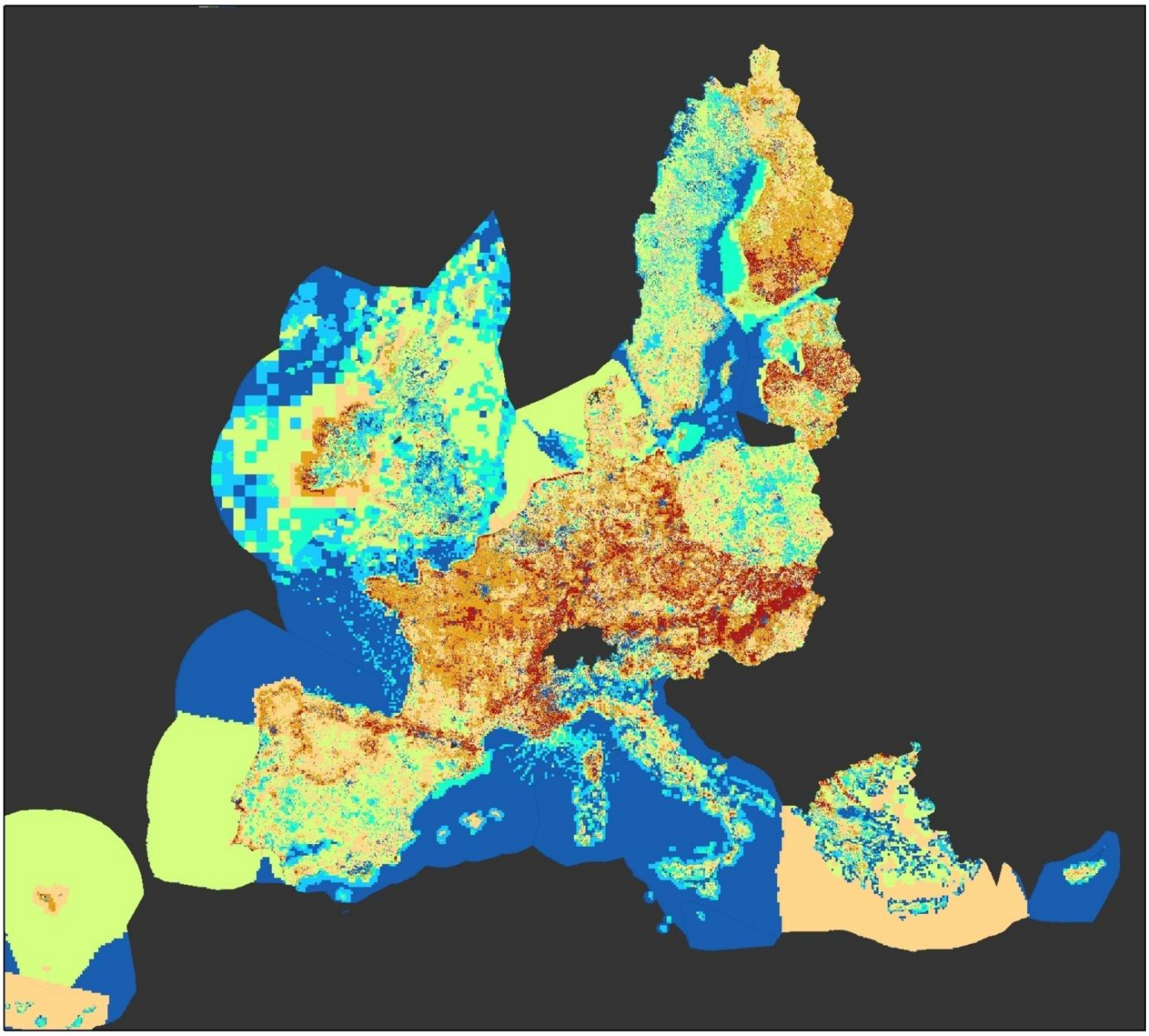
Developing an accounting method for species and habitats of European conservation importance



CEM Working Paper No 11

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Ivanov, E.D[1*]; Weber, J.-L.[2]; Spyropoulou, R.[2], Haines-Young, R.[1] and M. Potschin[1] (2013): Developing an accounting method for species and habitats of European conservation importance. CEM Working Paper No 11_Version 3.0, 20 pp.

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This is a CEM – EEA collaboration

File History

Version	Date	Activity
1.0	19.07.2012	Drafted by Emil Ivanov – to be circulated to co-authors for feedback
2.0	23.09.2012	Comments incorporated and uploaded
3.0	17.06.2013	Updated (maps and text)
3.1	21.06.2013	Slightly modified for wider consultation

CEM working papers can be downloaded under: http://www.nottingham.ac.uk/CEM/WorkingPapers.htm

No	Title
1	The Development of Scenarios for the UK National Ecosystem Assessment. Interim Report, 5/10.
2	The utility of existing scenario frameworks for the UK NEA. Interim Report, May 2010.
3	Scenarios for the UK NEA (a sub-global MA): A transparent and flexible methodology. June 2010.
4	Assessing User Needs of the UK NEA Scenarios through Focal Questions.
5	UK NEA Scenarios: Narratives. February 2011.
6	UK NEA Scenarios – Final Chapter. February 2011
7	Integrated Coastal Zone Management and the Ecosystem Approach
8	Integrated Coastal Zone Management and the Ecosystem Approach: International experience.
9	Ecosystem Service Terminology. An attempt of a Glossary
10	LEAC methodology for coast and marine accounts
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Content

Abstract

This paper describes a method for mapping and constructing environmental accounts for species and habitats of European conservation importance using data from the 'Article 17 Reports' generated by the EU25 countries. These data were published in connection with their first assessment under the EU's Habitat Directive, covering the period 2001 – 2006. They vary, however, in their quality and spatial detail, which makes their interpretation difficult. A downscaling procedure was therefore applied to enhance and harmonise the spatial data in a way allowing for international comparison at a landscape level. The aim of developing the accounts is to track and register the species and habitats numbers per unit area, and their conservation status and changes in either number or status in time. The paper describes how three spatially explicit accounts have been made using the distributional data within the Article 17 records in conjunction with European CORINE land cover data. These are: the total number of species or habitats of conservation importance present in a given area; the species' prevailing trends of change for population size or habitats' trend of change in area coverage; and prevailing future prospects for species. The species and habitat accounts presented here are designed to complement other ecosystem accounting elements, such as land accounts, biomass/primary production and water accounts, which together represent a composite ecosystem capital accounting framework.

Keywords: species and habitats, conservation importance, Article 17, NATURA2000, CORINE Land cover; biodiversity; ecosystem accounting.

Acknowledgements

This work was undertaken as part of the fast track implementation of simplified ecosystem capital accounts led by the European Environmental Agency, following the publication of an experimental framework for ecosystem capital accounting by EEA (2011).

