 415.7 million points for 2018 provides an estimated value for Germany's biodiversity stock of approximately €1.4 trillion (Schweppe-Kraft & Ekinci, 2021). Schweppe-Kraft & Ekinci (2021) assume a 3% annual return on this biodiversity-related natural capital, implying an implicit value for the 'Ecosystem and species appreciations' service flow of approximately €45 billion. The methodological approach also allows for the difference between existing "biodiversity wealth" and the biodiversity wealth that would exist if the objectives of the EU Habitats Directive were met to be determined. Schweppe-Kraft & Ekinci (2021) identify this as a biodiversity debt, estimated at about €60 billion under the pilot project (see Figure 5).

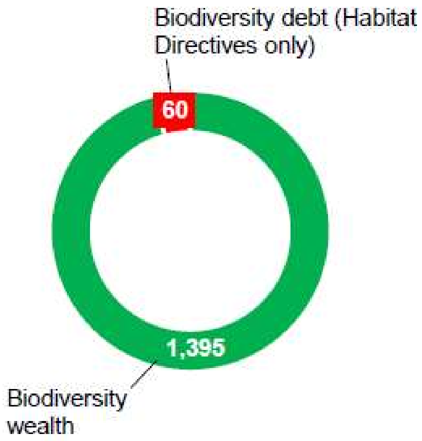

Figure 5: Biodiversity wealth and biodiversity debt (Billions Euro)

2.4.3. Key insights

The work reveals the following key insights for 'Accounting for Biodiversity' in Germany:

- Moving to a monetary valuation linked to restoration cost allows policy makers and ecosystem managers to clearly understand the budgetary requirements for delivering on objectives for biodiversity.
- The approach of linking biodiversity data with biodiversity debt demonstrates where underinvestment in biodiversity related natural capital is occurring and the widening gap of underinvestment over time.

- Linking information on the state of biodiversity, policy objectives for biodiversity and required restoration investment can be used to hold policymakers, implementing agencies and ecosystem managers to account.
- Comparison between the monetary assessment of ecosystem services to conserve biodiversity (‘Ecosystem and species appreciations’ service) and the value of other (especially provisioning) services allows for enhanced science-based methods for land allocation to different types of use (conservation, more or less intensive agriculture, forestry, etc.).

2.5. Greece

In 2017, the Greek National Agenda for Mapping and Assessment of Ecosystem and their Services (MAES) was drafted by a group of scientists of different scientific disciplines, aiming to support EU efforts on implementing the MAES part of the EU Biodiversity Strategy (Dimopoulos et al., 2017). This agenda included ecosystem mapping, condition, and ecosystem services assessment, as well as economic valuation and accounting. Since then, significant steps have been made by Greece in this direction. However, until now, no accounts for biodiversity have been produced for Greece.

This pilot assessment is a first attempt to integrate official floristic datasets, produced under the two habitat type mapping projects conducted in Greece in 2000 and 2015, respectively, into the thematic accounting for biodiversity described in the SEEA EA. The proposed thematic accounts are for terrestrial ecosystems (including rivers, lakes, and coastal lagoons) and are targeted to set the baseline for future accounting for biodiversity in Greece.

2.5.1. National biodiversity data used

The data used for thematic accounting for biodiversity were extracted from the officially approved databases of the Natura 2000 Sites of Community Importance (SCI) habitat types’ mapping project for the year 2000 and 2015. All data are derived from extensive field surveys at each Natura 2000 SCIs in Peloponnese, using a predefined field assessment protocol that included comprehensive floristic recording at each sampling plot site. Both surveys were conducted using the same protocol for floristic recordings. The main purpose of the protocols was to identify habitat type at each sampling plot, assess its condition and record typical species and species richness (for floral species).

The aforementioned dataset was used for the purposes of this study to compile biodiversity indicators for (a) the phytogeographical region of Peloponnese, (b) each Prefecture of Peloponnese (i.e., Achaia, Argolida, Arkadia, Korinthia, Ilia, Lakonia and Messinia), and (c) each Site of Community Importance (SCI). More precisely, the developed indicators are:

i. <u>Ecosystem types’ richness (MAES level 3):</u> Ecosystem types are identified following the recently developed typology for Greece, which assigned each habitat type code to the corresponding ecosystem type (see Kotsiras et al., 2020; Verde et al., 2020).

ii. Habitat type richness: Habitat types are derived for 2000 and 2015 databases for Natura 2000 SCIs in Peloponnese.

iii. Number of species listed under IUCN Red List threatened / extinction risk categories (i.e., Vulnerable, Endangered, Critically Endangered): As presented in the Flora of Greece Web database[9]. For this indicator, a baseline map for the total area of Peloponnese has been produced (inside and outside Natura 2000 areas), using the data from the Flora of Greece Web database, depicting current number of threatened taxa, at a 5x5 km resolution using a modified EEA Reference Grid (see Figure 6).

iv. Number of species listed in Annex II of Dir. 92/43/EEC: For this indicator, a baseline map for the area of Peloponnese has also been produced (inside and outside Natura 2000 areas), using the data from the Flora of Greece Web database, depicting current number of Annex II of the EU Habitats Directive (Dir. 92/43/EEC) taxa, at a 5x5 km resolution using a modified EEA Reference Grid (see Figure 7).

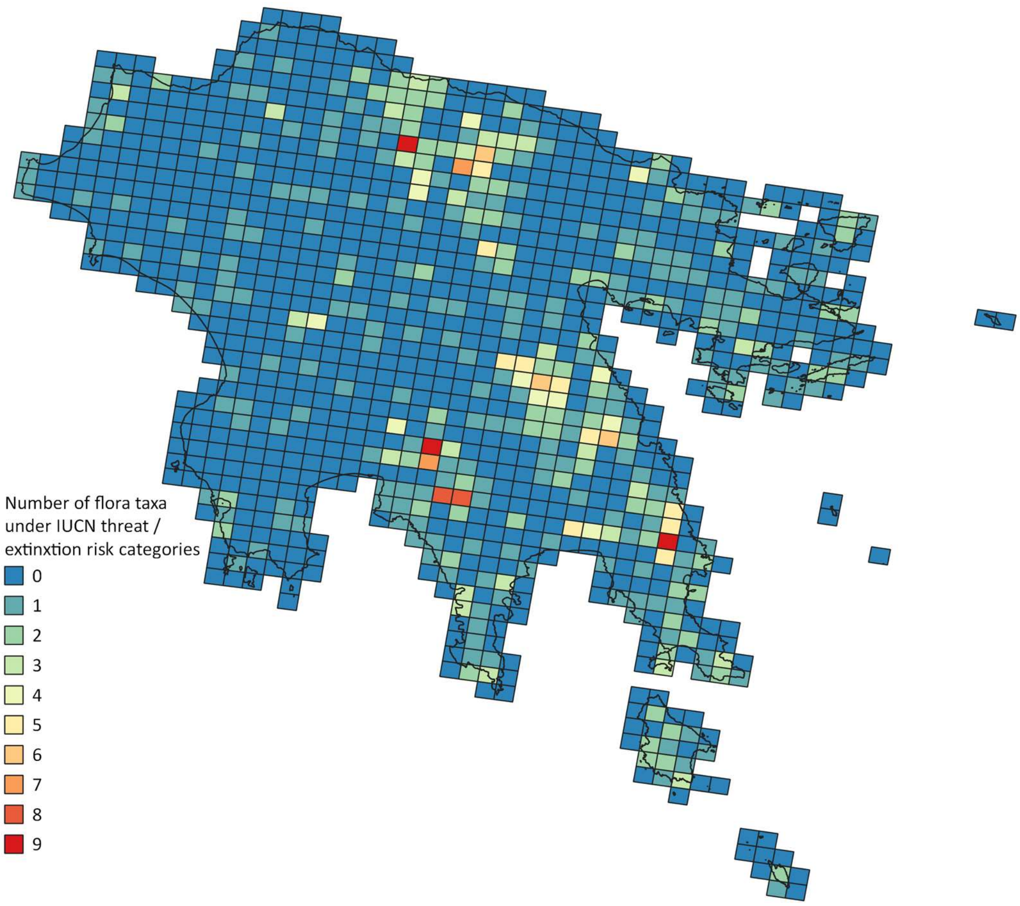

Figure 6: Number of flora taxa under IUCN threat / extinction risk categories in the Peloponnese, as a baseline map for future accounting, using a 5x5 km modified EEA Reference Grid for Greece.

[9] www.floraofgreeceweb.gr

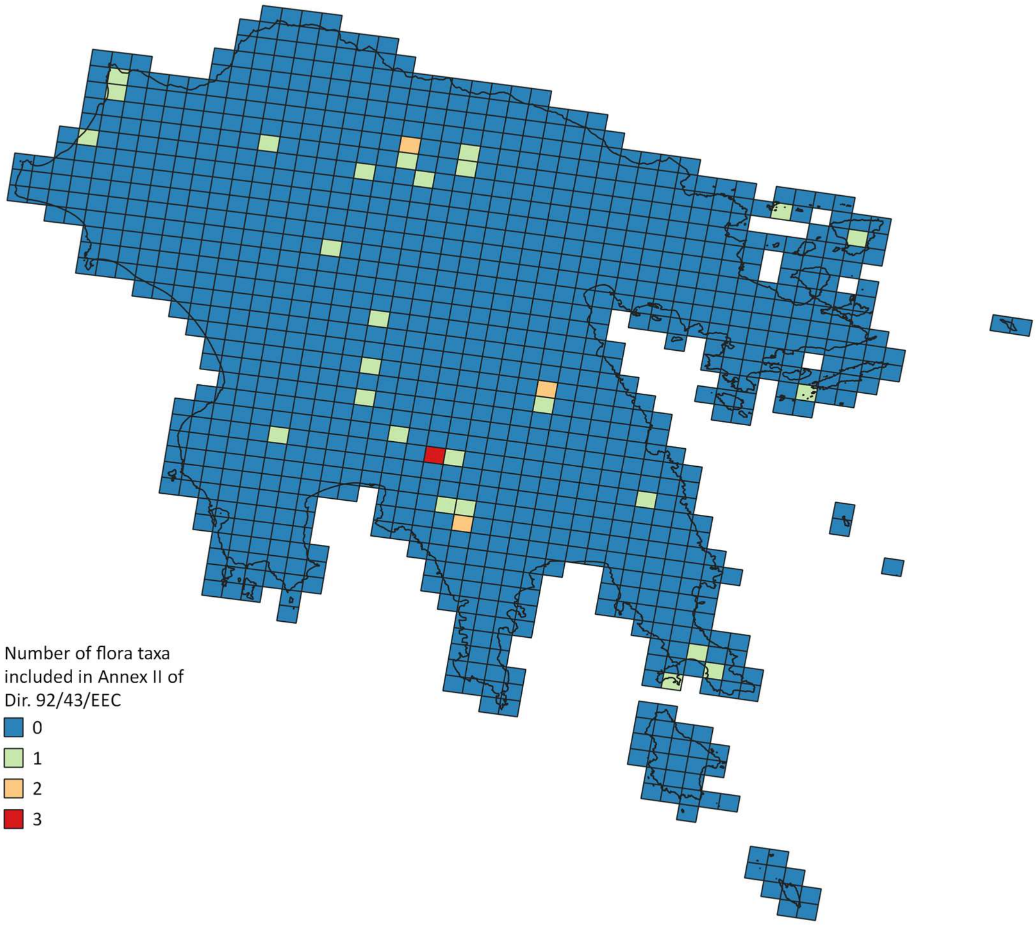

Figure 7: Number of Annex II (Dir. 92/43/EEC) flora taxa in the Peloponnese, as a baseline map for future accounting, using a 5x5 km modified EEA Reference Grid for Greece.

2.5.2. Compiling the Accounts

2.5.2.1. Habitat types and ecosystem types accounts

Ecosystem type and habitat type richness accounts include values and net change for the years 2000 and 2015 (Table 8 and Table 9). The accounts are compiled to understand habitat type gain or loss, per MAES level 3 ecosystem types, that indicates a relevant trend in habitat diversity. In general, the number of ecosystem types and habitat types (including priority habitats for conservation in the EU) slightly increased in 2015. Only the Mediterranean sclerophyllous forests and sclerophyllous vegetation in the Prefecture of Achaia and the Mediterranean sclerophyllous forests in the Prefecture of Corinthia showed decreases in the number of relevant habitat types (all by -1).

