



BOOK OF ABSTRACT

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I. SESSION DESCRIPTION

ID: T5a

Models for integrated ecosystem services assessments and future scenarios

Hosts:

	Title	Name	Organisation
Host:	Dr.	Stoyan Nedkov	NIGGG-BAS
Co-host:		Roy Remme	
Others involved:		Bart de Knegt Kremena Burkhard Rob Alkebade	

Abstract:

There is a rapidly growing need to assess the spatiotemporal consequences of ex-ante and ex-post scenarios on the delivery of multiple ecosystem services. This need is driven by various assessment and mapping initiatives, including many EU-wide assessment efforts and projects, such as MAES, ESMEALDA, OPERAs and OpenNess. With the rapid advancement in modelling of potential and current ecosystem service stocks and flows, there is a growing need for more integrated modelling approaches that address the consequences of multiple changes in drivers, pressures and biodiversity on multiple ecosystem services in space and time. Spatial modelling methods are advancing rapidly and decision makers are becoming ever more interested in integrating ecosystem services in policy and practice, constituted by the aforementioned initiatives. Therefore, there is a need to assess the consequences of different scenarios, consisting of multiple changes of for instance land use, land management and environmental pressures, on the delivery of multiple ecosystem services. Modelling multiple possible future scenarios is of key interest to policy makers, in order to assess the effects of their (spatial) plans. Back-casting is of importance to understand the developments of ecosystem service flows in combination with past policies and the assessment of their effectiveness. Scenario building through models provides the



opportunity to integrate multiple bio–physical and socio–economic variables and study their interactions and impact on ecosystem services. Models are the optimal tool for future scenario ecosystem services assessments and promote the better understanding of possible consequence of pressures and changes. Nevertheless, the overwhelming complexity of the system is hard to tackle in a “single model to rule them all” and there are still multiple perspectives that need to be represented in the models in order to build feasible future scenarios and support sustainable decision–making. There are many available modelling methodologies to assess different ecosystem services, also as bundles and trade–offs, but the interrelations between different services and with biodiversity aspects, as well as the underlying drivers and pressures, are still in their infancy. The development of more integrated ecosystem service models is necessary for robust temporal assessments of ecosystem service flows and to assess the consequences of present and possible future pressures on the synergies and trade–offs of ecosystem services and biodiversity. We invite speakers to present advancements in integrated ecosystem service modelling in relation to space and time representativeness, comprehensiveness and promptitude of the models to promote assessments and robust policy–making on ecosystem services and sustainable development.

Goals and objectives of the session:

This session is organised by ESP’s Thematic Working Group on Modelling and will offer an opportunity to present and share recent advances in development and application of integrated models and modelling tools, for the assessment of ecosystem services in Europe. The specific objectives of the session are:

- Provide an overview of integrated ecosystem service models that are being developed in the European context.
- Present integrated ecosystem service models that can be used for ex–ante and ex–post scenario assessments.
- Assess the interrelations between biodiversity, drivers and pressures and multiple ecosystem services.

Planned output / Deliverables:

A review of ecosystem services models in European context and recommendation of their application.

Options to prepare a common paper will be explored during the session.



Related to ESP Working Group/National Network:

[Thematic Working Groups:T5 – Modeling ES](#)

II. SESSION PROGRAM

SESSION PROGRAM

Date of session: Thursday, 18 October 2018

Time of session: 8:45 – 18:00

Timetable speakers

Time	First name	Surname	Organization	Title of presentation
8:45–9:00	Stoyan	Nedkov	NIGGG–BAS, BG National Institute for Public Health and the Environment, NL	Introduction to the Session
New advances on modelling				
9:00–9:15	Silvia	Rova	University Ca' Foscari of Venice, IT	An explorative modelling approach for the dynamic simulation of the provision of multiple ecosystem services
9:15–9:30	Stoyan	Nedkov	NIGGG– BAS, BG	Biophysical models for mapping and assessment of ecosystem services
9:30–9:45	Alex	Bertrand	Luxembourg Institute of Science and Technology, LUX	Spatial optimisation of urban ecosystem services: a multi-objective integer linear programming-based approach