1. Introduction

The Rio Summit of 1992 was a turning point in environmental policy making, when the UN Convention on Biological Diversity (CBD) was launched. It aims to preserve the biological diversity, and also to promote the fair and sustainable use of benefits related to biodiversity, including the genetic resources. The countries which have signed the convention (currently 168) are legally obliged to produce national strategies for biodiversity conservation as well as national reports regarding the strategy implementation. There are other initiatives, national or international which aim to conserve biodiversity and steer development of approaches and methodologies for monitoring its success. For example, the USA species recovery programmes were developed alongside that of the CBD although it did not ratify the convention. The European Union applies a comprehensive set of biodiversity conservation policies for nearly two decades. The European NATURA2000 network was established for meeting the political objective set in response to the CBD of 'significantly reducing the current rate of biodiversity loss by 2010' (European Commission, 2009).

The legally-binding obligations have stimulated novel technical and scientific developments and data collection on biodiversity and its links with ecosystem functioning and human impacts. Interdisciplinary approaches have also brought closer policy and science interaction in conservation policies and strategies, such as adaptive ecosystem management (Gunderson and Light, 2006). However, biodiversity loss continues at unprecedented rates (St-Loyus et al., 2009; Tisdell, 2011), caused by habitat loss, the single greatest threat, and alien species invasions being the second (Bryant, 2006). Land management and land use change cause habitat loss, degradation and fragmentation (Maitima et al., 2010), and also facilitate the spread of invasive species (Loewenthal, 2003). Competing land management objectives often obstruct the implementation of biodiversity conservation strategies.

Müssner (2005) emphasised that major obstacles for implementing biodiversity conservation objectives include the lack of sufficient ecological data and the lack of adequate methodologies to achieve the conservation targets. Broad-scale, generalized and repeatable methods for biodiversity assessment have remained of limited applicability (Müssner, 2005), due to the difficulty to model species distribution and conservation status, at the proper scales where key drivers of change need to be addressed by conservation measures. Site-level inventories and detailed modelling can be robust, but are context-specific, and often cannot be generalized or replicated (Borja et al., 2008). The gaps between work at different temporal and spatial scales therefore impede progress. A comparison and validation of results from various sources of biodiversity data should, however, help bridge these gaps, but classical validation approaches of 'ground-truthing' cannot be applied (Bai, 2010) and so new validation approaches are needed, that better match different scales and information sources.

2. Ecosystem accounting approach

Ecosystem accounting aims to supply policy-relevant information focused on the relations between human actions and natural processes at landscape level, in a way that is generalizable for international comparisons. The approach draws lessons from conventional economic accounting, such as a 'double (or more) entry' approach and an input-output logic (Weber, 2007) based on physical measurements and an understanding of mass-balance relationships. When the balance is achieved, and the accounting items match well, it can be said that the accounts are computed consistently and correctly, and therefore the approach itself offers novel, internally consistent set of 'validation' criteria. An ecosystem account is a multi-faceted concept and needs to address symmetrically at least four components as a minimum application: land, water, biomass and biodiversity. Such an application is being developed for the EU countries by the EEA (2011). At present, the different stage of development of these components impedes the achievement of a complete application, although some progress has been achieved for 'carbon' (IPCC, 2003; Ostle et al., 2009), land (EEA, 2006) and water. The EEA's application has been developed in close connection with the UNSD's process of integrating the economic and environmental accounts, which started more than two decades ago, by drafting and revising a handbook 'System of environmental and economic accounts' (United Nations, 2003).

This paper describes the development of an accounting method for biodiversity. The work was undertaken as part of the fast track implementation of simplified ecosystem capital accounts led by the European Environmental Agency, following the publication of an experimental framework for ecosystem capital accounting (EEA, 2011). The objective of the work was to summarise and present information on the status of species and habitats of European conservation importance in a spatially explicit way, to complement the information recorded in the other ecosystem capital accounting elements, such as land-cover, biomass/primary production (carbon), and water accounts. This paper describes the development and testing of a new accounting method that draws on the experience from the Land and Ecosystem ACcounting programme (LEAC, EEA, 2006). A particular focus has been to produce an acceptable accounting logic and an estimation procedure based on data sources now available at European scale.

The ecosystem accounts provide two general estimates: (i) a measure of the 'volume' or stock of natural capital for defined units of ecosystem types; and, (ii) measures of the quality functional integrity/performance of that stock. Ideally, in keeping with the idea of accounts both sets of measures should also give a picture of how stock and quality are changing over time (Weber, 2007). Thus any species account should follow the same format, and provide information on changes in either species number and conservation status at a certain location, between two given times. The count of number of species present in given area is represents the 'volume' of natural capital; the species conservation status – is a measure of its 'quality'. Changes in the conservation status over a period of time, may affect the original species number, if some initially extant species become extinct.

This approach is a data-driven, therefore spatially explicit ecosystem accounts can only be produced if available spatial data to address the accounting elements is collected. Often improvement and harmonization of these inputs is needed before extracting accounting outputs. The extraction is done through integrating the spatial data inputs in a reference grid, in which each cell is linked to accounting units of interest. The latter could be units defined by administrative areas, protected areas or natural delimitations such as river catchments, geo-morphological formations etc. or a combination of several of these units. Consequently, quantitative information on accounting stocks and flows is extracted using pivote tables. The accounts prepared in this way allow the outputs to be presented as tables, graphs or maps. Examples of such accounts could be presented as hectares of new forest plantations; new urban areas; lost wetlands etc. in coastal plains or mountain river catchments.

3. Development of accounting method for species and habitats of European Conservation Importance

There is not much experience on biodiversity accounting, although the subject was addressed during the latest SEEA revision process (Garnåsjordet et al., 2012) identifying relevant methods, indexes and data inputs, notably drawing on an example developed in Norway (Certain et al., 2011). The Norwegian experience is based on combined use of monitoring-based estimates, model-based estimates and expert information to estimate a 'Nature index' for country (Skarpaas et al., 2012) covering the major ecosystem types. On European level, the ecosystem account for species and habitats of conservation importance needs to provide estimates on a set of accounting elements summarising their distribution, abundance and conservation status in both temporal and spatially explicit way. For this purpose the first challenge was to collect geographically comparable inputs covering all the EU states.

Broad-scale species' distributions, based on presence absence approach have been mapped through predictive modelling (Phillips et al., 2006; St-Louis et al., 2009) and downscaling (McPherson et al., 2006; Bombi and D'Amen, 2012). Araujo et al. (2005) applied a downscaling approach to distribute European species atlas data to a finer resolution. Similar sources for producing estimates on species abundance and conservation status have not been identified at present. The International Union for Conservation of Nature (IUCN) is developing such assessment and data outputs globally and regionally, including Europe, but the European results are not yet completed.