Table 8: Number of habitat types per MAES level 3 ecosystem types in Peloponnese and its Prefectures, for the years 2000 and 2015. Net change is also presented; green colour indicates ecosystem type number increase; red colour indicates decrease; grey colour indicates no change. N/A means net change could not be calculated.

Regions and ecosystem types	Habitat types (2000)	Habitat types (2015)	Net change	Priority Habitat types (2000)	Priority Habitat types (2015)	Net change
Peloponnese	**37**	**50**	**13**	**5**	**9**	**4**
Prefecture of Achaia	**29**	**31**	**2**	**5**	**5**	**0**
Beaches, dunes, sands	3	3	0	0	0	0
Coastal lagoons	No data	1	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	3	3	0	0	0	0
Inland freshwater marshes	1	3	2	0	0	0
Inland saline marshes	3	3	0	0	0	0
Mediterranean coniferous forests	2	2	0	1	1	0
Mediterranean deciduous forests	4	4	0	1	1	0
Mediterranean sclerophyllous forests	2	1	-1	0	0	0
Moors and heathland	2	2	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	2	2	0	1	1	0
Reforestation	No data	1	N/A	No data	0	N/A
Sclerophyllous vegetation	3	2	-1	1	0	-1
Sparsely vegetated land	2	2	0	0	0	0
Temperate mountainous coniferous forests	2	2	0	1	1	0
Prefecture of Argolis	**3**	**3**	0	**0**	**0**	0
Mediterranean coniferous forests	1	1	0	0	0	0
Moors and heathland	1	1	0	0	0	0
Sparsely vegetated land	1	1	0	0	0	0
Prefecture of Arkadia	**22**	**27**	**5**	**3**	**4**	**1**
Beaches, dunes, sands	1	1	0	0	0	0
Coastal lagoons	No data	1	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	2	3	1	0	0	0
Inland freshwater marshes	1	1	0	0	0	0
Inland saline marshes	2	2	0	0	0	0
Mediterranean coniferous forests	1	1	0	0	0	0
Mediterranean deciduous forests	3	3	0	1	1	0
Mediterranean sclerophyllous forests	3	3	0	0	0	0
Moors and heathland	2	2	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	2	3	1	1	1	0

Regions and ecosystem types	Habitat types (2000)	Habitat types (2015)	Net change	Priority Habitat types (2000)	Priority Habitat types (2015)	Net change
Reforestation	No data	1	N/A	No data	0	N/A
Rivers and lakes	No data	1	N/A	No data	0	N/A
Sclerophyllous vegetation	2	2	0	0	0	0
Sparsely vegetated land	1	1	0	0	0	0
Temperate mountainous coniferous forests	2	2	0	1	1	0
Prefecture of Corinthia	**16**	**19**	**3**	**3**	**3**	**0**
Floodplain forests (Riparian forest/Fluvial forest)	2	2	0	0	0	0
Inland freshwater marshes	1	1	0	0	0	0
Mediterranean coniferous forests	1	1	0	0	0	0
Mediterranean deciduous forests	1	2	1	0	1	1
Mediterranean sclerophyllous forests	2	1	-1	0	0	0
Moors and heathland	2	2	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	1	2	1	0	1	1
Reforestation	No data	1	N/A	No data	0	N/A
Rivers and lakes	No data	1	N/A	No data	0	N/A
Sclerophyllous vegetation	2	2	0	0	0	0
Sparsely vegetated land	2	2	0	0	0	0
Temperate mountainous coniferous forests	2	2	0	1	1	0
Prefecture of Ilia	**21**	**35**	14	**1**	**4**	3
Beaches, dunes, sands	3	6	3	0	0	0
Coastal lagoons	No data	1	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	3	3	0	0	0	0
Inland freshwater marshes	1	3	2	0	0	0
Inland saline marshes	3	3	0	0	0	0
Mediterranean coniferous forests	2	2	0	1	1	0
Mediterranean deciduous forests	1	2	1	0	0	0
Mediterranean sclerophyllous forests	3	3	0	0	0	0
Moors and heathland	1	1	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	1	2	1	0	0	0
Peat bogs	1	2	1	0	1	1
Reforestation	No data	1	N/A	No data	0	N/A
Rivers and lakes	No data	2	N/A	No data	0	N/A
Sclerophyllous vegetation	1	3	2	0	1	1
Sparsely vegetated land	1	1	0	0	0	0

Regions and ecosystem types	Habitat types (2000)	Habitat types (2015)	Net change	Priority Habitat types (2000)	Priority Habitat types (2015)	Net change
Prefecture of Lakonia	**21**	**27**	6	**2**	**3**	1
Beaches, dunes, sands	4	4	0	0	0	0
Floodplain forests (Riparian forest/Fluvial forest)	3	3	0	0	0	0
Inland freshwater marshes	1	1	0	0	0	0
Inland saline marshes	2	2	0	0	0	0
Mediterranean coniferous forests	1	1	0	0	0	0
Mediterranean deciduous forests	No data	1	N/A	No data	0	N/A
Mediterranean sclerophyllous forests	2	3	1	0	0	0
Moors and heathland	1	2	1	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	1	1	0	0	0	0
Rivers and lakes	No data	2	N/A	No data	1	N/A
Sclerophyllous vegetation	3	4	1	1	1	0
Sparsely vegetated land	1	1	0	0	0	0
Temperate mountainous coniferous forests	2	2	0	1	1	0
Prefecture of Messinia	**26**	**33**	7	**3**	**6**	3
Beaches, dunes, sands	4	5	1	0	0	0
Coastal lagoons	No data	1	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	1	2	1	0	0	0
Inland freshwater marshes	1	1	0	0	0	0
Inland saline marshes	1	2	1	0	0	0
Mediterranean coniferous forests	1	2	1	0	1	1
Mediterranean deciduous forests	1	1	0	0	0	0
Mediterranean sclerophyllous forests	3	3	0	0	0	0
Moors and heathland	3	3	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	2	3	1	1	1	0
Sclerophyllous vegetation	5	6	1	1	1	0
Sparsely vegetated land	2	2	0	0	0	0
Temperate mountainous coniferous forests	2	2	0	1	1	0

Table 9: Number of MAES level 3 ecosystem types in Peloponnese and its Prefectures, for the years 2000 and 2015. Net change is also presented; green colour indicates ecosystem type number increase; grey colour indicates no change. N/A means net change could not be calculated.

	Number of MAES Level 3 ecosystem types (2000)	Number of MAES Level 3 ecosystem types (2015)	**Net Change (2000 to 2015)**
Peloponnese (Total)	**13**	**16**	3
Prefecture of Achaia	12	14	2
Prefecture of Argolis	3	3	0
Prefecture of Arkadia	12	15	3
Prefecture of Corinthia	10	12	2
Prefecture of Ilia	12	15	3
Prefecture of Lakonia	11	13	2
Prefecture of Messinia	12	13	1

2.5.2.2. Flora species indicators accounts

Flora species indicator accounts are compiled to understand potential biodiversity change inside Natura 2000 SCIs in Peloponnese and identify relevant trends. These indicators also act as ecosystem condition indicators for each ecosystem type (see National Set of MAES indicators for Greece as proposed by Kokkoris et al., 2020), thus providing information for ecosystem condition trends. The accounts include values and net change for the years 2000 and 2015, for a number of floral species listed under an IUCN Red List threat / extinction risk category and Annex II of the Habitats Directive (Dir. 92/43/EEC) floral species (Table 10). For the number of species under an IUCN threat / extinction risk category, the main changes observed are reductions in the number of threatened species in Sparsely vegetated land and in Moors and heathland. This is considered indicative of deterioration in the condition of these ecosystem types. This is because less IUCN threatened species are being identified at the sampling plots inside the Natura 2000 SCIs, suggesting conditions are less suitable for supporting them. No change is recorded for Annex II species. A separate analysis provides a comprehensive accounting table presenting the detailed results of the analyses per Prefecture, Natura 2000 SCIs, Ecosystem types and Habitat types.

Table 10: Flora species indicators per MAES level 3 ecosystem types in Peloponnese and its Prefectures, for the years 2000 and 2015. Net change is also presented; green colour indicates improvement; red colour indicates deterioration; grey colour indicates no change. N/A means net change could not be calculated.

Regions and ecosystem types	IUCN category (2000)	IUCN category (2015)	Net change	Annex II of Directive 92/43/EEC (2000)	Annex II of Directive 92/43/EE (2015)	Net change
Peloponnese	**23**	**10**	**-13**	**4**	**4**	0
Prefecture of Achaia	**6**	**4**	**-2**	**2**	**2**	0
Beaches, dunes, sands	1	0	-1	0	0	0
Coastal lagoons	No data	0	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	1	0	-1	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Inland saline marshes	0	0	0	0	0	0
Mediterranean coniferous forests	2	1	-1	0	0	0
Mediterranean deciduous forests	0	0	0	0	0	0
Mediterranean sclerophyllous forests	0	1	1	0	0	0
Moors and heathland	2	0	-2	1	1	0
Natural grasslands with woody species (W.C.D. < 30%)	0	1	1	0	0	0
Reforestation	No data	0	N/A	No data	0	N/A
Sclerophyllous vegetation	2	1	-1	0	0	0
Sparsely vegetated land	3	1	-2	1	1	0
Temperate mountainous coniferous forests	1	0	-1	0	0	0
Prefecture of Argolis	**0**	**0**	**0**	**0**	**0**	0
Mediterranean coniferous forests	0	0	0	0	0	0
Moors and heathland	0	0	0	0	0	0
Sparsely vegetated land	0	0	0	0	0	0
Prefecture of Arkadia	**7**	**3**	**-4**	**1**	**1**	0
Beaches, dunes, sands	0	0	0	0	0	0
Coastal lagoons	No data	0	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	0	0	0	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Inland saline marshes	0	0	0	0	0	0
Mediterranean coniferous forests	1	0	-1	0	0	0

Regions and ecosystem types	IUCN category (2000)	IUCN category (2015)	Net change	Annex II of Directive 92/43/EEC (2000)	Annex II of Directive 92/43/EE (2015)	Net change
Mediterranean deciduous forests	1	1	0	1	1	0
Mediterranean sclerophyllous forests	0	0	0	0	0	0
Moors and heathland	1	1	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	0	0	0	0	0	0
Reforestation	No data	0	N/A	No data	0	N/A
Rivers and lakes	No data	0	N/A	No data	0	N/A
Sclerophyllous vegetation	1	1	0	0	0	0
Sparsely vegetated land	3	0	-3	1	1	0
Temperate mountainous coniferous forests	2	0	-2	0	0	0
Prefecture of Corinthia	**6**	**3**	-3	**1**	**1**	0
Floodplain forests (Riparian forest/Fluvial forest)	0	0	0	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Mediterranean coniferous forests	1	1	0	0	0	0
Mediterranean deciduous forests	0	0	0	0	0	0
Mediterranean sclerophyllous forests	1	0	-1	0	0	0
Moors and heathland	3	1	-2	1	1	0
Natural grasslands with woody species (W.C.D. < 30%)	1	0	-1	0	0	0
Reforestation	No data	0	N/A	No data	0	N/A
Rivers and lakes	No data	0	N/A	No data	0	N/A
Sclerophyllous vegetation	0	1	1	0	0	0
Sparsely vegetated land	2	0	-2	0	0	0
Temperate mountainous coniferous forests	1	0	-1	0	0	0
Prefecture of Ilia	**1**	**1**	**0**	**0**	**0**	0
Beaches, dunes, sands	1	0	-1	0	0	0
Coastal lagoons	No data	0	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	0	0	0	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Inland saline marshes	0	0	0	0	0	0
Mediterranean coniferous forests	1	1	0	0	0	0

