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Editorial

Mapping and assessment of ecosystem condition and ecosystem services across different scales and domains in Europe

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Assessment frameworks, ecosystems, biophysical, socio-cultural, economic, ESP SEE

Introduction

Mapping of ecosystems and their services is an important activity that can effectively contribute to understanding how ecosystems support human well-being and furthermore promote the sustainable use of natural resources (Burkhard and Maes 2017). Action 5 of the EU Biodiversity strategy to 2020 calls for member states to map and assess their ecosystems and services they provide. As a follow up to the strategy, an initiative on Mapping and Assessment of Ecosystems and their Services (MAES) was launched and a working group of researchers, experts and stakeholders was established. During the last few years, several European countries conducted National Ecosystem Assessments (NEA). There is a diversity of approaches and methods applied in NEAs which makes comparisons between them challenging. Although those published after the EU Biodiversity

Strategy aimed to comply with it, there is still need for “standardization or at least harmonization of data collection, indicators and methods to assess biodiversity and ecosystem services” (Schröter et al. 2016). The importance (value) of ecosystems and their services can be expressed in different ways but basically, there are three value domains: biophysical, socio-cultural and economic (Groot et al. 2010, Martín-López et al. 2014). Mapping of ES is inherently related to the topic of scale and there are various aspects of scales which need to be taken into account (Frank and Burkhard 2017).

Goods and services delivered by the ecosystems are needed for the life and survival of mankind. Moreover, the "ecosystem approach" appears to be the most appropriate conceptual framework supported by "proven-inpractice" methodology orientated to ensure sustainability and conservation of natural systems. This Special Issue explores the process of mapping and assessment of ecosystem services (ES) at different scales and domains. It addresses such important topics as: the assessment of ecosystem condition; provisioning of ecosystem services and their valuation; and the ways in which ES can be maintained and enhanced. This Special Issue is an outcome of the conference “Mapping and assessment of ecosystem services – Science in action” which was organised within the framework of the Project “Methodological assistance for ecosystems assessment and biophysical valuation” (MetEcoSMap)*1 in February 2017 in Sofia, Bulgaria. The Project was part of the programme “BG03 Biodiversity and ecosystem services” at the request of the Financial Mechanism of the EEA Office in relation to another support mechanism initially envisaged by the Ministry of Environment and Water (MoEW) in Bulgaria. The partners in this Project are MoEW, Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (IBER–BAS), Norwegian Institute for Nature Research (NINA) and the Executive Forest Agency at the Ministry of Agriculture and Forestry (EFA-MAF). The Project developed a Methodological framework including:

1. European context, concepts and definitions;
2. Nine methodologies for each ecosystem type adapted for Bulgaria of MAES analytical framework;
3. In situ verification guide;
4. Monitoring guidelines at an ecosystem level. The Project also supportedseven mapping projects for the nine ecosystem types outside NATURA (about 67% of Bulgarian territory) and two additional projects – “Pollination services in Bulgarian rural landscapes” and “Biological and chemical indicators of soil condition in Bulgarian agro-ecosystems”.

The objectives were both scientific and administrative (coordination and capacity building), addressing the challenge of a nationwide assessment and large-scale mapping of ecosystems condition and services. The conference “*Mapping and assessment of ecosystem services – Science in action*” was focused on the methods for mapping of ecosystem services, the challenges and problems with their implementation in the national assessments related to MAES. It was organised by IBER-BAS, MoEW, NINA in collaboration with the Bulgarian National Network in Ecosystem Services Partnership (ESP)*2, Bulgarian National LTER Network (LTER-Bg)*3, National Institute of Geophysics,

Geodesy and Geography - BAS and Forest Research Institute - BAS. The programme for the conference was organised around three main topics:

1. Mapping of ecosystems and general assessment frameworks;
2. Assessment of ecosystem's condition;
3. Mapping and assessment of ecosystem services (biophysical and socio-cultural perspective).

In the framework of the Conference, the Workshop "Ecosystem services assessment and evaluation – panacea or Pandora's box?", was carried out.

The Special Issue is formed by a series of self-contained papers connected by the overall aim of the conference. It presents case studies at different scales, ranging from Pan-European to national (Germany, Norway, Greece, Bulgaria and Belgium), regional and local, as well as assessments based on different value domains i.e. biophysical, socio-cultural and economic.