Although EU level conservation policies are long established, it was not until 2007 that the Member States first reported systematically on the conservation status of habitats and species covered by the Habitats Directive. These reports, which are known as the 'Article 17 Reports', currently document the conservation status of the habitat types and species of Community interest across the EU 25 for the period 2001-2006. The conservation status has been assessed for each species and habitats per unit of distribution (range). The latter are not limited only to the areas of NATURA2000 but cover national territories, including their territorial (sea) waters. The units are defined by the intersection of the European Biogeographic regions and country boundaries. In addition marine zones are defined. In the future data will be reported on a six year cycle, presenting an opportunity to update and further develop the ecosystem capital accounting. These data clearly offer the potential for building accounts for species and habitats at pan European scales.

For the fast track implementation of European ecosystem capital accounts it was decided to explore the information available for a preselected subset of 1059 species (plants, mammals, amphibians, reptiles, arthropods) and 231 habitats included in the Annexes of the Habitat Directive (Council Directive 92/43/EEC), which have been considered through a policy processes as having European conservation importance. The following accounting elements were defined and mapped:

- A number of species and habitats of European conservation importance present in a given area (representative for the time when the countries carried out their assessments for the period 2001 - 2006); and,
- Quantitative changes in species' abundance and habitats' coverage. For species, the abundance change is expressed as either increasing, stable or decreasing trend in their population size and for habitats - increasing, stable or decreasing trend in their coverage

In addition, the following indicators were estimated for summarising the performance of conservation policies at European level:

- prevailing trend of the population sizes of the species and the coverage of the habitats present in a given area. The prevailing trends are indicative of possible changes in conservation status since the first identification and designation of the habitats and species in the 90-ies; and,
- the species' prevailing future prospects were mapped too, which can help to assess whether the current trend in conservation success may continue or change in the near future.

Although all of these elements and indicators are available in spatially explicit form and harmonized on European level in a single geo-database (Articla 17 database), further spatial data processing and analyses were needed to estimate the accounting outputs.

4. Accounting inputs and accounts estimation

Article 17 data are reported by the EU member states, and harmonized by the European Topic Centre on Biodiversity as part of the implementation of the European NATURA2000 network. The latter was set up by the EU in response to its commitments under the Convention in Biological Diversity and the political commitment of ‘significantly reducing the current rate of biodiversity loss by 2010’ (European Commission, 2009)[1].

The assessment of the ‘conservation status’ for species is based on trends in range, population, habitat quality and future prospects, and for habitats – trends in range and coverage. The Member States followed an agreed set of guidelines, but produced and reported their assessments at a varying level of detail and quality in relation to species and habitats distributions and their conservation status. Conclusions about the conservation status were summarised in an additional set of categories defined by an agreed set of criteria, where 'favourable conservation status' (FCS) is the category that represents the overall objective to be reached for all habitat types and species of Community interest. In the context of a species, it describes situations where the population dynamics are interpreted as indicating that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and that its range is neither reducing for the foreseeable future, and will continue to be sufficiently large to be maintained in the long-term. When a species is assessed as falling short of these criteria it is reported as having ‘unfavourable conservation status’; this can be deemed either ‘inadequate’ or ‘bad’, depending on the severity of the conservation threats that are facing it. Figure 1 shows the current situation for Europe.

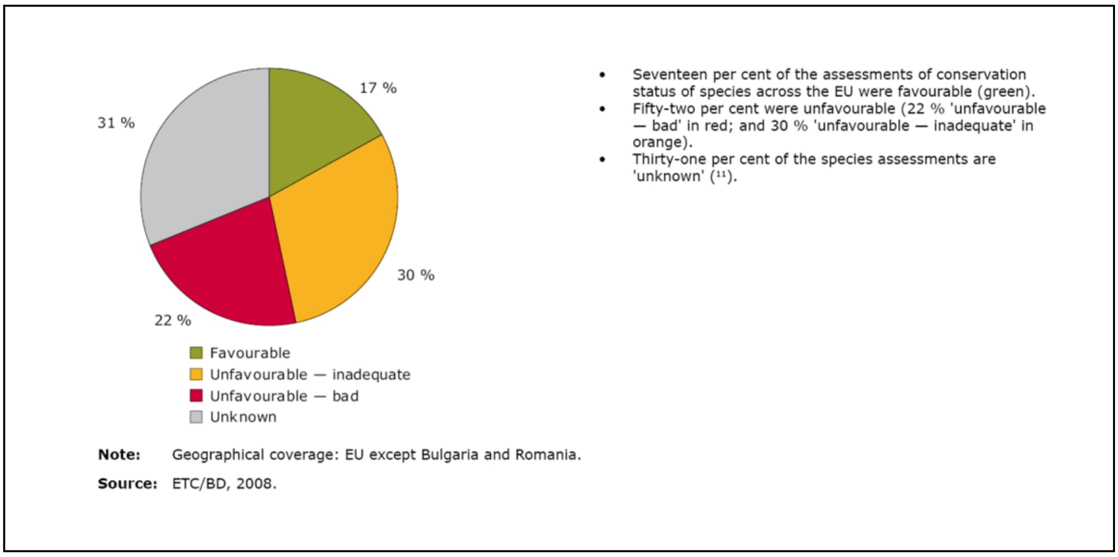


Fig. 1: Conservation status of species reported for Europe, 2000-2006 (after EEA, 2010)

Fig. 1 presents the Article 17 species data at a highly aggregated way. The rich body of information that lies beneath it can, however, be used to construct more detailed, spatially specific measures of biodiversity status that could provide one input to the proposed experimental accounts. Specifically, the underlying Article 17 database provides:

[1] This commitment has now been updated: ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

a. The species and habitats distribution ranges harmonized for a 10 km x 10km grid for EU 25, for around 2000 species of Community Importance.

b. The detailed status assessments for the elements that informed the final judgment about conservation status for each species, namely:

	Species of community importance	**Habitats of Community importance**
Trends	Trends of change in range size, habitat quality and population size	trends of change in range and area coverage
Future prospect	An indication of the likely future prospects for the species	
Conclusions	The conclusions made in relation to: the size of the species range; the size of the species population; the quality the species habitat; the future conservation status of the species; and, the overall assessment about the species conservation status	The conclusions made in relation to: the size of the habitat range; the area coverage; the habitat structure; the future conservation status of the habitat; and, the overall assessment about the habitat conservation status

Each of the trend parameters are assessed as: decreasing; unknown; stable; increasing trend. The future prospects can be either: bad; poor; unknown or good. The analysis of the nine parameters can then be used to define a degree of consensus on the species conservation status and future. As a first step, however, only two parameters were selected and processed to build a species account, the trend of change in population size and future prospect; and one for the habitats, the trend of change in area coverage. The trend in population size for species and area coverage for habitats were selected, for being the parameter most often defined on the basis of quantitative evidence, e.g. counts of individuals for each species or counts of location where it is found (more for the habitats), an estimate of minimum and maximum population size and further references.