Regions and ecosystem types	IUCN category (2000)	IUCN category (2015)	Net change	Annex II of Directive 92/43/EEC (2000)	Annex II of Directive 92/43/EE (2015)	Net change
Mediterranean deciduous forests	0	0	0	0	0	0
Mediterranean sclerophyllous forests	0	0	0	0	0	0
Moors and heathland	0	0	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	0	0	0	0	0	0
Peat bogs	0	0	0	0	0	0
Reforestation	No data	0	N/A	No data	0	N/A
Rivers and lakes	No data	0	N/A	No data	0	N/A
Sclerophyllous vegetation	1	1	0	0	0	0
Sparsely vegetated land	1	0	-1	0	0	0
Prefecture of Lakonia	**5**	**3**	**-2**	**1**	**1**	0
Beaches, dunes, sands	1	0	-1	0	0	0
Floodplain forests (Riparian forest/Fluvial forest)	0	0	0	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Inland saline marshes	0	0	0	0	0	0
Mediterranean coniferous forests	0	0	0	0	0	0
Mediterranean deciduous forests	No data	0	N/A	No data	0	N/A
Mediterranean sclerophyllous forests	0	0	0	0	0	0
Moors and heathland	0	0	0	0	0	0
Natural grasslands with woody species (W.C.D. < 30%)	0	0	0	0	0	0
Rivers and lakes	No data	0	N/A	No data	0	N/A
Sclerophyllous vegetation	1	0	-1	0	0	0
Sparsely vegetated land	5	3	-2	1	1	0
Temperate mountainous coniferous forests	0	0	0	0	0	0
Prefecture of Messinia	**10**	**1**	**-9**	**2**	**2**	0
Beaches, dunes, sands	0	0	0	0	0	0
Coastal lagoons	No data	0	N/A	No data	0	N/A
Floodplain forests (Riparian forest/Fluvial forest)	0	1	1	0	0	0
Inland freshwater marshes	0	0	0	0	0	0
Inland saline marshes	0	0	0	0	0	0

Regions and ecosystem types	IUCN category (2000)	IUCN category (2015)	Net change	Annex II of Directive 92/43/EEC (2000)	Annex II of Directive 92/43/EE (2015)	Net change
Mediterranean coniferous forests	1	1	0	0	0	0
Mediterranean deciduous forests	0	0	0	0	0	0
Mediterranean sclerophyllous forests	1	1	0	0	0	0
Moors and heathland	5	0	-5	1	1	0
Natural grasslands with woody species (W.C.D. < 30%)	2	0	-2	0	0	0
Sclerophyllous vegetation	2	1	-1	0	0	0
Sparsely vegetated land	6	0	-6	2	2	0
Temperate mountainous coniferous forests	0	0	0	0	0	0

2.5.2.3. Combined presentation

A combined presentation integrating all accounting results of the analysis is presented in Table 11. This provides an overview of the selected biodiversity indicators trends inside Natura 2000 SCIs and creates the baseline for future assessments. The results presented herein support using 2015 as a baseline/reference year for future accounts. Even though the methods followed were almost identical in the 2000 and 2015 surveys, recent typologies, digital cartographic material, high resolution satellite imagery and more accurate GPS devices and GPRS networks suggest that the 2015 assessment should be considered as the best available reference point for biodiversity accounts inside Natura 2000 sites. Moreover, the number of IUCN and Annex II taxa herein reported using a 5x5 modified EEA reference grid for Greece, is considered as an adequate starting point (reference) for identifying changes for those indicators in spatial and temporal terms, within the Greek territory and communicate accounting results via thematic maps.

2.5.3. Key insights

The work reveals the following key insights for ‘Accounting for Biodiversity’:

- The proposed accounts for biodiversity in Greece, as presented for the pilot study in the floristic region of Peloponnese, are based on freely available floristic datasets from national monitoring and mapping processes under the Habitats Directive obligations.

- Providing all data and analysis assigned to relevant habitat and ecosystem types makes the thematic accounts for biodiversity relevant for management and supports decision making for conservation actions, especially inside Natura 2000 SCIs.

Table 11: Combined presentation for biodiversity indicators inside Natura 2000 SCIs, in Peloponnese and its Prefectures, for the years 2000 and 2015. Net change is also presented; green colour indicates improvement; red colour indicates deterioration; grey colour indicates no change

	MAES - LEVEL 3 (2000)	MAES - LEVEL 3 (2015)	**Net Change (2000 to 2015)**	Habitat types (2000)	Habitat types (2015)	**Net Change (2000 to 2015)**	Priority Habitat types (2000)	Priority Habitat types (2015)	**Net Change (2000 to 2015)**	Listed in IUCN threat categories (2000)	Listed in IUCN threat categories (2015)	**Net Change (2000 to 2015)**	Annex II of Directive 92/43/EEC (2000)	Annex II of Directive 92/43/EE (2015)	**Net Change (2000 to 2015)**
Peloponnese (Total)	**13**	**16**	3	**37**	**50**	13	**5**	**9**	4	**23**	**10**	-13	**4**	**4**	**0**
Prefecture of Achaia	12	14	2	29	31	2	5	5	0	6	4	-2	2	2	0
Prefecture of Argolis	3	3	0	3	3	0	0	0	0	0	0	0	0	0	0
Prefecture of Arkadia	12	15	3	22	27	5	3	4	1	7	3	-4	1	1	0
Prefecture of Corinthia	10	12	2	16	19	3	3	3	0	6	3	-3	1	1	0
Prefecture of Ilia	12	15	3	21	35	14	1	4	3	1	1	0	0	0	0
Prefecture of Lakonia	11	13	2	21	27	6	2	3	1	5	3	-2	1	1	0
Prefecture of Messinia	12	13	1	26	33	7	3	6	3	10	1	-9	2	2	0

- Similar accounts could be produced, based on biodiversity data provided by the Birds Directive monitoring scheme.

- Combined accounts for biodiversity (e.g., birds and flora/tree species richness type) can be produced for each ecosystem type. This provides a streamlined presentation for decision-makers.

- Other types of datasets can be integrated to account for biodiversity. For instance, Greece has an extensive, spatially informed database for its flora (more than 1,2 million occurrences), and was used in this study for the thematic representation at the 5x5 km grid cell level, which can be used as the baseline for future accounting for biodiversity (see Kotsiras et al., 2020, for forest floristic diversity), and ecosystem condition.

- This pilot study revealed that EU Nature Directives can be used as a standardised source for biodiversity accounting, while biodiversity data and other data recorded during the mapping and monitoring projects in Member States, can be evaluated for integration into accounting for ecosystem condition, following the SEEA EA requirements for indicator selection.

- Reference level values should be set for each level of accounting (e.g., national, regional, ecosystem type, habitat type) using statistical analyses or predefined values from the literature, were applicable.

- The ongoing Red List Project for Greek biodiversity (flora and fauna species), upon its completion, will also provide the baseline information for all threatened species. This could be used to compile accounts for threatened species.

2.6. The Netherlands

The Netherlands have produced ecosystem condition accounts for 2013, 2015 and 2018. The 2013 accounts include biodiversity indicators for ecosystem condition (See Sub-section 3.2, Lof et al., 2019). These 2013 accounts provided the foundation for the first set of experimental biodiversity accounts for the Netherlands, published in 2020 for the period 2006-2013 (see Bogaart et al., 2020). Given that the publication of the accounts pre-dates the release of the SEEA EA in 2021, the SEEA Experimental Ecosystem Accounting framework (UN et al., 2014) and associated Technical Recommendations (UN et al., 2017) have been applied when compiling these accounts. Following the release of the SEEA EA in March 2021, the Netherlands produced a comprehensive set of accounts for the period 2013-2018 (van Berkel et al., 2021) and a partial update for 2020 (van Berkel et al., 2022). Currently, the biodiversity account is being updated for the period 2013 to 2020 as well, with some initial results presented herein.

The purpose of the biodiversity accounts compiled for the Netherlands is to monitor the intrinsic and ecological quality of ecosystems, focusing mainly on terrestrial ecosystems (land and inland waters) and based mainly on official biodiversity indicators published in the Dutch government's Compendium of Environmental Data (CLO) (Bogaart et al., 2020). Accounting for biodiversity in the Netherlands encompasses two levels, the ecosystem and the species level.

2.6.1. National biodiversity data used

A major data source for ecosystem accounting in the Netherlands is the Network Ecological Monitoring (NEM). The NEM is a partnership of ministries, provinces, Statistics Netherlands and the Netherlands Environmental Assessment Agency (PBL). NEM coordinates data collection and processes these data to produce official biodiversity statistics, which are then disseminated through the Compendium of Environmental Data (CLO) (Bogaart et al., 2020). This includes the Living Planet Index (LPI) for the Netherlands (1990 – 2020).[10]

The primary data source for ecosystem-level biodiversity used in the Netherlands accounts is the ecosystem type map compiled to support ecosystem extent accounting in the Netherlands. The ecosystem type map moves beyond existing maps based on land cover to deliver a mapped typology with a focus on ecology and ecosystem services (van Berkel et al., 2021). The approach follows the SEEA EA guidelines and associated principles for delineating ecosystem assets (see Sec. 3.37 of the SEEA EA) and aims to allow alignment to the IUCN Global Ecosystem Typology. In addition, information on protected area extent and habitat conservation status are included in the ecosystem condition accounts (e.g., Lof et al., 2019).

For species-level biodiversity, the data used for compiling the Dutch Red List and Living Planet Index are used in the biodiversity accounts compiled for 2006 - 2013 (Bogaart et al., 2020). The Dutch Red List is a national application of the IUCN Global Red List[11] and associated threat status categories based on species trends and rarity. For the Dutch Red List, these comprise regionally extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened, in addition to species that are not threatened. Depending on the threat status of species in different groups, the Dutch Red Lists are updated approximately every ten years. So far, the Dutch Ministry of Nature have commissioned official Red Lists for 18 species groups in the Netherlands. At the time of producing the biodiversity accounts, Red Lists of Dutch species were available for 1995 and 2005. As such, a virtual Red List was constructed for 2013 to enable threatened species accounts to be compiled (Bogaart et al., 2020).[12]

[10] https://www.clo.nl/indicatoren/nl1569-living-planet-index
[11] https://www.iucnredlist.org/
[12] Appendix A of Bogaart et al., (2020) indicates virtual Red Lists are compiled using the same methodology for establishing the official Red Lists.

The Red List of Dutch species informs the compilation of the threatened species accounts, which account for the extinction risk of 1771 species (Bogaart et al., 2020). The RLI has two components. The RLI Length indicates the change in the number of species on the Red List defined as the number of threatened species. The RLI Colour indicates the combined threat level. The threatened species accounts focus on seven species groups comprising: Butterflies; reptiles; mammals; amphibians; breeding birds; dragonflies; and vascular plants. Figure 8 shows the values of the two RLI components for these 7 species groups.

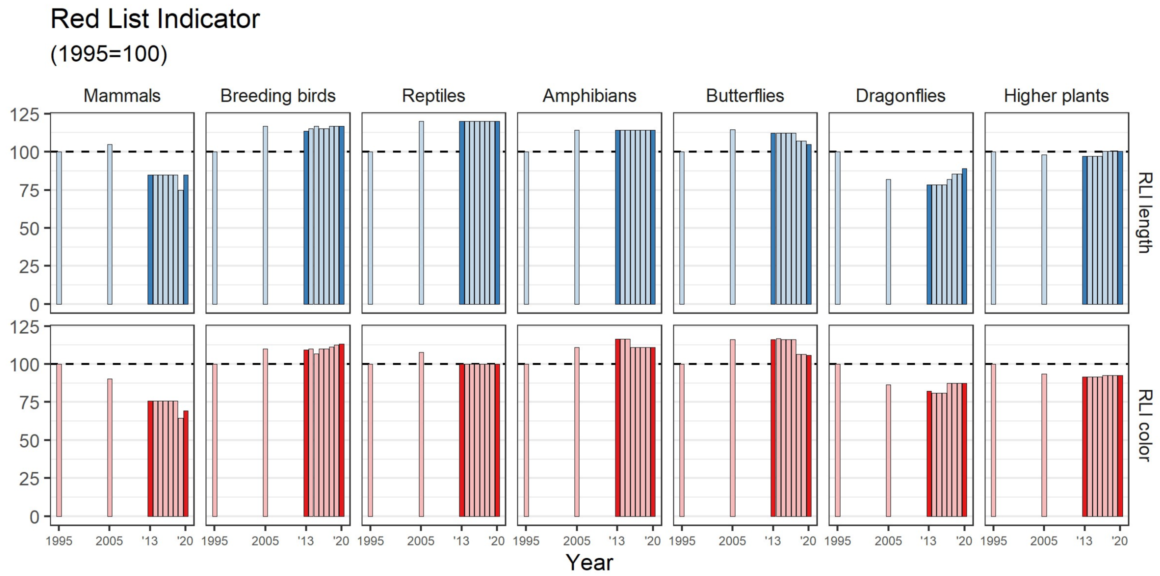

Figure 8: Red List Indicators per species group. Focal years 2013 and 2020 are highlighted *(Updated from Bogaart et al., 2020)*.