Main topics of the Special Issue

The Special Issue contains 12 papers which cover various aspects of ES mapping and assessment (see Table 1). They can be grouped around the three main topics of the conference (see above) which are presented in the following subsections. The first one was focused on ecosystem typologies used at European and national scales and the assessment frameworks developed at continental and national levels, as well as the correspondence between the approaches applied in different countries. The four papers in this subsection show integrated assessment frameworks designed for Pan-European (Burkhard et al. 2018) and national scale (Grunewald et al. 2017, Dimopoulos et al. 2017, Skre 2017) mapping. The second subsection is focused on mapping of specific ecosystem services in case studies across Europe. This is the main topic of seven papers but it is also more or less mentioned in all other papers (Table 1). The third subsection is dedicated to the assessment of the ecosystem's condition which deals mainly with data and analyses of drivers (land use, management), pressure (land-take, pollution, climate change) and their impact on the structure and function of the ecosystems. There are two papers focused especially on this topic (Dimitrov et al. 2018, Nedkov et al. 2017) but it is also addressed in several other papers (Grunewald et al. 2017, Jacquemin et al. 2017, Dimopoulos et al. 2017, Koulov et al. 2017).

Table 1.

Summary of special issue papers.

Topics:

1. Mapping of ecosystems and general assessment frameworks;
2. Assessment of ecosystem's condition;
3. Mapping and assessment of ecosystem services.

Special issue paper	**Grunewald et al. 2017**	**Burkhard et al. 2018**	**Skre 2017**	**Nijnik and Miller 2017**	**Koulov et al. 2017**	**Nikolaidou et al. 2017**
Main topic	1	1	1	2	2	2
Related topic	2,3	2,3	2		3	
Location	Germany	General	Norway	UK (Scotland)	Bulgaria	Greece
Scale	National	Pan-European to national	National	National/local	Local	Regional
Value-domain	Biophysical	all	Economic	Socio-cultural	Economic	Biophysical/ socio-cultural
Related ecosystem	Forest, urban, fresh water, cropland	all	all	Forest	Urban, forest, cropland, grassland, space	not specified
ES mapped and/or assessed	Fibres and other mat., flood protection, mass stabilisation, experiental use of plants etc.	all	all	bundle of services	bundle of services	bundle of services
Ecosystem condition	not specified	not specified	qualitative assessment			
Special issue paper	**Dimopoulos et al. 2017**	**Jacquemin et al. 2017**	**Stange et al. 2017**	**Yaneva et al. 2018**	**Nedkov et al. 2017**	**Dimitrov et al. 2018**
main topic	1	2	2	2	3	3
related topic	2,3	3			2	2
Location	Greece	Belgium	Norway	Bulgaria	Bulgaria	Bulgaria
Scale	National	National	Local	Local	National	local

Value-domain	all	Biophysical	Biophysical	Biophysical	Biophysical	Biophysical
Related ecosystem	all	Cropland	Urban	Forest	Urban	Urban
ES mapped and/or assessed	all	Pollination	Pollination	Global clim. reg., decomp. and fixing processes	Global clim. reg, local clim. reg.	
Ecosystem condition	not specified	Vulnerability of crops			spatial structutre of urban ecosystems	phytosanitary status

General mapping and assessment frameworks

The assessment of ecosystems and their services needs spatially explicit data representing the landscape heterogeneity for different areas. Burkhard et al. (2018) underline the need for an integrated framework for mapping and assessment of ecosystems and their services that would support and coordinate the EU member state activities to achieve EU Biodiversity Strategy goals. They present a framework that builds on existing works done by the MAES working group and provides a 9-step approach directed to set up related research and development initiatives and to guide all involved parties through the different steps and related tasks of the process.

A set of indicators for nationwide assessment and monitoring of ecosystem services in Germany has been developed through several ongoing projects (Grunewald et al. 2017). The authors proposed a total number of 51 indicators applicable for 21 CICES classes that have been prioritised for the country by expert-based assessment. Maps of usable wood, avoided soil erosion, flood retention and accessibility of green spaces illustrate the indicators' application. However, “the establishment and legitimating of ES indicators are still at an early stage in Germany” (Grunewald et al. 2017), therefore the authors recommend particular measures developed within the nationwide framework and further integration of the works on different aspects of ES mapping including TEEB NEA-DE and IPBES works.

A conceptual framework for mapping and assessment of ES in Greece is presented by Dimopoulos et al. (2017). It took into account the specifics of the country and the availability of information within the given timeframe. It incorporates ecological data from monitoring and habitat mapping of the Natura 2000 network. The framework is organised into two steps, the first one includes mapping of ecosystem types and assessment of ecosystem condition while the second is focused on the ES mapping. The latter envisages mapping of ES supply, flow and demand as well as ES priority areas mapping, based on a set of indicator matrices. The framework pays special attention to the scale issue which “is considered as crucial for the creation of a reliable index to conduct large (national) scale

assessments for various services” (Dimopoulos et al. 2017). The framework is developed within the framework of the Hellenistic Ecosystem Services Partnership (HESP)*4, which also developed an action plan for mapping and assessment of ES in Greece.