In previous work(Ivanov, 2010), the Article 17 species distribution maps were intersected with the 10km x 10km grid of Europe and counts of total species reported as present, as well as species with good and bad future prospects were extracted on the basis of the overlapping distributions. The method enabled the exploration of important aspects of biodiversity conservation at the European level (according to feedback with EEA project managers), despite the difficulty of achieving a harmonized picture with sufficient spatial detail to match with land-cover and other ecosystem accounts. More importantly, this test helped us to define improvement options. A main limitation, however, was the varying quality and completeness of the data reported by the Member States for the Article 17, both in terms of the assessed species conservation elements and also the spatial precision of the species distributions and ranges. The extent of these data incompleteness issues is assessed in the final report of the European Commission (2009) regarding the first Article 17 HD reporting. It states that, some 13% of regional habitat assessments and 27% of regional species assessments were reported by the Member States as ‘unknown’. The ‘unknowns’ are most common for the marine species (57%) and habitats (40%). To address the problem of data incompleteness, we examined several simple metrics, namely the above mentioned accounting elements, , including counts of species with different trend values (increasing, stable, or decreasing) and future prospects (good, poor, or bad). These were mapped and explored individually and also by looking at the difference between increasing versus decreasing, good and bad, in order to map a prevailing trend from the set of 'known species'.

To address the limitation of varying spatial detail of the reported species' and habitats' distribution ranges, an additional procedure for enhancement and harmonization of their distributions was developed. Thus the original ranges in 10km x 10km grid were adjusted using the European CORINE land cover map for year 2000 (EEA, 2006), at a resolution of 250m. CORINE LC is a standardised land cover inventory derived from satellite imagery for all the EU and EEA associated countries for three dates: 1990, 2000 and 2006. The spatial adjustment was possible for a subset of the reported species and habitats, according to their likelihood to be found within broad ecosystem types. Further each broad ecosystem type was characterised and mapped by a grouping of CORINE LC classes (see Annex I). The matching of species to ecosystem types and land cover classes is defined by experts and included in Annex 3 of the EU 2010 Biodiversity Baseline (EEA Report No 12/2010). The majority of the species and habitats assessments were retained in this subset; from the original 5885 species, 4580 were retained, and from the 2879 habitats, 2834 were retained.

Table 1: Eight ecosystem types defined by a grouping of CORINE LC classes

	Ecosystem type	Land cover types
1	Agro-ecosystems	Rainfed and irrigated arable lands, permanent and mixed cultivations
2	Grassland ecosystems	Pastures and natural grasslands
3	Shrubland ecosystems	Scherophyllous veg., moorlands, transitional woodlands
4	Forest ecosystems	Coniferous, broadleaf and mixed forest
5	Wetland ecosystems	Inland marshes and peatbogs
6	Freshwater ecosystems	Lakes and water cources
7	Coastal ecosystems	Beaches, dunes, rocks, lagoons, estuaries, salt marshes, intertidal flats
8	Marine ecosystems	Sea water

Hence, the expert-identified relations between species and habitat distribution within broad ecosystem types and the broad ecosystem types being defined by a set of land-cover classes, were applied to downscale the original coarse ranges at 10km x10km to likely distribution patches at 250m x250m. We expected that in this way the varying spatial detail of the reported species and (Table 1) habitat ranges would be harmonized and improved. For example, ranges which were reported rather generally covering entire regions, would be improved by masking out unsuitable areas, such as urban residential or industrial zones). However, in the original tables of expert-identified relations the species and habitat were usually included in more than one broad ecosystem type, and also the same land cover classes were included in more than one ecosystem types. Therefore the downscaling procedure was designed in a way allowing to have all species and habitat represented in each ecosystem type, according to the expert definitions; but then all repetitions to be cleared out by allocating each ecosystem type on non-overlapping CORINE land cover class groupings (shown in Annex I). The data processing steps were as follows:

a) linking species/habitat to broad ecosystem type and conservation assessment values;
b) separation of the species and habitats into eight groups according to their belonging to a broad ecosystem type;

c) intersection each of the eight subsets with a 10km x 10km European reference grid;

d) extraction of counts of species/habitat numbers per grid cell in six items: decreasing trend, stable trend, unknown trend, non-assessed, increasing trend and total number and likewise for future prospect;

e) linkage of each of the accounting items to the 10km x 10km European grid;

f) conversion of each of the 6 item per ecosystem type to a raster layer for both habitats and species;

g) mapping of the eight ecosystem types as filters (boolean, with value 0 or 1), in a raster layer by grouping the non-overlapping CORINE LC classes;

h) application of the filter per ecosystem type at 250m x 250m spatial resolution for each of the accounting elements separately;

i) estimation of accounting outputs of interest, for example total number of species and habitats of community importance, also total number of species and habitats with increasing, decreasing and stable trends of change; and,

j) estimation of spatial indicators to judge conservation success at aggregated level, for example a prevailing trend of population size changes and prevailing future prospect for species.

In this way we estimated spatially explicit accounts on species and habitats of European conservation importance, using the assessments from the Art. 17 first reporting period 2000 – 2006. By using the assessments on trends of change in area coverage for habitats and population size for species, since their first inventories and designation in the 90ies a temporal dimension could be addressed too. Therefore the developed accounting method offers a unique test of assessing distribution, abundance and conservation status of species and habitats at European level. The results and their interpretation are explained in the following section.

5. Results

The results at this stage are intended as a testing demonstration of the method of developing a species and habitats account for a wide area using incomplete and varying quality inputs. The main accounting elements and indicators are shown in the following order: total number of species/habitats (Fig. 2); number of species/habitats with either increasing, stable or decreasing trend of change in population size (for species) and area coverage (for habitats) (Fig. 4); an estimation of the prevailing trends (Fig. 5) based on the above trend accounts and also a prevailing future prospect score for species (Fig. 6). Then, we show further examples, viewing the prevailing population trend for species in broad ecosystem types (Fig. 7).