The Living Planet Index (LPI) is a well-known global indicator for communicating trends in species abundance over time.[13] The LPI of the Netherlands communicates on the trend of 361 species of mammals, breeding birds, reptiles, amphibians, butterflies, dragonflies and freshwater fish. The reference level adopted for the LPI of the Netherlands is the species abundance for 1990. This reflects the time when new policies were initiated and provides a benchmark for comparison for subsequent improvements or further deteriorations. Consequently, this reference levels should not be seen as a reference level or target for "good" species abundance.

As well as reporting LPI by species group, the LPI can also be used as a compositional state indicator for ecosystem condition. By focusing on habitat specialists, the species trend data within the LPI can be organised for different ecosystem types. Figure 9 illustrates this approach for six broad ecosystem types, comprising: Agricultural; Coastal Dunes; Forest: Heathland; Wetlands and Urban. To analyse the ecological quality of ecosystems in Netherlands, an alternative approach was utilised that is also based on species abundance data. The approach consists of comparing monitoring data

[13] https://livingplanet.panda.org/en-gb/

on the abundance and presence of species to that which would be expected in 1950, which represents a time before the impacts of agricultural intensification led to widespread ecological impacts. The approach has been systematically applied to selected ecosystem types using monitoring data for 457 species, including butterflies, reptiles, breeding birds, and vascular plants. The approach yields an ecosystem-scale index called Mean Species Abundance (MSA), which is the average abundance for all species scaled to a value of 100 for the 1950-level. The MSA is capped at 100 to prevent species that do well in anthropogenic environments to compensate for those that are impacted.

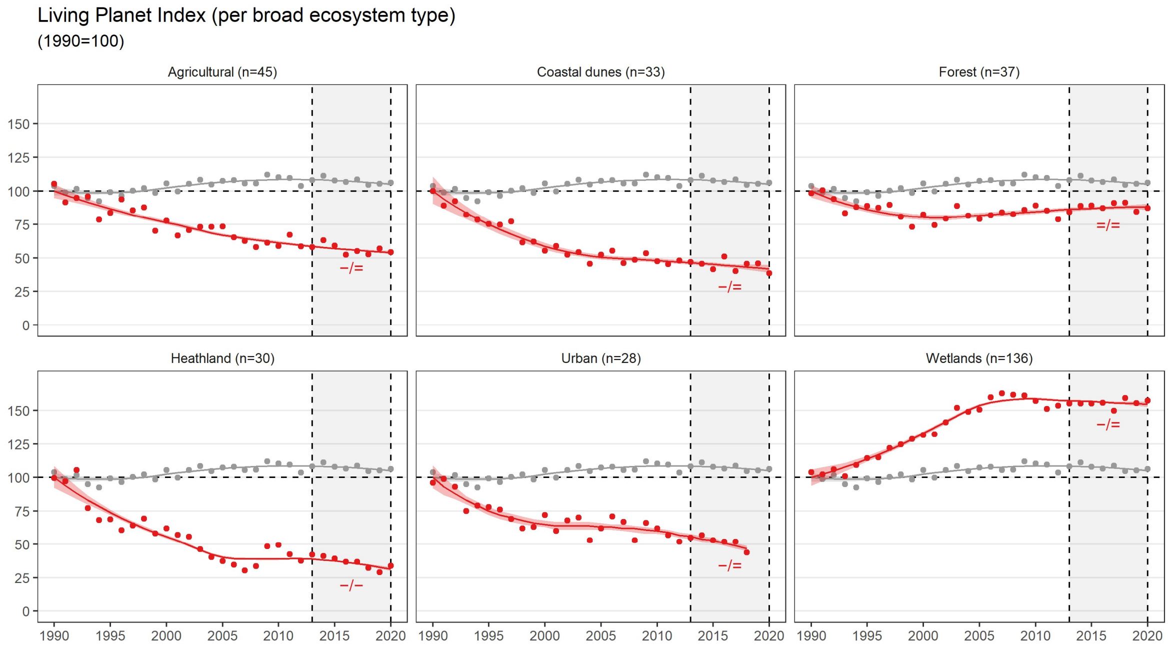

Figure 9: Living Planet Indices for six broad ecosystem types

2.6.2. Compiling the Accounts

The ecosystem extent account helps to understand the trends in ecosystem level biodiversity. In addition, the ecosystem condition accounts employ data on the level of protection for natural and semi-natural ecosystems (i.e., extent protected by Natura 2000 and other national protected area designations), as well as their conservation status reported under Article 17 of the Habitats Directive (see Lof et al., 2019). This communicates on the extent of different broad ecosystem types that are of excellent, good or average conservation status, as assessed by the Netherlands under their reporting obligations of the Habitats Directive.

The species-level biodiversity accounts include a Red List indicator account and associated threatened species account, a Living Planet Index account, an ecosystem quality account and a combined biodiversity account for the Netherlands (Bogaart et al., 2020). The species-level biodiversity accounts communicate trends over two-time scales: a longer time horizon (from circa

1990 to recent times); and, a shorter accounting period from 2013 to 2020. This shorter period is aligned with the focus of other current SEEA EA accounts for the Netherlands (i.e., the extent, condition, physical and monetary supply-use of ecosystems, Bogaart et al., 2020). It is important to highlight that while the Red List Indicator (RLI) account approach is based on monitoring trends in threat status, the Living Planet Index (LPI) focuses on estimates in abundance of biodiversity (Bogaart et al., 2020).

2.6.2.1. Threatened Species Accounts

In the Netherlands, both the components of Red List Indicators (Length and Colour) are integrated into an index and used to compile the Red List Indicator Account for 2013 to 2020 (see Table 12). Length indicates changes in the number of species on Red Lists, while the RLI Colour indicates the aggregated degree of threat. Length shows a slight increase between 2013 and 2020. Colour shows a slight increase for both nature and for freshwater. However, 2020 values are higher for terrestrial and lower for freshwater compared to their 1995 reference levels, suggesting a contrasting degree of threat for these two broad environments.

Table 12: Red List Indicator account for 2013-2020. Indicator values for other years are included for reference (Updated from Bogaart et al., 2020).

		All ecosystems		Terrestrial / dry nature		Freshwater / wetlands	
	Year	**RL Length**	**RL color**	**RL Length**	**RL color**	**RL Length**	**RL color**
	1995	100.0	100.0	100.0	100.0	100.0	100.0
	2005	100.6	96.5	125.8	115.5	92.3	93.2
Opening stock	**2013**	**98.8**	**94.4**	**119.7**	**113.8**	**89.7**	**90.3**
	2014	99.0	94.5	119.7	113.8	89.7	89.3
	2015	99.1	94.1	122.7	116.7	87.2	86.4
	2016	99.0	94.3	121.2	119.0	87.2	85.4
	2017	101.6	95.5	119.7	118.4	89.7	91.3
	2018	101.6	94.9	121.2	117.2	92.3	96.1
	2019	101.3	94.6	122.7	118.4	87.2	91.3
Closing Stock	**2020**	**101.6**	**94.8**	**121.2**	**118.4**	**89.7**	**92.2**
Net change		2.8	0.4	1.5	4.6	0.0	1.9

For tracking the risks of extinction for various species, a threatened species account has also been developed. Virtual Red List (as described in Section 2.6.1) for 2013 and 2020, along with a dedicated classification system to map changes in Red List status, were incorporated for the compilation of the account from 2013–2020. As six multiple levels of status yielded 36 possible transitions, each of the 1771 species (part of the RLI) is categorised into one of these transition categories. These transition categories are mapped onto six different mutation types. As shown in Table 13, this allows trends in the number of species transitions between threat status categories to be tracked over accounting periods and linked to the causes of these transitions. As Table 13 reveals, a net trend in increases in threatened species (+19) and, commensurate, decreases in species whose threat status of least concern (-19) is observed between 2013 and 2020.

The previous accounting period 2006-2013 showed an improvement in the overall threat status of threatened species (i.e., an overall decrease in threatened species and increase in species assessed as being of least concern) (Bogaart et al. 2020). However, this trend reverses between 2013 and 2020. Since there are more years recorded in the period 2013-2020, there is more certainty on this deterioration in the general threat status species in the Netherlands in recent years.

Table 13: Threatened species account for the Netherlands, 2013–2020. Grey cells denote logical impossibility.

		Red List categories							
		Extinct	Critically endangered	Endangered	Vulnerable	Near threatened	**Total Red List**	Least concern	**Total**
Opening stock (2013)		85	105	149	209	127	**675**	1096	**1771**
Additions									
	Local extinctions	2					**2**		**2**
	Rediscoveries of local extinct species		1	0	0	2	**3**	1	**4**
	From lower threat categories		5	11	5		**21**	0	**21**
	From higher threat categories			3	13	5	**21**		**21**
	New additions to list		0	2	6	22	**30**		**30**
	Removals from list							10	**10**
	Total additions	2	6	16	24	29	**77**	11	**88**
Reductions									
	Local extinctions		2	0	0	0	**2**	0	**2**
	Rediscoveries of local extinct species	4					**4**		**4**
	To lower threat categories		6	11	4		**21**		**21**
	To higher threat categories		0	2	13	6	**21**		**21**
	New additions to list							30	**30**
	Removals from list		1	2	4	3	**10**		**10**
	Total reductions	4	9	15	21	9	**58**	30	**88**
Closing stock (2020)		83	102	150	212	147	**694**	1077	**1771**

2.6.2.2. Species Abundance (LPI) Accounts

The LPI is based on the principle that the more species that show negative population trends, the stronger the overall decline and the more the state of nature is degrading (the corollary also holds). The LPI account provides opening and closing LPI values for the 2013 – 2020 accounting period, together with net changes. As highlighted in Figure 9, species trends can be disaggregated by ecosystem type by focusing on habitat specialists. As shown in Table 14, using this approach allows for LPI values to be determined for the opening and closing of the accounting period for broad ecosystem types. In this fashion, the LPI can be used as a signalling tool for changes in ecosystem quality (i.e., a composition indicator of ecosystem condition). As the LPI account presented in Table 14 reveals, the overall status of species-level biodiversity was essentially stable between 2013 and 2020, although large relative decreases are highlighted in heathland ecosystems.

Table 14: LPI account for the Netherlands, 2013–2020. LPI values for opening and closing years are smoothed values. The change assessment is taking uncertainty in these smoothed values into account.