An evaluation of ES in Norway, based on a review of the available public reports and research articles, is presented by Skre (2017). It includes estimates and validation of ecosystem services and gives a basis for identifying some conflicts between stakeholders regarding different ecosystem services. A wide variety of ecosystem types is included e.g. mountain ecosystems, forests, agricultural areas, freshwater ecosystems, marine ecosystems and urban areas. The paper deals with how to implement questionnaires and cost-benefit analysis for ES valuation at a national scale.

Mapping individual ecosystem services in case studies

Biophysical methods for mapping ecosystem services are used to quantify the capacity of ecosystems to deliver services and the amount of this capacity to ensure human benefits. Socio-cultural methods are related to the analysis of human preference, uncovering individual and collective values and perceptions towards ecosystem services in non-monetary units. The sessions dedicated to those methods were focused on the challenges and problems in the spatial aspects of the ES assessment, the challenges in their application for mapping purposes and their potential to derive indicators for ecosystem services supply, flow, demand and trade-offs. The papers included in this Special Issue present mapping of individual or groups of ecosystem services in different case studies around Europe.

Due to the many types of ecosystem services, it is preferable to group them together before attempting further evaluation. A GIS-based ES mapping and valuation model is tested within the real administrative boundaries of a typical municipality in Bulgaria for the purposes of territorial policy integration (Koulov et al. 2017). They also suggest analysing the "Total Economic Value" as the first step in the integrated assessment of ecosystem services in a specific administrative territorial unit. Koulov et al. (2017) succeed in updating the basic terminology supporting ES classification and evaluation by the introduction of the term “ecosystem services dysergy” in the valuation theoretical framework. The investigation overcomes some of the challenges of the application of ES valuation methods at the municipal level and the geospatial analysis of their results. The opportunities, challenges and limitations in the practical application of the ecosystem services concept are outlined.

Yaneva et al. (2018) present an original scientific interpretation of a still controversial issue of the spatial and temporal scales of ecosystem services’ mapping and assessment. They focus on the spatial patterns and the forest ecosystems’ dynamics over time by drawing attention to the soil properties and analysing their influence on ecosystem services supply potential. The study performs a successful experiment on the integration of forest ecosystems monitoring data (ICP Forests) into the biophysical assessment of ecosystem services because it manages to produce reliable maps of two different services (see Table 1). They review generated outcomes with reference to the DPSIR scheme and give feedback on the changes in the terrestrial ecosystems in the last 25-30 years.

Nikolaidou et al. (2017) comment on the particularly important issue of compatibility (synergy) between activities on ecosystem services' concept implementation in practice with well-established biodiversity conservation approaches and policies such as Habitats (92/43/EC) and Birds Directives (79/409/EC), the Water Framework Directive (2000/60/EC) and the Noise Directive (2002/49/EC). They explore the potential correlation between territories of different or multiple designation types and their capacity to provide ecosystem services. The authors emphasise the need for further clarification of the criteria for assessment of such areas. Nikolaidou et al. (2017) suggest that the designation status of an area can be used as "an alternative tool for environmental policy, indicating the capacity for ES provision". Multiple designations of areas can be used as proxies for detecting hotspots of ecosystem services. Such type of integration of established evaluation and designation with the ecosystem services' concept perspectives creates an effective approach for communication with stakeholders and policy-makers in order to motivate them in complying with new standards and demands for nature conservation and environmental management.

The need for mechanisms to capture benefits and costs, as well as its incorporation in decision-making, is discussed by Nijnik and Miller (2017). They argue that ecosystems are complex systems, where neither the ecosystems nor the services that they provide are a sum but are an interrelated system of components. Instead of monetary valuation, they propose participatory approaches, based on mixed methods or the integration of methods. The application was demonstrated by national and local scale studies in Scotland which enable them to evaluate the multiple services provided by forest ecosystems. They conclude that these approaches can provide more complete, comprehensive and impartial insights into a range of benefits that humans derive from ecosystems (Nijnik and Miller 2017).