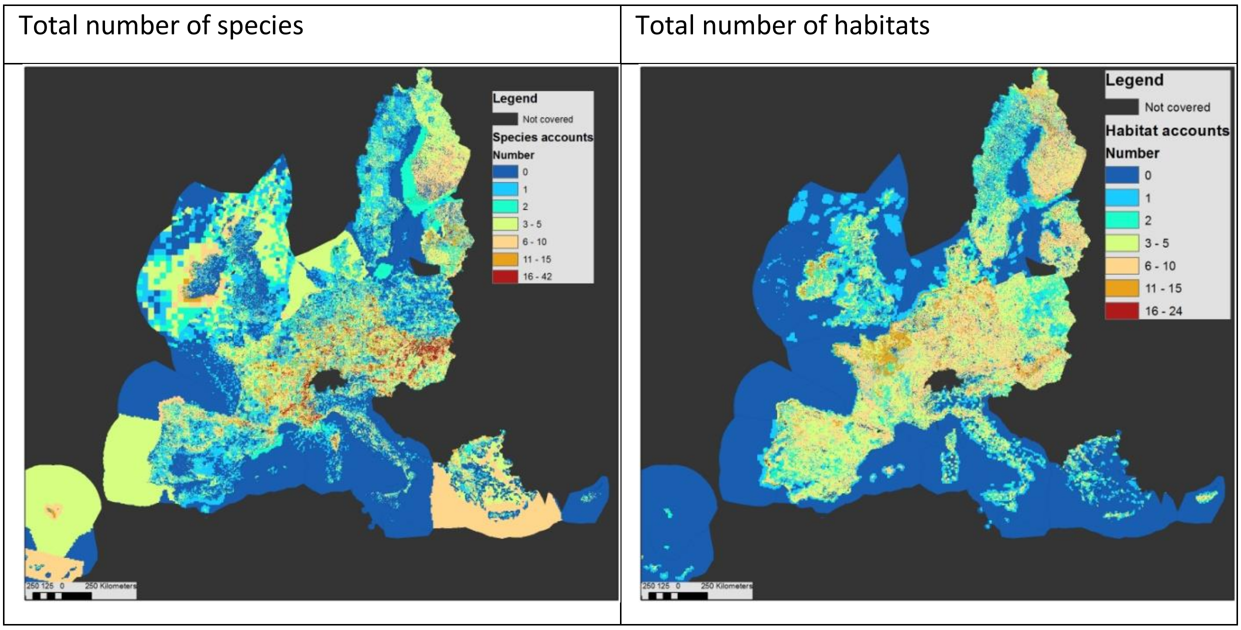


Fig. 2: Total number of species (left) habitats (right) of European conservation importance

The account for species numbers ranges between 0 and 42, which is the maximum number of species of community importance that can be found per 250m x 250m grid cell. High numbers are indicative of areas containing many species; while low numbers and 'no species' mean either that few species may be present or input data incompleteness. The overall distribution of the species across Europe still shows clear patterns related to the quality of the reported data for Article 17 HD (highest density in Central Europe, and rather low in the Mediterranean). This implies that the distribution ranges need improvement, especially for the Mediterranean countries. Generally the patterns should follow a gradient of increasing species density from the northern latitudes to the southern and from the western to the eastern latitudes of Europe, consistent with the total numbers of species included in the Habitat Directive as shown per assessment unit in Fig. 3 (lowest in Alpine Finland, 33 and Ireland, 40 species and highest in Mediterranean Spain, 264 and Hungary, 208). However, the species number account indicates realistic distribution patterns at a landscape level. For example, lowest values appear mostly in areas of very intensive and homogenous land use such as the river valleys of Guadalquivir (south Spain) and Po (north Italy); also the areas of most intensive cereal production surrounding Paris, and timber production in south west France.

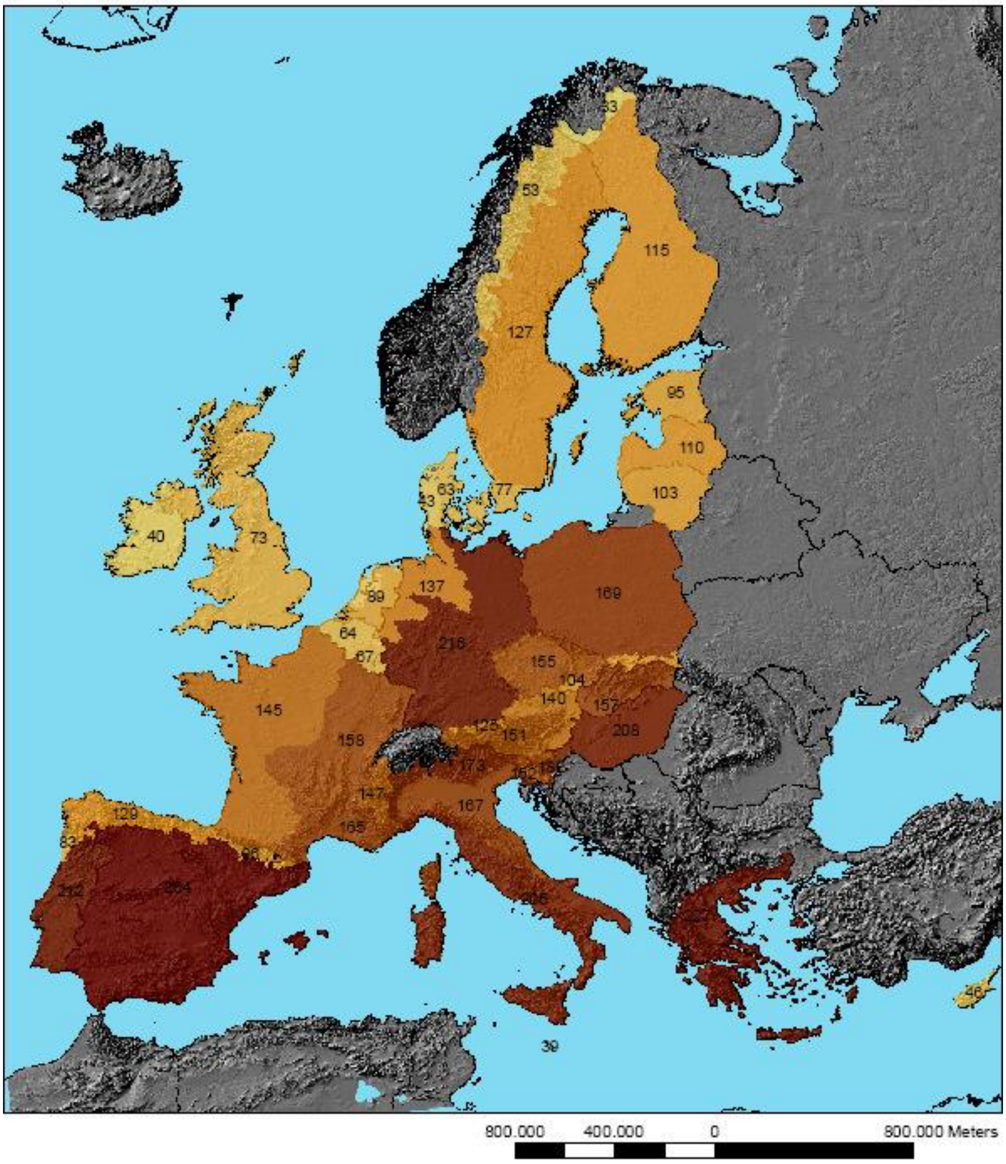


Fig. 3: Total number of species of community importance per assessment unit

The account for habitat numbers ranges between 0 and 24 per grid cell. Their distribution shows more harmonized patterns across the countries and bio-regions, and unlike the species, high numbers are found in intensively used areas like North France. These high numbers however are mostly with decreasing trend of area coverage, as Fig. 4 indicates.