Ecosystem (sub)type	CLO	Living Planet index 2013	2020	Change in LPI Absolute	Relative	Assessment
All Terrestrial and Freshwater	1569	108.4	105.2	-3.3	-3%	Stable
Terrestrial	1579	85.0	81.9	-3.1	-4%	Stable
Terrestrial nature	1581	57.5	54.4	-3.09	-5%	Decreasing
Forest	1162	86.3	88.3	1.98	2%	Stable
Open nature	1586	39.9	35.5	-4.37	-11%	Decreasing
Heathland	1134	39.1	31.4	-7.68	-20%	Decreasing
Coastal Dunes	1123	46.9	41.9	-5.04	-11%	Stable
Freshwater and wetlands	1577	157.3	154.7	-2.64	-2%	Stable
Agricultural	1580	58.7	54.2	-4.48	-8%	Stable
Urban	1585	56.0	47.0*	-9	-16%	Stable

** For the Urban LPI closing stock the year 2018 was used instead of 2020.*

2.6.2.3. Ecosystem Quality Accounts

To compile an ecosystem quality account, MSAs have been disaggregated to broad ecosystem types in an approach similar to the LPI account. The changes in the ecological quality are expressed as changes in MSA for five terrestrial ecosystem types for the period 2006-2013 (not updated for 2020). As shown in Table 15, the MSA in three terrestrial ecosystems are stable, two are increasing and one is decreasing in quality. The long-term trends assessment in Table 15 is based on data from the CLO.[14]

Table 15: Ecosystem quality account for 2006-2013 (Bogaart et al., 2020)

Ecosystem	MSA Opening	Closing	Change absolute	relative	interpretation	Long term trend (1994–2017)
Terrestrial						
overall	37.8	37.8	0	0%	Stable	Decreasing/Stable
Forest	32.3	35	2.7	8%	Increasing	Stable
Grassland	29.2	33.4	4.2	14%	Increasing	Stable
Heathland	32.6	32.3	-0.3	-1%	Stable	Decreasing/Stable
Coastal dune	47.1	43.9	-3.2	-7%	Decreasing	Decreasing
Wetlands	47.5	45.9	-1.6	-3%	Stable	Decreasing/Stable
Freshwater						
overall	36.2	39.8	3.6	10%	Increasing	Increasing

To provide a holistic and integrated overview of biodiversity across the Netherlands, the ecosystem quality account is provided in a combined presentation with data from the ecosystem extent and LPI accounts. This is presented as Table 16 (not updated for 2020). In addition, the Netherlands have also experimented with the use of spatially explicit information on butterflies for national

[14] CLO 2052: https://www.clo.nl/indicatoren/nl2052-trend-kwaliteit-natuurtypen

biodiversity accounting (Bogaart et al., 2020) and other species groups in the Limburg province (Remme et al., 2016).

Table 16: Combined Biodiversity Account (Bogaart et al., 2020).

Ecosystem (sub)type	Extent			Living Planet index			MSA ecosystem quality		
	2006	2013	Change	2006	2013	Change assessment	2006	2013	Change assessment
All Terrestrial and Freshwater				107.7	108.9	1% Stable			
Terrestrial				85	87	2% Stable			
Terrestrial nature				59	60	2% Stable	37.8	37.8	0 Stable
Forest	326903	329540	1%	93	98	5% Increasing	32.3	35	8% Increasing
Open nature				39	38	-3% Stable			
Heathland	38343	41493	8%	42	37	-12% Decreasing	32.6	32.3	-1% Stable
Coastal Dunes	24010	22049	-9%	57	54	-5% Stable	47.1	43.9	-7% Decreasing
Semi-natural grassland	49841	57790	14%				29.2	33.4	14% Increasing
Freshwater and wetlands				144	144	0% Stable			
Freshwater	408344	421246	3%				36.2	39.8	10% Increasing
Wetlands	37006	47669	22%				47.5	45.9	-3% Stable
Agricultural	1867094	1822362	-2%	63	56	-11% Decreasing			
Urban	519289	546967	5%	63	56	-11% Decreasing			

Notes:
Forest' includes permantenly vegetated coastal dunes
Urban' includes built-up environments and public green space

2.6.3. Key insights

The work reveals the following key insights for 'Accounting for Biodiversity':

- The Netherlands biodiversity accounts contain "official" statistics on biodiversity related models and the data contained in the account is complementary to the results in a separate report on the state of the Dutch ecosystem.
- The RLI and LPI based accounts demonstrate how data from well-established national processes for monitoring species-level biodiversity can be used to inform thematic accounts for biodiversity. These are also well recognised indicators from the conservation community that will be recognisable to many decision-makers.
- The ecosystem quality account also used 'Mean Species Abundance' (MSA) as an accounting item, another indicator that is reasonably well understood in the environmental management community. This demonstrates mainstreaming of key conservation science outputs into the SEEA.
- For the MSA, 1950 is proposed as an appropriate reference level as it reflects a time when widespread ecological impacts from intensive agriculture where largely absent. This may be relevant to other countries in Europe, particularly for compiling ecosystem condition indicator accounts.
- Bringing all the key data from the biodiversity account into a combined presentation provides decision-makers with a broad oversight of emerging biodiversity trends and issues. This streamlined presentation is likely to be helpful in engaging decision-makers.

- As part their thematic accounting for biodiversity, the Netherlands include ecosystem level biodiversity accounts. In particular, they include information on protected area and the protection and conservation status of different ecosystem types. This makes the accounts relevant to management (e.g., with respect to the protected areas system) and policy concerns (e.g., with respect to the EU Habitats Directive)

- The species-level biodiversity accounts produced by the Netherlands are largely non-spatial. The work demonstrates how species-level data can be organised to inform species-level biodiversity within broad ecosystem types on the basis of habitat specialisation or preferences. This can also broadly inform the compositional state characteristics of ecosystem condition.

- The advantage of moving to spatially explicit data to achieve a full spatial integration of ecosystem and species level biodiversity data for ecosystem accounting is recognised. The Netherlands is experimenting with determining relevant spatial patterns of biodiversity based on occupancy models for butterflies that can inform these types of approaches. This will be further developed as part of the Netherlands accounting for biodiversity activities.

- Current policy challenges focusing on ecosystem deterioration due to excess nitrogen deposition call for more spatial detail and options for site stratification than was originally foreseen when developing the ecological monitoring network and programme. This calls for both a synthesis of official monitoring data and opportunistic observational data, and an appropriate design of additional monitoring schemes that are aligned with the structure of ecosystem accounts.

2.7. Norway

Norway has invested substantially in developing and implementing measurement approaches for tracking the state biodiversity at different scales. In particular, via the Norwegian Nature Index[15], a composite biodiversity index based on combining the abundance of species and surrogate indicators within an aggregation framework to form a national index (Certain et al., 2011). The Norwegian Institute for Nature Research (NINA) has also been evaluating the application of a biodiversity index in Oslo as part of the urban ecosystem accounting project (NINA, 2017), as further developed through the MAIA project.

Another important biodiversity relevant index recently developed in Norway is the Index-Based Ecological Condition Assessment framework (IBECA) (Jakobsson et al., 2021). This also provides a structured framework for organising information on ecosystem condition, which is highly relevant to

[15] https://www.naturindeks.no/

the ecosystem condition typology of the SEEA EA. Norway is currently using and further developing IBECA for ecosystem condition assessment (ECA) at national and regional scales. The first national level condition assessments for forests and mountains have been completed (Framstad et al., 2022). Within the IBECA assessments for forests and mountains, the NI is an indicator of biodiversity. Work is also ongoing in assessing combined data sources, platforms and presentations required to populate core and thematic ecosystem accounts, meet local planning needs, national SDG reporting requirements and expected EUROSTAT reporting requirements (Nybø et al., 2020). The IBECA is also being tested at local scale via a pilot application in Nordre Follo, a municipality in Southeast Norway.

2.7.1. National biodiversity data used

Both the NI and IBECA are empirically based frameworks for condensed reporting on the state of nature. They provide composite indices for different major ecosystem types, intended to synthesise and communicate trends in nature to policy makers and the public. A key feature of both the NI and IBECA is the explicit consideration of reference conditions. These are essential for normalising variables, spatial aggregation and generating indicators for compilation of the ecosystem condition indicator (and index) accounts of the SEEA EA framework. As such, the experiences in using these approaches in Norway shed light on tractable approaches to integrate different biodiversity data (especially species level data) into ecosystem accounts.

2.7.1.1. Norwegian NI data

The NI is calculated from multiple data sources. The NI in 2020 included 260 different indicators from marine, terrestrial and limnic ecosystems. Descriptions of data sources of individual indicator pages can be found on the Naturindeks webpage.[16] Data has been gathered by different biodiversity relevant monitoring programmes across sectors, as well as associated expert assessments. The Norwegian Institute of Bioeconomy Research contributed with indicators of forests, semi-natural grasslands and heathlands. The Institute of Marine Research and the Norwegian Institute for Water Research (NIVA) has contributed with indicators for coastal and ocean ecosystems. NIVA has also contributed with data on freshwater biology. The NTNU University Museum has reported on indicators for mosses, based on expert assessment and data from the Norwegian Biodiversity Information Centre's Species Map Service.

NINA has contributed with indicators from all major ecosystems within the NI from a variety of monitoring programmes funded via the Norway Environment Agency. These include monitoring important animal populations, such as large predators, deers, mountain foxes, seabirds, salmonids and a number of threatened species. A number of indicators are obtained from the Programme for Terrestrial Monitoring (TOV), national monitoring with respect to the EU Water Framework

[16] https://www.naturindeks.no/Indicators

Directive and Long Range Transport Convention, the SEAPOP monitoring programme for the marine realm and the Norwegian Biodiversity Information Centre's Species Map Service.

2.7.1.2. IBECA data

The Index Protocol is based on the approach used in the Nature Index for Norway and assessments under the Water Framework Directive. Töpper & Jakobsson (2021) set out the protocol for calculating the IBECA. It has common features with the proposed system for assessment of ecosystem condition in the SEEA EA.

The IBECA is considerably more parsimonious than the NI. Jakobsson et al., (2021) describes the indicators used to assess the ecological condition of forest and alpine ecosystems using the IBECA. As shown in Figure 10, these 11 indicators are grouped into seven overarching ecosystem characteristics. Scaling of the indicators against a common reference value allows composite indicators of overall ecological condition to be derived (central ellipse in Figure 10).

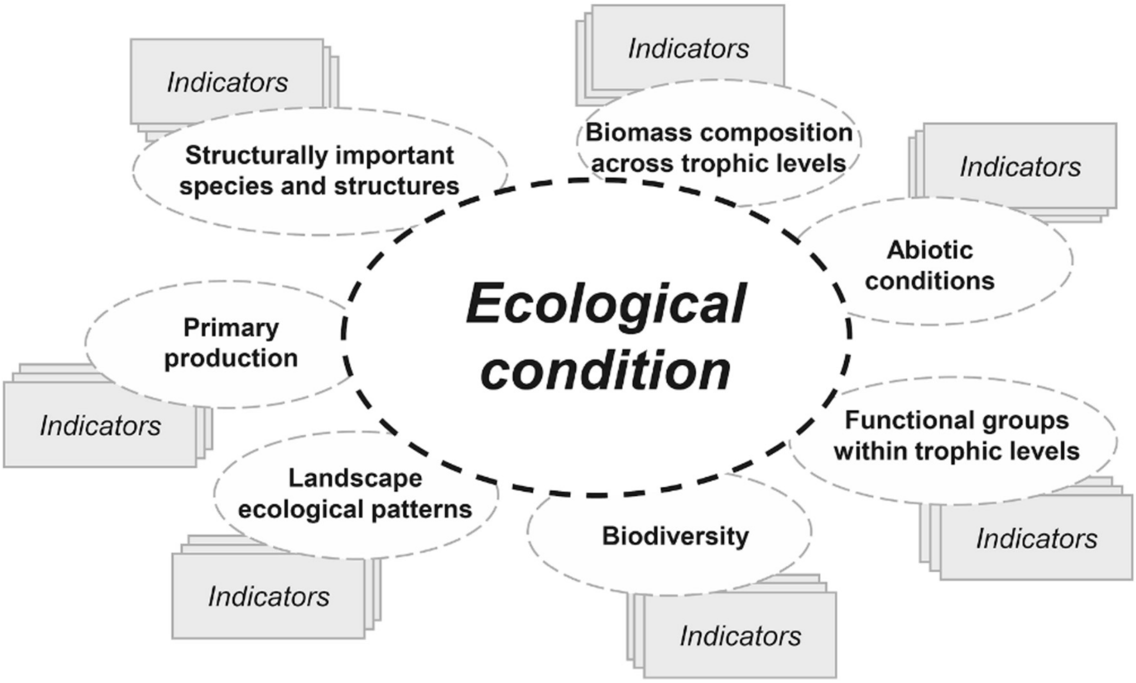

Figure 10: IBECA Framework (Jakobsson et al., 2021)

The data sources for these indicators are largely the same as the NI, but supplemented with new indicators not directly related to species abundance (as is the NI) but more related to the seven ecosystem characteristics (Figure 10). For example, the forest condition accounts include the NI as an indicator of the ecosystem characteristic of biodiversity. In addition, indicators reflecting other ecosystem characteristics include the absence of alien vascular plant species, the proportion of forest area > 1 km from technical infrastructure, the proportion of old forests, vegetation indicators for species response to climate change, nitrogen and humidity, primary production (NDVI) and the biomass of herbivores and carnivores. All new indicators were based on monitoring data only, no expert assessment was included in the estimation of these indicators. Important monitoring programmes were the National Forest Inventory, the Terrestrial Monitoring Programme (TOV), the new vegetation monitoring programme (ANO) and monitoring programmes for carnivores and moose.