Two papers (Jacquemin et al. 2017, Stange et al. 2017) deal with assessment and mapping of pollination service. Mapping and assessment approach for informing about zoning decisions regarding urban honeybees by using a modified version the ESTIMAP pollination model is proposed by Stange et al. (2017). The model is applied in Oslo metropolitan area and the study demonstrates testing the policy relevance of ecosystem mapping tools beyond the general purpose of awareness-raising by providing some broader general lessons for ecosystem mapping and assessment. The application of the model enables the authors to produce three kinds of maps, i.e. pollinator habitat quality, relative honeybee foraging and relative resource demand of foraging honeybees. They conclude that, for cities like Oslo, urban development can also produce intermediate levels of habitat fragmentation and result in greater amounts of highly suitable edge habitats that can be found in rural landscapes (Stange et al. 2017). On the other hand, Jacquemin et al. (2017) evaluate the pollination service on a country-wide scale in Belgium by estimating the value of the contribution of insect pollination to the product used for human consumption. They use a methodology for evaluation of pollination at the national level based on crop dependency ratios. The results are presented in the form of maps of total production value and pollination value in monetary terms.

Mapping ecosystems condition

The ecosystem condition for the purpose of MAES is the physical, chemical and biological condition of an ecosystem at a particular point in time (Burkhard et al. 2018). The discussions on this topic during the conference were focused on the identification of appropriate indicators for quantification of the ecosystem condition and the spatial representation of these indicators. Two papers in this Special Issue present different aspects of the ecosystem's condition. Nedkov et al. (2017) proposed an "integrated index of spatial structure" of urban ecosystems which incorporates built types and land cover from the Local Climate Zones (LCZ) concept with urban ecosystems' classes developed on the basis of MAES typology. The index is used to define vegetation cover and assess the ecosystem condition as part of a general assessment framework for urban ecosystems. The index provides an appropriate basis for characterisation and assessment of the urban ecosystems' condition and ecosystem services and enables the definition of the internal heterogeneity of the urban ecosystems at national level which is one of the main challenges in studying urban ecological systems (Nedkov et al. 2017). Dimitrov et al. (2018) present assessment of the health status of the tree and shrub vegetation in urban green infrastructure in a case study of Karlovo (Bulgaria) by using an integrated application of in-situ observation and remote sensing by Unmanned Aerial Vehicle technology. They prove that the implementation of this flexible approach provides rapid and low-cost results, with good quality of the generated information, which is appropriate as a basis for monitoring of green systems in urbanised areas.

The ecosystems' condition is also mentioned in some of the other papers. The vulnerability of crops to pollinator insect disappearance (Jacquemin et al. 2017) can be used as an indicator for the condition of the agricultural ecosystem which strongly affects pollination service provision. The rate of vulnerability across Belgium is presented in maps which show its spatial variability between different provinces. As Jacquemin et al. (2017) point out, this also makes it possible to discuss the relevance of certain agri-environmental measures by taking into account these dependency relationships between crops and pollinators. Their study shows the necessity to define policy recommendations in favour of the protection of pollinator insects. Koulov et al. (2017) place the assessment of the ecosystem state as an integral part of their framework of the investigation. The schemes, proposed by Burkhard et al. (2018) and Grunewald et al. (2017), define the assessment of ecosystem condition as a key element of the general assessment framework. In addition, Grunewald et al. (2017) point out that a database, that is at least partially provided by the ongoing ecosystem services and condition assessment, is needed for the National Capital Accounting.

Conclusions

The collection of papers, which we offer here, covers important aspects of mapping and assessment of ecosystem services related to the MAES process and emphasises the research progress in different countries across Europe. The general mapping and

assessment frameworks presented in this collection provide a good basis for further harmonisation of data collection and methods application which is an important contribution for the achievement of the EU Biodiversity strategy goals. The case studies present ES mapping predominantly on a national and local scale, with only one dealing with regional scale mapping. The methods used in the studies are based on all three value domains, but biophysical domains are predominant. The services, which are mapped and assessed, vary in different studies but there is a tendency towards the cover of more services in a single study as only two papers are focused on a single service. The studies on the assessment and mapping of the ecosystem condition, presented in the papers of this Special Issue, are still few and not well developed compared to ES studies. There are only two papers focused especially on ecosystem condition and they also deal with ecosystem services. The works from Greece and Bulgaria reveal some specifics for southeast Europe and demonstrate the progress in these countries in the MAES process which was also found in the EU funded ESMERALDA project*5. They can be used by the other countries in the region and the knowledge could be easily transferred through the ESP SEE regional chapter*6.

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Conflicts of interest

We declare no conflict of interests.

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Endnotes

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*2 https://www.es-partnership.org/community/regional-chapters/south-east-europe/bulgaria/
*3 http://www.lter-europe.net/lter-europe/infrastructure/networks/bulgaria/
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