Trends in species' population size change	Trends in habitats' area coverage change

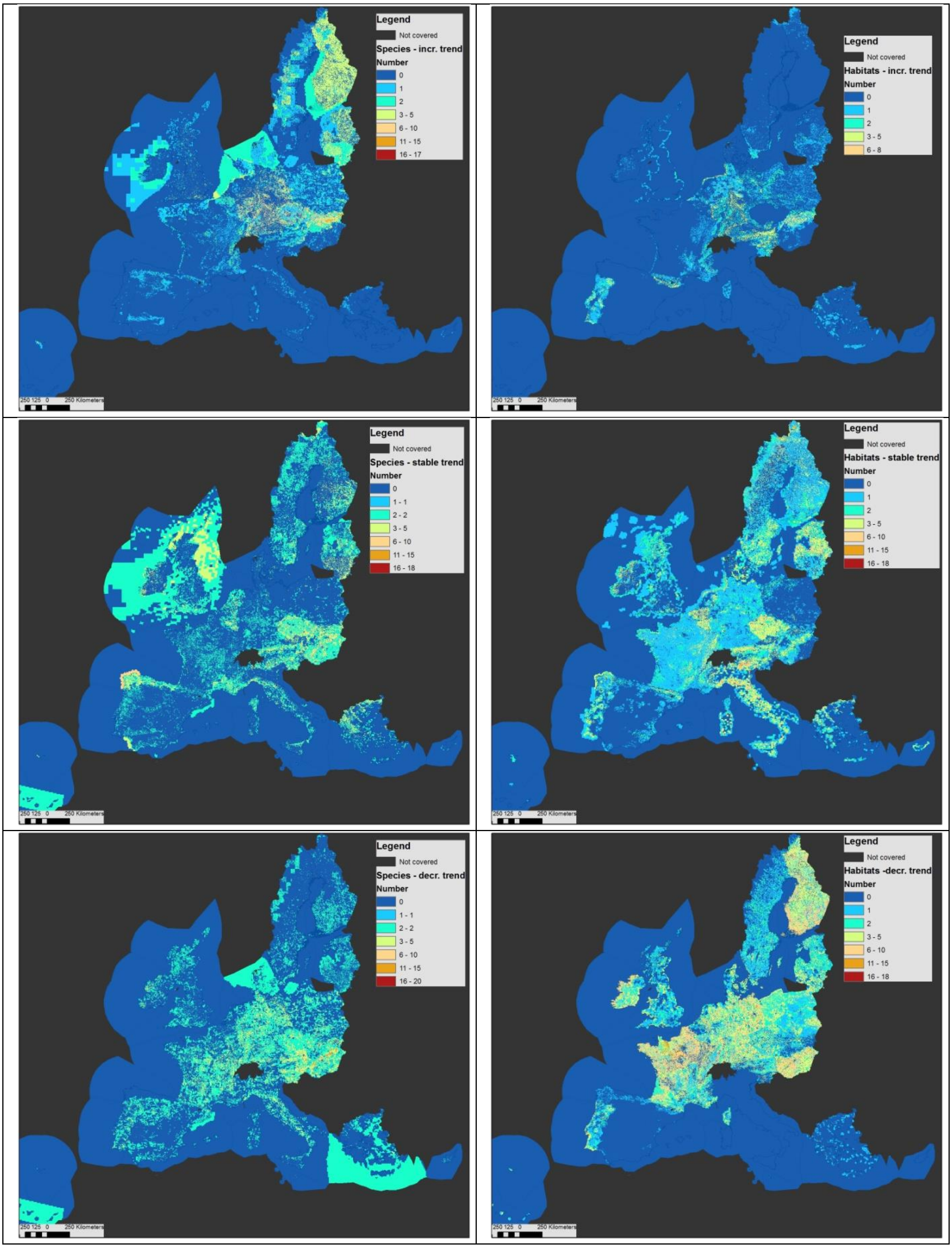


Fig. 4: Number of species and habitats of European conservation importance with either increasing (top page), stable (middle page) or decreasing (bottom page) trend of change in population size (for species, left) and area coverage (for habitats, right).

The account of species with changing population trends and habitats with changing area coverage can only be interpreted in relation to the total number of either group. This is for the reason that for too many species and habitats the trends were assessed as unknown or left black. Therefore only the high values on Fig. 4 can be indicative of changes in abundance and coverage.

The scores of prevailing conservation trends reveal whether the species of community or habitat importance may be experiencing positive or negative changes over the last decade (population trend and area coverage assessment, Figure 5) and also in the near future (future prospect of species assessment, Figure 6).

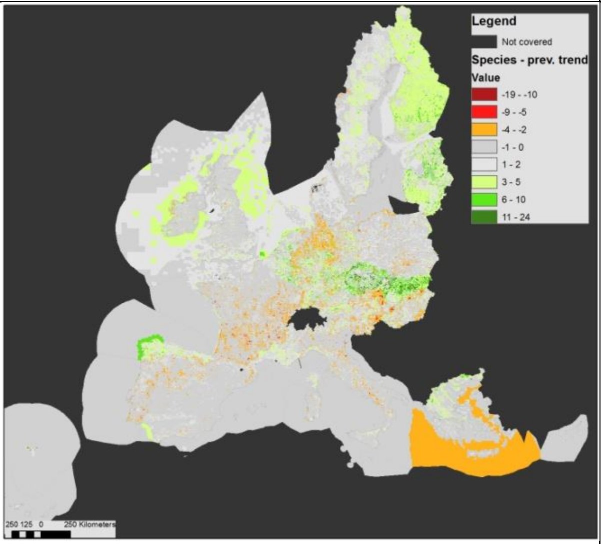
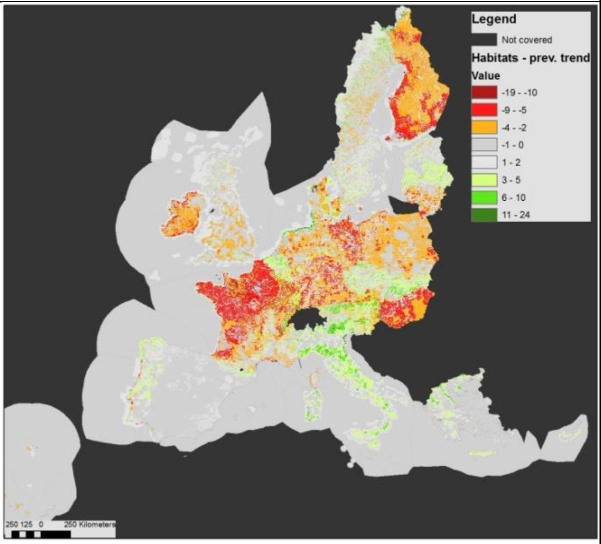
Prevailing population trends of species	Prevailing area coverage of habitats
	

Fig. 5: Estimation of the prevailing trends of change in population size for species of European conservation importance and in area coverage for habitats

The prevailing trends were estimated using the subset counts for each ecosystem type as follows:

Prevailing trend = (stable + increasing) – decreasing

Therefore the problem of missing or unknown assessment should be minimised by looking at the difference between positive (bright colours) and negative (dark colours) changes. The contrast between neighbouring areas, such as north France and Belgium; Hungary and Slovakia imply rather a discrepancy in the applied assessments than actual conservation changes, otherwise the prevailing trends of area coverage for habitats would imply grave conservation problems. Nevertheless, similar indications were reported in the European Commission's 'EU 2010 biodiversity baseline', where it is stated that 65% of habitats and 52% of species are in 'unfavourable' conservation status.