For the upcoming assessment of condition of alpine/mountain ecosystems, additional indicators will be included. These include vegetation response to climate change, absence of alien species, primary production and absence of technical infrastructure. In addition, indicators on species such as bird, small game, reindeer and arctic fox will be included. It is also noted that several of the indicators for biomass composition between trophic levels and for functionally important species are relevant to measuring the functional state characteristics of ecosystem condition (for all indicators see supplementary material, Jakobsson et al., 2021). For further details on the source data, see Nybø et al., (2019, in Norwegian).

2.7.2. Compiling the Accounts

Within Norway, the structured approach of the NI is considered to provide a 'Thematic Account for Biodiversity'. The IBECA framework is well aligned with the SEEA EA Ecosystem Condition Typology (ECT), with indicators adopted for testing application in forest and alpine ecosystems directly corresponding to the compositional, chemical state and landscape characteristics of the SEEA EA ECT.

Both the NI and the IBECA set out approaches for scaling of biodiversity and other data variables to generate indicators. In order to scale across different variables, a reference condition is required. For the IBECA, the reference condition is defined as 'intact ecosystems'. This is defined with respect to recent natural or semi-natural biodiversity and ecosystem functioning. Historic extinctions are not considered and species introduced before 1800 CE are regarded as native, climatic conditions follow the normal period (1961–1990) and modern intensive or large-scale human pressures are absent (Jakobsson et al., 2020).

As reference conditions and scaling procedures are also a general requirement of the SEEA EA ecosystem condition accounting framework for moving from ecosystem condition variable accounts to ecosystem condition indicator and index accounts, the experiences of Norway provide important insight into how to integrate biodiversity monitoring data into these accounts. Further information is provided by Jakobsson et al., (2021) and Töpper & Jakobsson, (2021).

A useful feature for significant change detection of both the NI and IBECA is that they have a statistical component. This means they can produce confidence intervals for different indicators and aggregates. Also, as knowledge and data improve, the IBECA and NI will be recalculated for historical years, thus updating assessments to the latest and best knowledge available.

2.7.2.1. Aggregating indicators into a quantitative assessment of ecosystems

The NI aggregates from a set of species indicators in a single spatial unit (Step A, Figure 11) to averaging several spatial units (Step D, Figure 11) (note Step 'C' is no longer implemented in the current NI for Norway). To account for the fact that not all taxa, functional groups, or geographical areas can be studied to the same degree, indicator values are weighted. A summary for how the overall index can be calculated is shown in Figure 11. It can be seen how Steps A to E could yield a thematic account for biodiversity for an ecosystem similar to the ecosystem condition index account presented in Table 5.4 of the SEEA EA. Several publications and technical resources for calculating the NI are available from the NINA webpage.[17] This includes a GitHub repository containing the R package code for calculating the NI.

Certain et al., (2013) provided a review of the links between the SEEA EEA (2012) and the NI. Numerous points of correspondence between the NI framework and the SEEA EEA framework are identified, although the authors suggest the NI is best suited to supporting informing on ecosystem condition. This reflects the fact that major ecosystem types align with the ecosystem asset and ecosystem types in the updated SEEA EA. Given the nature of the indicators considered in the NI, it is particularly relevant for informing on compositional characteristics associated with species level biodiversity.

As the hierarchical structure of the NI is different to that of the SEEA EA ECT, it provides information on different 'biodiversity entities'. As shown in Figure 11, the NI is balanced with respect to trophic groups, primary producers, primary consumers, intermediate consumers and top predators to reflect overall biodiversity. Some indicators are defined as 'extra representative' and those indicators are weighted to represent 50% of the index. These indicators reflect the abundance of several species, for instance some invertebrate indices. The weighting system was agreed upon by the ecologist researcher group representing marine, limnic and terrestrial ecosystems supporting NINA developing the NI.

The EUROSTATs Task Force proposal for standardising reporting on ecosystem condition indicators, as part of EU and EEA implementation of UN SEEA EA, uses a simpler set of area-based indicators. They do not use reference levels as in the IBECA approach. NINA follows the EUROSTAT Task Force work through Statistics Norway's representative. NINA has provided feedback regarding needs for improvement, including the lacking connection between ecosystem condition indicators proposed for MS reporting on ecosystem condition, and physical ecosystem services, and lacking reference levels. Independent of EUROSTAT minimum reporting requirement on ecosystem condition, NINA

[17] https://www.nina.no/english/Environmental-monitoring/The-Norwegian-Nature-Index

and Norwegian environmental authorities plan to continue implementing and improving the IBECA system within the country.

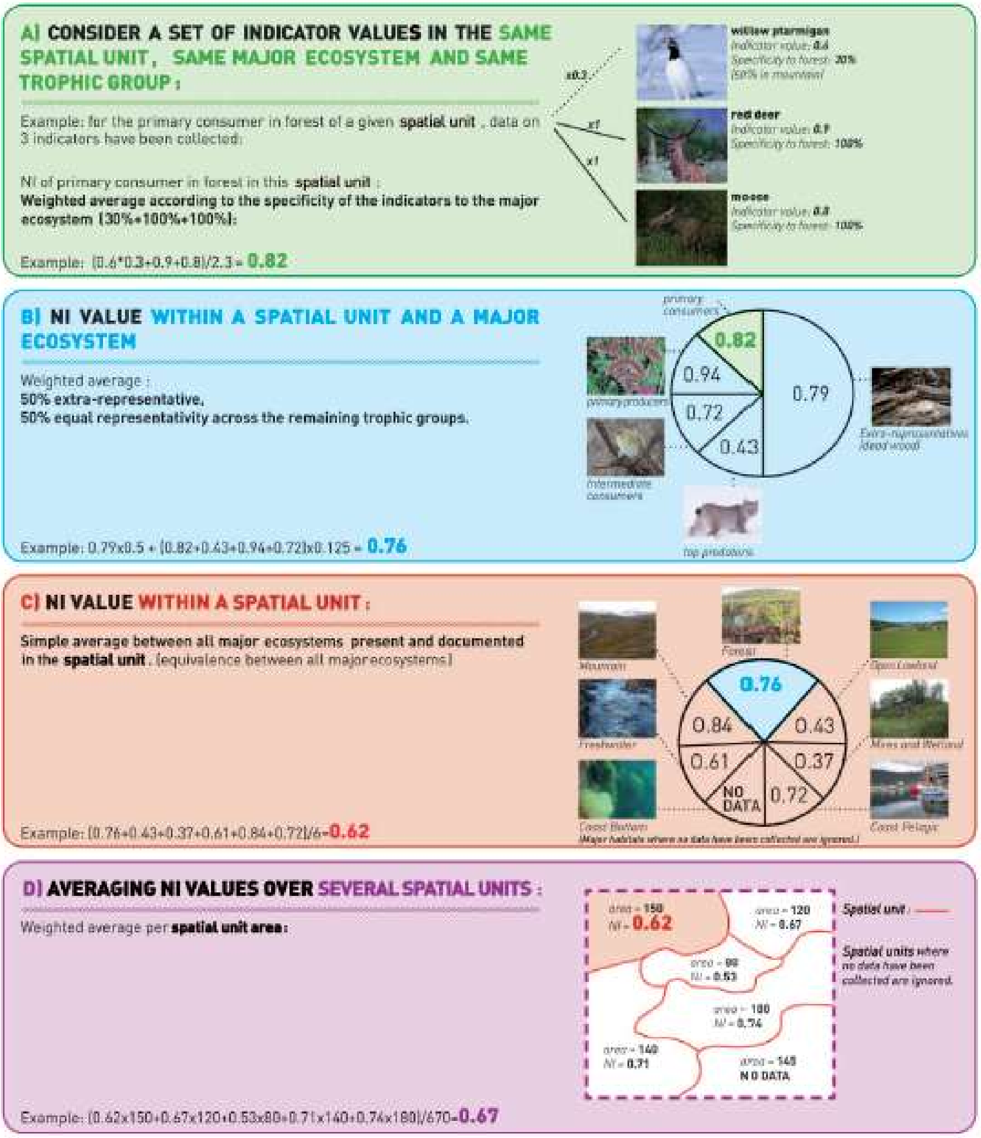

Figure 11: Example of NI Aggregation process, revised after Certain et al., (2011) *(Note Step 'C' is no longer implemented in the current NI for Norway).*

2.7.2.2. Using the IBECA for Ecosystem Accounting

Jakobsson et al., (2021) provides a cross comparison of the 11 indicators used in the IBECA approach for the forest and alpine ecosystems tested in Trøndelag county, central Norway, in 2019with the SEEA EA ECT. Table 17 summarises the results, revealing how data from biodiversity monitoring can be used to generate indicators that can inform ecosystem condition accounting via the SEEA EA. This includes species level data on deer, predators, bilberry, deciduous trees, as well as invasive species, relevant to the compositional state characteristics of ecosystem condition (as per the SEEA ECT). At the 2021 national forest assessment, more indicators were included in the assessment.

Table 17: Correspondence between indicators used for IBECA for forest ecosystem assessment in Trøndelag county (Jakobsson et al., 2021).

Indicator	SEEA EA ECT					
	Abiotic		Biotic			
	Physical State	Chemical State	Compositional state	Structural state	Functional state	Landscape
Area proportion of invasive species			✓			
Area proportion >1km from infrastructure						✓
Deer Species Population			✓			
Predators population*			✓			
Area proportion old growth forest						✓
Bilberry coverage			✓			
Dead wood total volume				✓		
Dead wood >30 cm volume				✓		
Nitrogen deposition		✓				
Indicator value of vegetation for nitrogen		✓				
Deciduous tree species (3 species)			✓			

*Potentially this could be a functional state characteristic of ecosystem condition.

The aggregate condition of forest ecosystems in Trøndelag county was found to have significantly reduced to 0.48 of the reference condition value of 1 (95% Confidence Interval = 0.45 – 0.51). As Jakobsson et al., (2021) describe, a threshold is needed for understanding what this means in terms of 'good' versus 'poor' ecosystem condition, acknowledging the lack of a clear distinction of what constitutes a *good* ecological condition for any given indicator. They adopt the value of 0.6 as representative of a threshold for good ecological condition when interpreting the results.[18]

Reflecting on Table 17, it is apparent that the component indicators of the IBECA could also be organised in the format of ecosystem condition Index account presented in Table 5.4 of the SEEA EA.

[18] Jakobsson et al., (2021) define a 'significant reduction' of ecological condition as values < 0.6 with a 95% CI not overlapping 0.6, and values where the 95% CI overlaps 0.6 as a 'marginal reduction' of ecological condition. Values > 0.6 with a 95% CI not overlapping 0.6.

Whilst the IBECA provides a different aggregation hierarchy of indicators, Jakobsson et al., (2021) also successfully test the aggregation into sub-indexes for the different hierarchy of the SEEA EA ECT.

2.7.2.3. Links between subnational applications of the IBECA and Ecosystem Accounting

2.7.2.3.1. OSLO CASE STUDY

Urban ecosystems are not covered by the Norwegian Nature Index. A main barrier to the NI in urban systems has been a lack of spatially representative species monitoring data and of a methodological approach to determine a reference condition. The URBAN EA project lead by NINA collected a representative stratified sample of vascular plants across urban morphologies in Oslo in 2017 and carried out multi-species distribution modelling (pollinator-friendly, limestone specialists and invasive species). Models use a set of predictors including landcover types, bedrock and soil types, slope, curvature, aspect, sun exposure and infrastructure (Skarpaas et al., in progress).

These models have been applied as part of the MAIA project to demonstrate urban ecosystem condition accounting. With such models, one can experiment with different approaches to the definition of reference conditions in the 'contemporary ecosystem' of the built zone. For example, by setting infrastructure variables to zero, a pre-industrial reference condition for the built zone can be defined. Such a modelled "natural" reference can be discussed versus modelled references for "contemporary ecosystems" (McNellie et al., 2020), in light of municipal biodiversity conservation and planning objectives.