In similar way, we estimated also the prevailing future prospect for species of conservation importance:

Prevailing future prospect = good – (bad + poor)

Prevailing future prospect of species

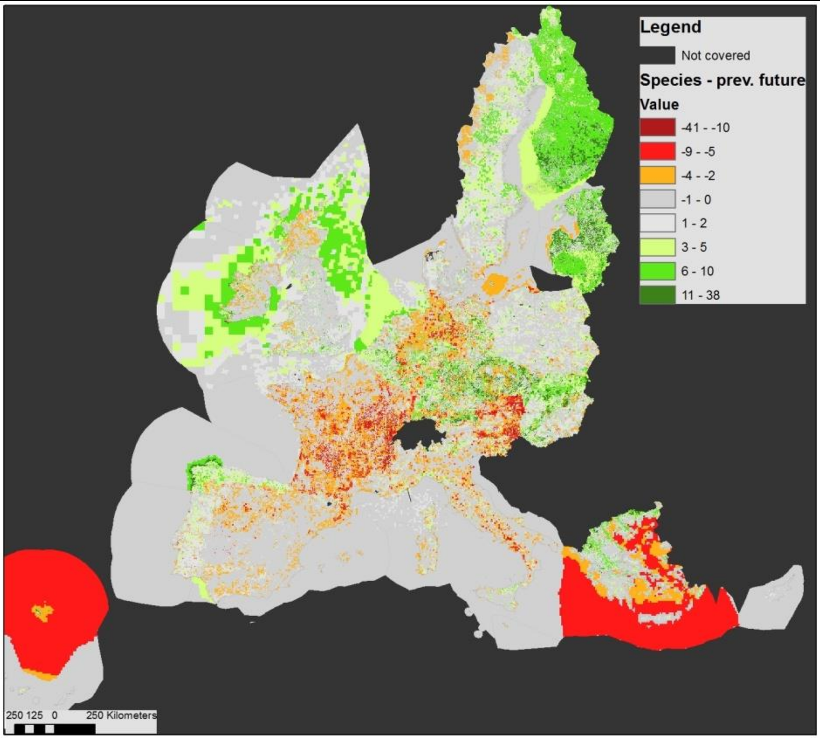


Fig. 6: Estimation of the prevailing future prospect for species of European conservation importance

The positive values (in bright colours) indicate that there are more species with good future prospects. Where bad or poor future prospects prevail the values are negative (dark colours).

Species population trends in the different ecosystem types reveal distinctive patterns. As illustrated in Fig. 7, forests show more positive scores, while agro-ecosystems more negative ones, especially in south Europe.

Prevailing population trends in agro-ecosystems	Prevailing pop. trends in forest ecosystems

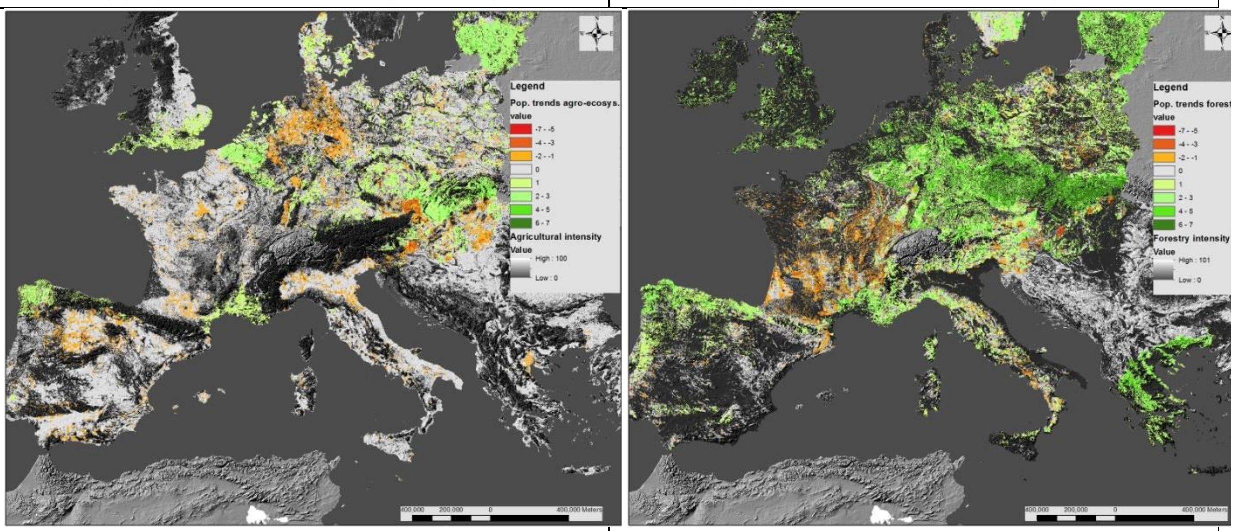


Fig. 7: Scores of prevailing population trend for agro-ecosystems (left) and forest ecosystems (right).

Accounts on species and habitats of European conservation importance were extracted for the NATURA2000 sites designated on both the terrestrial and the marine part of the EU Mediterranean countries. Mean values of species and habitats numbers for all the sites within a country, as well as mean prevailing trend are shown in the table below.

Table 2: Mean estimates of species and habitats for NATURA2000 in the EU Mediterranean countries

Country		NATURA2000 estimates					Estimates out of NATURA2000	
	Terrestrial and marine area (ha)	NATURA 2000 area (ha)	% from total	Number of sites	Mean number of spec. and habitats	Mean prev. trends	Mean number of spec. and habitats	Mean prev. trends
Cyprus	10730760	227242.1	2.1	61	5.2	0.4	2.6	0.1
Spain	151007357	18885693.4	12.5	1802	5.9	0.4	5.3	0.3
France	99255446	15308037.4	15.4	1753	11.1	-1.0	9.5	-2.6
Greece	62559851	5528397.1	8.8	419	4.9	2.0	4.1	1.4
Malta	5575842	24177.2	0.4	39	2.0	0.3	1.3	0.2
Italy	83915746	7784734.0	9.3	2565	5.6	3.1	2.8	1.7
Slovenia	2040757	1101634.5	54.0	286	9.2	0.4	9.1	-0.1

These mean values indicate that numbers of habitats occur proportionally higher in the countries where more area is designated within NATURA2000 network, the prevailing trends within NATURA are also higher and positive in comparison with the mean values from the areas out the network.