2.7.2.3.2. NORDRE FOLLO CASE STUDY

The goal of the Nordre Follo pilot project is to perform an Ecosystem Condition Assessment (ECA) using the IBECA at the scale of a single municipality in Southeast Norway ("Nordre Follo"), and to explore and develop ways for integrating ECA across scales. This scale of focus reflects effective ecosystem management and area accounting may sometimes need to be coordinated at more local spatial scales. This pilot is part of ECOGAPS, an interdisciplinary project centred on improving ecosystem-based management through better integration across spatial and institutional scales.[19]

The Nordre Follo pilot project requires ECA to be downscaled. Downscaling (and upscaling) approaches encounter multiple methodological and conceptual issues the project will explore. Further challenges include finding the datasets and candidate indicators which a) cover relevant aspects of the ecosystems; b) for which it is possible to define a reference state (especially challenging for contemporary and semi-natural ecosystems); and c) which have an appropriate

[19] https://www.oslomet.no/en/research/research-projects/ecogap-bridging-knowledge-and-decision-making-across-sectoral-silos-and-levels-of-governance

spatial resolution. On this last point, many of the datasets used in the national assessments are unlikely to have the resolution needed for a local assessment.

Communicating results in a way that is both relevant for and accessible to land managers, with relevancy mostly referring to matching the spatial scale of the ECA and the level of land management, is also a practical challenge that needs to be overcome. The insights from this pilot will be highly relevant for ecosystem condition accounting at municipal scales.

2.7.3. Key Insights

The experiences in Norway with respect to the NI and IBECA reveal the following insights with respect to 'Accounting for Biodiversity':

- Both the NI and IBECA provide operational frameworks for scaling biodiversity data for inclusion in ecosystem condition indicator and index accounts of the SEEA EA. The application of the approaches provides relevant practical insights to ecosystem condition accounting via the SEEA EA and the integration of biodiversity monitoring data items into these accounts.
- The NI demonstrates it is possible to harmonise and aggregate biodiversity data from a broad range of institutions and monitoring programs into a national thematic biodiversity account. The IBECA also highlights a more parsimonious approach for organising biodiversity monitoring data, which may be better suited to ecosystem condition accounting.
- The IBECA describes a reference condition for scaling biodiversity data that is operational for Europe and historic human impacts that will be relevant to other European countries.
- Both the NI and IBECA frameworks allow for standardised estimates of the condition of biodiversity in ecosystems that can be compared between and across ecosystems.
- Decision-makers benefit from clear thresholds indicative of 'good ecological condition' for different condition indicators. Such a threshold has been used for the Norway application of the IBCA in Trøndelag county.
- In Norway, municipalities are the principal authority for land use plans. While regional or municipal spatial resolution of the NI and IBECA condition indicators provide consistent national level indicators of biodiversity and ecosystem change, their usefulness for spatial prioritisation of restoration and conservation actions is low. Current research and development efforts are focused on downscaling IBECA to support municipal land use planning, and pilot studies are focusing on implementing ecosystem condition indices for urban systems.

2.8. Spain and Andalusia

In Spain, the Agroforestry Accounting System (AAS) has been developed to integrate the values of ecosystem services, products, incomes and environmental assets into national accounts. The AAS builds on the exchange value criterion as supported by the System of National Accounts (SNA) and the SEEA EA. The AAS provides a spatially explicit accounting framework for integrating physical and economic information on forests, which has been applied in the Spanish region of Andalusia (see Campos et al., 2019).

The AAS integrates a wide range of data. This includes information on threat status of a list of forest species, their distribution and the willingness to pay (WTP) of households for their protection (one of thirteen ecosystem services included in the AAS and omitted from national accounts and an ecosystem service omitted from the SEEA EA). The list of threatened forest species and maps of their distribution was also used to calculate a composite index communicating the relative (non-monetary) conservation value of threatened biodiversity in Andalusia's forests (see Díaz et al., 2020).

2.8.1. National biodiversity data used

The underlying data basis for calculating the threatened species index is described in Díaz et al., (2020) and the supplementary material of Campos et al., (2019). The initial list of threatened species is based on the Annexes of the EU Birds and Habitats Directives. From these, species whose distributions did not include Andalusia and species that were not linked to forest habitats were removed on the basis of the information provided by the most recent national Red Books of threat status. This list was then completed with species endemic to Andalusia that are either 'Critically Endangered' or 'Endangered' according to the regional Red Books covering Andalusia but not covered by the EU Birds and Habitats Directives. The final threatened species list comprises 224 species including 81 plants, 76 birds, 31 mammals, 22 arthropods, 6 reptiles, 5 amphibians, and 3 molluscs.

In order to inform the spatially explicit approach of the AAS, species distribution maps were derived for the presence / absence of the 224 threatened species identified. These distribution maps were obtained from regional distribution maps of threatened species provided by the regional Administration; the Spanish Vertebrates Database; Red Books of Andalusia invertebrates and plants; databases of the Anthos project for vascular plants (those not included in the Red Books); the national butterfly atlas for diurnal Lepidoptera; and the Spanish atlas of wintering birds. Where available, official maps at the 1km grid scale or finer were used. Where coarse scales only were available (mainly at 10k grid scale), these were downscaled to 1km grids on the basis of habitat and altitude preferences of species.

The type of forest habitat occupied by each species in Andalusia was then obtained from a comprehensive literature review on species requirements after grouping the forest types defined in the Andalusian vegetation map into fewer categories. Thus, the 72 forest land types identified in the vegetation map were grouped into 16 types based on dominant species and woodland structure. The potential presence-absence of each of the 224 species across the forest patches was identified in the Andalusian Forest map. These presence-absence patterns and estimates of the distribution area of each species were the basis for estimating the economic exchange value of threatened biodiversity existence in Andalusian Forests (Campos et al., 2019).

Díaz et al., (2020) developed a weighting methodology to reflect the relative functional non-economic conservation value of different threatened species. Relative weights were assigned to each species based on seven factors. These comprised: species threat status; functional role of species (i.e., ecosystem engineers and keystone species); knowledge on the species available, as well as disturbances factors due to forest fragmentation, wildfires, grazing and silviculture. The weighing factors for the list of species varied between 2 and 14, with critically endangered and reintroduced species having the highest factors (Díaz et al., 2020).

Conservation values were then determined for each forest grid cell by aggregating the weighting factors described above across all species present in the cell to calculate a composite index of conservation value. The performance of this approach was tested by comparing the resulting conservation values in protected and unprotected areas, as well as in different forest systems. The distribution of these conservation values and protected area boundaries are shown in Figure 12.

2.8.2. Compiling the Accounts

The approach described by Díaz et al., (2020) is highly relevant to the species accounting described in the SEEA EA (chapter 13.3). The process of deriving species distribution maps for different forest ecosystem types would allow species accounts for threat status and distribution to be compiled for the forests of the Andalucía Region relatively readily. Similar accounts can be envisaged in 'Accounting for Biodiversity' tracking trends in aggregate conservation values, including inside and outside of protected areas and other management areas of interest. This would provide a very useful biophysical aggregate to support the monetary aggregates presented in the AAS.

The AAS uses the term 'environmental income' as an aggregate measure of the annual value of ecosystem services plus the change in the monetary value of ecosystem assets over a year (termed 'Enhancement/Degradation adjusted [environmental] net operating surplus' in the SEEA EA, see Table 11.3). Environmental Income combines with Manufactured Capital Income and Labour Costs from activities to create the Total Income from forests in the AAS. Accordingly, Environmental Income from different ecosystem services can be estimated by subtracting labour costs and normal returns on manufactured capital from total income. Campos et al., (2019) explore the links between Environmental Income and the SEEA EEA further.

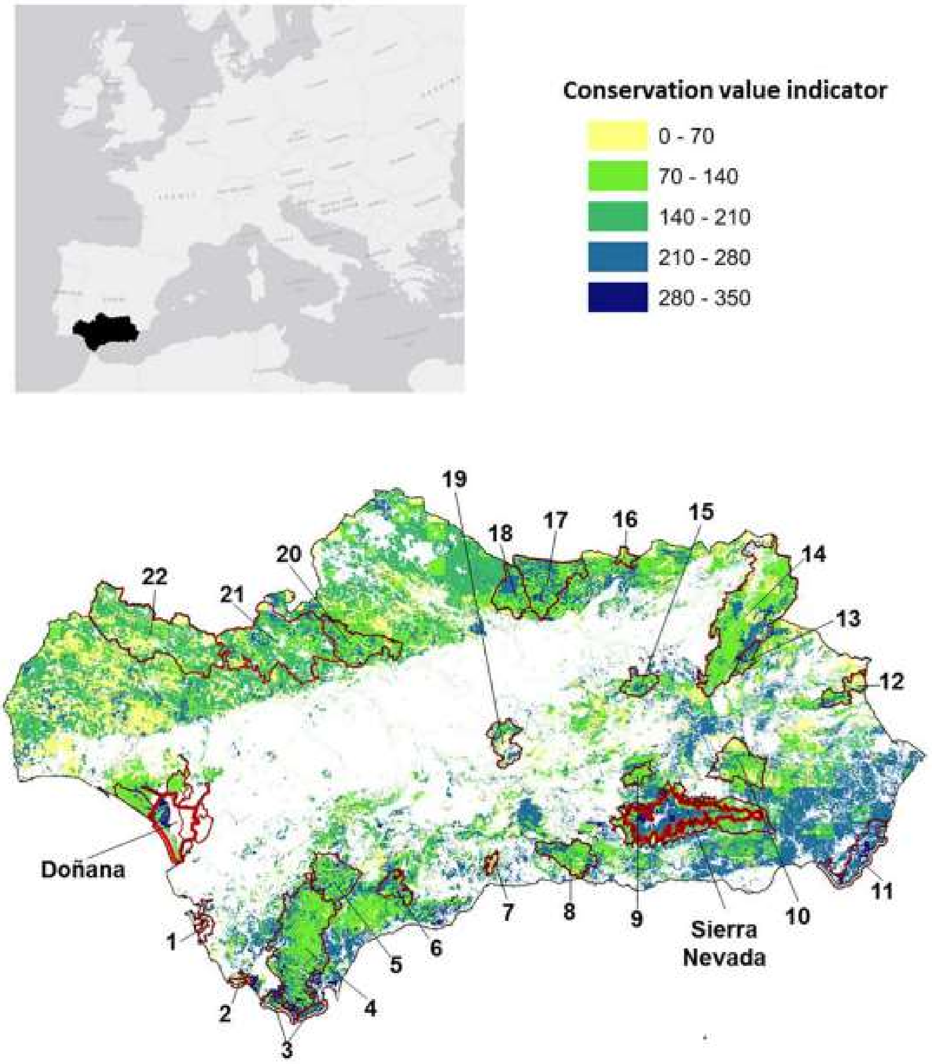

Figure 12: Map of the values of the relative conservation index of Andalusian forests (Díaz et al., 2020)

The AAS considers a broad range of provisioning, regulating and cultural ecosystem services. This includes threatened species preservation (broadly equivalent to the 'Species and ecosystem appreciation' service of the SEEA EA reference list). To measure the exchange value for passive use (termed non-use by the SEEA EA) of the threatened species preservation service, Willingness to Pay (WTP) estimates were derived from a stated preference survey administered across Andalusian households. In this survey, respondents preferences for a range of outcomes were elicited, including improved conservation status for currently threatened species and how much they were willing to pay each year for these outcomes (see supplementary material, Campos et al., 2019). The simulated exchange value approach was employed to make the WTP estimates consistent with the exchange value concept of the national accounts. The simulated exchange value approach estimates the price and quantity that would prevail if a final product consumed without market price were traded in a hypothetical market (see Caparrós et al., 2017).

The Andalusia study uses the simulated exchange approach to integrate existence values for threatened forest species into the AAS. Further work to upscale the AAS from Andalucía to national application is being pursued. This will provide additional insights on integrating biodiversity into accounts and aggregates of environmental income.