The results at this stage are intended as a testing demonstration of the methods applied for a wide area and using incomplete and varying quality inputs. They need further improvement, validation and harmonization before being recommended for policy informing applications.

6. Discussion and conclusions

The accounting method for species and habitats of European conservation importance was designed to produce estimates indicating richness, abundance and conservation status for the entire territory of the EU countries in spatially explicit form. In this way we set up a framework linking information on human actions, including both drivers of change and threats to biodiversity, and conservation measures, with its effect on species and habitats. Land cover and land use change have been used to develop integrated assessments in similar studies. For example Czúcz et al. (2012) performed a country level assessment for plant species in Hungary, demonstrating the applicability of the Natural Capital Index (ten Brink, 2007) at a scale of spatial detail suitable to support conservation strategies. The ecosystem accounting approach is intended as a policy-support tool due to the possibility to link bio-physical and socio-economic information per reporting units for which strategic decisions are often discussed, for example decisions addressing spatial development versus nature conservation needs. Therefore, the tool allows to estimate and extract spatial statistics per units, such as municipalities or NATURA2000 sites, for which species and habitats numbers and conservation status can directly be viewed in comparison with local GDP, population, industrial sector outputs and other quantitative indicators.

In this first step towards developing an operational tool, a major challenge for the work has been to extract and harmonise the available inputs, to define and estimate appropriate accounting items for species and habitats, and report them spatially so that comparable results could be published across all the European countries and also addressing temporal changes. Several wide-area assessments, inventories and spatial modelling studies on European biodiversity were reviewed, but no appropriate inputs could be identified for this work. The Article 17 database and the European CORINE land cover offered unique, although incomplete inputs to perform a first test and devise the accounting method. Although progress can be made using these sources, data availability and data quality are identified as the main constraints for constructing a complete set of accounts. In the future other species data can be explored to extending and improving the method, and for its application in other areas, including: the IUCN red-list species; and the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean. The latter identifies species of 'Mediterranean conservation importance' (Annex II: List of Endangered or Threatened Species) and commits the countries that have signed the Barcelona Convention to fulfil monitor and report their of conservation status, in a similar way as done for the European Article 17 Habitats Directive. An update of the Article 17 assessments are carried out at presents by the EU member countries and the new database will present an opportunity for filling gaps in data quality and the assessments, as well as for improving the accounting method. However, a systematic assessment of biodiversity distribution, abundance and conservation status remains a major challenge, even if certain groups of species, such as large mammals and birds are well known.

In this application, the number of species and habitats found per reporting unit is possibly the most reliable estimate of the tested accounting items and more specifically the areas where higher numbers are found, representative for the assessment period 2000 - 2006. The applied simple downscaling procedure on the basis of land cover gives a possibility to perform further analysis and determine where habitats and species of conservation importance may have been lost after this period, by looking at land use change. Since each of the eight ecosystem types is represented by a set of suitable CORINE land cover classes, if certain classes were changed into unsuitable, for example wetland to urban, the ecosystem type as well as the species and habitats pertaining to it, would be undergoing negative trends in abundance and conservation status, or could be getting locally extinct. In the current application, the estimated numbers of species with changing trends in population size or habitats with changing trends in area coverage are probably not well represented in the downscaled version, for the reason that the individual species and habitat assessments are valid for the wide units defined by countries and bioregions and within each of these units, there could be variability that could not be addressed through land cover. For example the trends of the same species and habitats maybe different for different wetlands found in the assessment same unit. Yet, the fact that national experts evaluated the overall trend as changing, it is more likely that this situation prevails. Further development and refinement of the downscaling inputs and approach will allow to take into account other important factors affecting the abundance and conservation changes of the habitats and species.

Independent validation of the three accounting elements, species/habitats distribution, abundance and conservation status has to be developed, addressing spatial and temporal variability at European scale. Again, the setup of the European NATURA 2000 network offers a unique opportunity to examine the success of conservation actions confronted with full range of threats, impacts and drivers of change, in the different part of the continent.

At this stage validation of the accounts and indicators has not been undertaken. Before attempting to relate these European level estimates to local and site sources of species numbers and their conservation status, the unknown and missing assessments should be addressed. The distribution ranges used here need further improvement and harmonisation. We could also improve the accounting method, also by incorporating additional sources of wide-area inputs, such as the IUCN species assessments.

7. References

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Annex I

ecosystem type		Corine LC class		
1 Agro-ecosystems	12	211	Non-irrigated arable land	
1 Agro-ecosystems	13	212	Permanently irrigated land	
1 Agro-ecosystems	14	213	Rice fields	
1 Agro-ecosystems	15	221	Vineyards	
1 Agro-ecosystems	16	222	Fruit trees and berry plantations	
1 Agro-ecosystems	17	223	Olive groves	
2 Grassland ecosystems	18	231	Pastures	
1 Agro-ecosystems	19	241	Annual crops associated with permanent crops	
1 Agro-ecosystems	20	242	Complex cultivation patterns	
1 Agro-ecosystems	21	243	Land principally occupied by agriculture, with significant areas of natural ve	
1 Agro-ecosystems	22	244	Agro-forestry areas	
4 forest ecosystems	23	311	Broad-leaved forest	
4 forest ecosystems	24	312	Coniferous forest	
4 forest ecosystems	25	313	Mixed forest	
2 Grassland ecosystems	26	321	Natural grasslands	
3 Shrubland ecosystems	27	322	Moors and heathland	
3 Shrubland ecosystems	28	323	Sclerophyllous vegetation	
3 Shrubland ecosystems	29	324	Transitional woodland-shrub	
7 coastal ecosystems	30	331	Beaches, dunes, sands	
7 coastal ecosystems	31	332	Bare rocks	only within 10 km coastal strip
7 coastal ecosystems	32	333	Sparsely vegetated areas	only within 10 km coastal strip
	33	334	Burnt areas	
	34	335	Glaciers and perpetual snow	
5 wetland ecosystem	35	411	Inland marshes	
5 wetland ecosystem	36	412	Peat bogs	
7 coastal ecosystems	37	421	Salt marshes	
7 coastal ecosystems	38	422	Salines	
7 coastal ecosystems	39	423	Intertidal flats	
6 Freshwater ecosystems	40	511	Water courses	
6 Freshwater ecosystems	41	512	Water bodies	
7 coastal ecosystems	42	521	Coastal lagoons	
7 coastal ecosystems	43	522	Estuaries	
8 sea ecosystems	44	523	Sea and ocean	