2.8.3. Key insights

The work reveals the following key insights for 'Accounting for Biodiversity':

- The procedure for deriving distribution maps for priority conservation species and deriving associated existence values (based on the exchange value concept) can be applied to any region of the EU, if the process starts with the lists of species of the Birds and Habitat Directives. This also ensures a clear policy linkage.
- The spatial accounting approach and the maps of relative, non-monetary conservation values can help decision-makers in prioritising land use planning, conservation actions and protected area management. This can also be linked to the condition of ecosystems with respect to their conservation potential.
- The AAS includes accounting items that reflect the existence value that Spanish households place on the biodiversity of Andalusia's forests. As government agencies increasingly carry out analysis of the cost and benefits of public policy options, this monetary information can be extremely useful to decision-makers. This could form the basis of compensation services to landowners to secure this ecosystem service and its public benefits.
- Spatially-explicit forest total income estimates, such as those obtained from the AAS, can help inform more efficient public spending. For example, by concentrating resources in areas offering higher income (both in market and non-market terms).
- Environmental Income (EI) also considers future use of ecosystem services (i.e., changes in the values of monetary asset accounts). This can provide greater insight for policy makers interested in long term sustainable development outcomes.

3. RESEARCH QUESTIONS

This report presents practical insights with respect to accounting for biodiversity from eight MAIA countries. The experiences of the MAIA countries summarised herein, provide an inventory of rich experiences from which to address our research questions.

3.1. Using National Biodiversity Monitoring for Ecosystem Accounting

The first research question to answer was: How can existing national biodiversity monitoring processes be adapted for informing Accounting for Biodiversity and ecosystem condition accounting? The experiences from the MAIA countries with respect to this are summarised below:

- The established processes for organising monitoring data for reporting on the EU Birds Directive (e.g., Bulgaria), EU habitats Directive (e.g., Greece), EU Marine Strategy Framework (e.g., France), National Biodiversity Indexes (e.g., Norwegian Nature Index and IBECA) and official statistics (e.g., the LPI in the Netherlands) provide a key source of information for ecosystem accounting. As these processes require reconciliation and harmonisation of data, they streamline the data processing steps required for compiling condition and other thematic accounts for biodiversity.

- Species abundance or richness accounts can also yield summary indicators that can support ecosystem condition accounting (as can the underlying monitoring data directly). They can also yield indicators relevant to cultural ecosystem services, such as bird watching and hunting (e.g., see proposal for Finland).

- Several countries have undertaken two or more IUCN Red List type assessments for understanding national trends in extinction risk of species. These allow for 'Threatened Species Accounts' to be compiled, as demonstrated for the case of the Netherlands and Bulgaria.

- Where spatial referencing for national biodiversity data and indices is limited, information on species can be assigned to different broad ecosystem types based on habitat preferences. This is demonstrated in the LPI accounts for the Netherlands and is being adopted in Bulgaria using Article 12 Reporting Data for the Birds Directive. This approach provides a signalling tool for changes in ecosystem condition.

- There are a number of existing, structured frameworks for organising national biodiversity information and calculating composite indexes. These can be adapted to inform the SEEA EA Ecosystem Condition Typology (ECT). In Finland, the use of the ELITE Index for informing on the structural characteristics tracked in the ecosystem condition indicator accounts is demonstrated. Similarly, possibilities are also demonstrated for using the IBECA Index in Norway for informing on the SEEA EA ECT. Where these structured frameworks are cross cutting (e.g., the IBECA), they facilitate standardised estimation of the condition of biodiversity in ecosystems that can be compared between and across ecosystems.

- Defining reference conditions for compiling ecosystem condition accounts is clearly very challenging in Europe. In many cases, established biodiversity monitoring and assessment processes have tackled this. For the structural characteristics of forests in Finland, this has been determined via an expert group. This is also the approach adopted for the Norwegian Nature Index. The Netherlands adopts 1950 as a reference level for ecological quality accounts. This is because 1950 represents a time before the impacts of agricultural intensification led to widespread ecological impacts. For the IBECA Index in Norway, the reference condition is 'intact ecosystems', where historic extinctions are not considered, species introduced before 1800 CE are regarded as native, climatic conditions follow the normal period (1961–1990) and modern intensive or large-scale human pressures are absent.

- For the case of Marine Ecosystem Accounting, France demonstrates how national biodiversity data organised into the descriptors of the European Marine Strategy Framework Directive (MFSD) can be used for ecosystem condition accounting linked to policy objectives for biodiversity. Specifically, ecosystem functionality, conservation and ecosystem service capacity categories.

- Biotope points are an established biodiversity measurement approach in Germany used for informing biodiversity off-setting. It integrates information on threatened species distribution, as well as ecosystem threat status and other biodiversity monitoring data from, *inter-alia*, the EU Nature Directives. An approach is demonstrated for Germany, where biotope points are valued based on associated restoration costs to meet science-based policy targets (i.e., as per the EU Habitats Directive). This allows monetary values for the 'Ecosystem and species appreciations' service to be included in Ecosystem Services Accounts based on dividend or interest rate applied to aggregated biotope points.

- The Agroforestry Accounting System (AAS) implemented in Andalusia makes a link to policy by integrating spatially explicit information on the distribution of the biodiversity entities considered to be under threat in the EU Birds and Habitats Directives. These could allow Species Accounts for threat status and distribution to be compiled for the forests of the Andalusia Region (although this has not been implemented in practice). It is demonstrated how these distribution data can also be combined into a spatially explicit composite indicator of conservation value. This can be linked to the condition of ecosystems with respect to their conservation potential.

3.2. Biodiversity data items for better decision-making

The second research question to answer was: What specific biodiversity data items could be included in SEEA EA accounts (including species) for better guiding decisions on biodiversity? The experiences from the MAIA countries with respect to this are summarised below:

- Red List assessments measure the extinction risk of species to catalyse species conservation action. Integrating this data into the suite of ecosystem accounts via threatened species accounts (or similar) can help inform a more integrated planning for achieving conservation objectives.

- In Finland, it is demonstrated that changes in structural characteristics of forest ecosystem condition do not explain variation in compositional condition very well (based on bird species data). As such, compositional state indicators must be included in ecosystem condition accounts if decision-makers are to understand trends in species assemblages in ecosystems and not, incorrectly, infer them for other ecosystem condition indicators.

- The marine ecosystem accounts being produced in France adopt science-based policy-based targets as reference levels for condition. The valuation of the "Ecosystem and species appreciation service" in Germany also adopted the EU Habitats Directive targets as a reference. Similarly, in the Netherlands biodiversity accounts, a policy-based reference level is adopted for the LPI based accounts (the year 1990). The SEEA EA does not advocate for these use of policy targets. However, using these policy targets as reference levels provide a complementary means of using accounts to track progress towards national biodiversity objectives and for holding policy-makers and government agencies to account.

- The extended analyses by France and Germany allow for a "Biodiversity Debt" to be determined. This illustrates the level of national underinvestment in biodiversity (and by extension natural capital), and how this is evolving, to decision-makers. From these accounts, required costs can be quantified to address this debt and to make the case for budgetary investments to achieve society's objectives for biodiversity.

- The Netherlands have produced protected area extent accounts. Similar accounts have recently been published by Statistics South Africa (Statistics South Africa, 2021). Protected areas are typically a central piece of a country's conservation strategy. They are also increasingly used to secure important ecosystem services and climate change adaptation benefits. As such, the integration of information on this type of land use into the broad set of SEEA EA accounts will be helpful for decision-makers evaluating different land use and sustainable development options.

- For Greece, accounts for biodiversity have been produced for protected areas in the Peloponnese region. These accounts are relevant for management and support decision making for conservation actions, especially inside Natura 2000 Sites of Community Importance.
- Accounts that are based on well recognised indicators and approaches from the conservation community (e.g., Red List Index or Living Planet Index) will be recognisable to many decision-makers and, likely, easier to understand.
- Bringing all the key data from different ecosystem and species accounts into a combined presentation provides decision-makers with a broad oversight of emerging biodiversity trends and issues. This streamlined presentation is likely to be helpful in engaging decision-makers (as demonstrated by the combined presentations from Greece and the Netherlands).
- As identified for the IBECA Index, decision-makers need a threshold for understanding what is 'good' versus 'poor' ecosystem condition, so the implications of trends presented in ecosystem condition and thematic biodiversity accounts can be understood. For the IBECA Index, it is suggested this threshold could be 60% of the reference condition. Similar thresholds have been employed for defining good ecological status via the EU Water Framework Directive.
- The Agroforestry Accounting System (AAS) implemented in Andalusia provides a novel application for estimating the conservation value of forests using stated preference and simulated value approaches. The AAS uses this value and that of other ecosystem services to generate an aggregate of Environmental Income, which considers both current and future ecosystem services flows. Decision-makers can compare this with other income streams from forests and determine appropriate trade-offs and, potentially, compensation to optimise forest economic planning outcomes in a way that explicitly considers biodiversity.

4. CONCLUSIONS

Based on the review of MAIA experiences in using data from national biodiversity monitoring processes in their accounting efforts, there are a number of ways that national biodiversity monitoring data can support ecosystem accounting. Indeed, the established processes for organising these data for reporting or for index calculation can substantially reduce the data collation and harmonisation burden for accounting for biodiversity using the SEEA EA. This is also essential for achieving coherence across national environmental and economic policy objectives.

Notwithstanding the above, further experimentation and documentation of best practice approaches to integrating established biodiversity monitoring processes and frameworks within the accounts of the SEEA EA is required. For example, the use of consistent reference levels is essential. This report provides a first step towards distilling insights generated via MAIA countries. In addition, processes such as EUROSTATs Task Force proposal for standardising reporting on ecosystem condition indicators as part of the implementation of the SEEA EA should aim to provide further insights in these regards.

The advantage of moving to spatially explicit data to achieve a full spatial integration of ecosystem and species level biodiversity data for ecosystem accounting is also recognised in the SEEA EA. However, several of the accounts presented in this report are non-spatial. As the implementation of the SEEA EA increases and more resources are deployed, it is anticipated that more countries will be evaluating the raw biodiversity monitoring data they hold and how this can inform a spatially explicit approach to accounting for biodiversity (as highlighted for the case of nitrogen deposition in the Netherlands). This will greatly enhance the analytical flexibility of accounts and their potential to be compiled for various ecosystem types and accounting areas of policy interest.

Spatial approaches to accounting for biodiversity are being pursued in the Netherlands, where they are experimenting with determining relevant spatial patterns of biodiversity based on occupancy models for butterflies. In Norway, related research and development efforts are focused on downscaling IBECA to support municipal land use planning. In Oslo, work is proceeding on multi-species distribution modelling to inform a thematic account for biodiversity based on the Norwegian Nature Index. These efforts will provide important insights for other practitioners on spatially explicit accounting for biodiversity options across scales.

Beyond the technical compilation aspects of accounting for biodiversity, there is a need to stimulate the use of ecosystem accounting as a means of mainstreaming biodiversity into economic and development planning across government. This report highlights important accounting items and structures for accounting for biodiversity that may be most useful for decision-makers. For example, thematic accounting for biodiversity offers a means to develop combined presentations of integrated information on biodiversity, the benefits it provides and the pressures it faces to decision-makers.

This can often provide a simplified picture to decision-makers on the potential synergies and trade-offs between biodiversity, economic and social objectives that are associated with different planning options. Further experimentation and discussion with users of such presentations is required to see how these can best be developed to meet their needs. Where links can be made to policy targets and thresholds indicative of good condition for biodiversity, this is likely to be very helpful for guiding decision-makers.

Beyond useful presentations of accounting data, further work is required on extended analysis to mainstream information on biodiversity into planning processes via the SEEA EA. The accounting activities being pursued in France and Germany provide interesting developments in this area, by linking accounts informing on distance to targets to cost-based analysis of attaining associated biodiversity objectives. The Agroforestry Accounting System (AAS) application in Andalusia also provides a framework for integrating biodiversity into economic planning for forests. Further experimentation and development of these types of extended applications of the SEEA EA and supporting tools for mainstreaming biodiversity into economic planning processes should be prioritised. This is essential if society is to transition to a truly sustainable development pathway that secures better outcomes for biodiversity and people and delivers on the ambitions of the EU Biodiversity Strategy and European Green Deal.

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