Time	First name	Surname	Organization	Title of presentation
9:45– 10:00	Kremena	Gocheva	IBER – BAS, BG	Improving the accuracy of complex models: towards an universal assessment method for uncertainty in combination modelling
10:00– 10:15				Discussion
Future scenarios for ecosystem services				
11:30– 11:45	Paula	Harrison	Centre for Ecology & Hydrology, UK	Assessing future interactions between nature and society using scenarios and integrated models: experiences from IPBES
11:45– 12:00	Vilém	Pechanec	Palacký University Olomouc, SZE	Modelling tools for the prediction of driver impacts on biodiversity and ecosystem services at habitat level
12:00– 12:15	Zuzana	Harmachkova	Stockholm Resilience Centre, SWE	Future uncertainty in scenarios of ecosystem services provision: Linking differences among narratives and outcomes
12:15– 12:30	Anita	Bayer	Karlsruhe Institute of Technology, DE	Future human demands in land use models and their



Time	First name	Surname	Organization	Title of presentation
				effect on ecosystem functionality
12:30–12:45	Luis	Santamaria	EBD-CSIC, ESP	Models as consensus-building tools: Collaborative modelling and the integrated assessment of ecosystem services
12:45–13:00				Discussion
Future scenarios for ecosystem services in water systems				
14:30–14:45	Pelayo	Menéndez Fernández	IH Cantabria, ESP	Assessing the role of coral reefs and mangroves for coastal flood protection under climate change scenarios
14:45–15:00	Arturas	Razinkovas-Baziukas	Klaipeda University, LTU	Outlook to the future: will the climatic changes alter the ecosystem services of the Baltic coastal lagoon?
15:00–15:15	Didac	Jorda-Capdevila	Catalan Institute for Water Research, ESP	An integrated strategy for the assessment of multiple freshwater-related ecosystem services under global change conditions
15:15–15:30	Anett	Schibalski	Technische Universität Braunschweig, DE	Spatio-temporal quantification of the



Time	First name	Surname	Organization	Title of presentation
				impact of climate change, sea-level rise and land management on the provision of multiple coastal ecosystem services
15:30–15:45	Edna	Cabecinha	University of Tras-os-Montes and Alto Douro, PRT	ALICE: Improving biophysical models to link terrestrial, riverine and coastal interfaces accounting for biodiversity and ecosystem services
15:45–16:00				Discussion
Applying ES models in decision support				
16:30–16:45	Roy	Remme	National Institute for Public Health and the Environment, NL	The Natural Capital Model for the Netherlands – integrated modelling of ecosystem services and biodiversity
16:45–17:00	Maria	Felipe-Lucia	University of Bern, SHE	Prioritizing sites for ecological restoration based on ecosystem services
17:00–17:15	Ricardo	Moreno-Llorca	University of Granada, ESP	Past and future assessment of ecosystem services based on land use



Time	First name	Surname	Organization	Title of presentation
				changes to help decision making in protected areas planning
17:15–17:30	Hanbing	Zhang	China Agricultural University	Multi-Scenarios Simulation of Land Use for Reducing Wind Erosion in The Typical Agro-pastoral Ecotone
17:30–18:00				Discussion

III. ABSTRACTS

The abstracts appear in alphabetic order based on the last name of the first author. The first author is the presenting author unless indicated otherwise.

1. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Future human demands in land use models and their effect on ecosystem functionality

First author: Anita Bayer

Other author(s): Reinhard Mey, Richard Fuchs, Andreas Krause, Peter Verburg, Almut Arneth

Affiliation, Country: Karlsruhe Institute of Technology, Germany

In the wide field of modelling, a number of land use models exist that provide consistent time series and gridded data of historic land use and/or possible pathways of future land use following projected human demands. To fulfil these demands, land use models face a number of complex challenges, such as using incomplete global datasets as the basis, deciding on a way and degree of complexity to translate socio-economic drivers or policy directions into absolute land use changes, etc. In this study we make use of one recently developed land use model (CLUMondo) and three frequently used land use and integrated assessment models (IMAGE, MAgPIE, LUH) that provide data for in total 15 different futures of global land use. Land use scenarios follow projected developments of future human



demands under a business-as-usual scenario, provide alternative pathways under different climatic developments (RCPs), or have additional demands superimposed to business-as-usual (e.g. land-based climate mitigation with BECCS or afforestation, biodiversity conservation). In a first step, we evaluate differing strategies to select multiple possible future human demands and to translate them into land use maps and changes over time. In a second step, we quantify and compare ecosystem service indicators (C storage, NPP, evapotranspiration, N leaching, crop yields, water supply, BVOCS) for the different land use options until 2040 that were simulated with the LPJ-GUESS global vegetation model. The analysis reveals how well demands (e.g. a carbon dioxide removal target) that were initially implemented by the land use models were met under a potentially more realistic, process-based modelling approach and what the effects of these few implemented demands are on a suite of ecosystem services. This provides a valuable insight to the question whether land use models capture everything that is needed to set up realistic projections of future land use based on projected human demands.

Keywords: land use models, DGVMs, land use scenarios, ecosystem service indicators

2. *Type of submission:* **Abstract**

T. Thematic Working Group sessions: [T5a Models for integrated ecosystem services assessments and future scenarios](#)

Spatial optimisation of urban ecosystem services: a multi-objective integer linear programming-based approach

First author: Alex Bertrand

Other author(s): Tom Elliot, Benedetto Rugani

Affiliation, Country: Luxembourg Institute of Science and Technology, Luxembourg

Global urbanisation trends combined with growing pressures on resources require that sustainability research better understands the complexity of urban ecosystems. Urban ecosystem services (UES) are the positive externalities that supply benefits to humankind in urban systems. In order to avoid or at least limit the subsequent degradation of these UES due to urbanisation, optimisation measures targeting the constraining pressures must be assessed and deployed. Such an approximate optimisation can be based on land cover configurations, as UES are linked to cover typologies. The aim of this work is to design an integrated operations research (OR) model to address the high complexity of such optimisation (e.g. high number of potential configurations, economic and spatial constraints)



of urban systems. An OR approach allows to understand how land covers may be optimally configured to ensure maximum ecosystem service provision while considering various constraints. The proposed model takes traditional OR methods, namely multi-objective integer linear programming, using lookup tables with land cover performance scores to maximise a set of UES using an epsilon-constraints approach. In addition to the avoidance of ecosystem services degradation, economic constraints are also included in the model. The proposed approach is then demonstrated in an urban case study using Burkhard et al (2009) performance scores and considering 7 different land uses and 5 ecosystem services. Based on the limitations of the model, needs for future developments in the field of optimisation of ecosystem services, e.g. the specification of economic constraints, acknowledgement of spatio-temporal dynamics, are finally discussed.

Keywords: Ecosystem services, urban systems, land cover optimisation, multi objective linear programming

3. *Type of submission: Abstract*

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

ALICE: Improving biophysical models to link terrestrial, riverine and coastal interfaces accounting for biodiversity and ecosystem services

First author: Edna Cabecinha

Other author(s): Samantha Hugges, Rui Cortes, João Cabral, Mário Santos, Simone Varandas, Luis Filipe Sanches Fernandes, Fernando Pacheco, João Santos, Martinho Lourenço, José Aranha, Domingos Lopes, João Paulo Moura, Diane Burgess, Cendrine Mony, Thomas Houet, Stefano Balbi, Ferdinando Vila, Mariana Milagaia, Marco Magalhães, Johanna Beganton, Jose Alvarez-Martinez, Pepe Barquín

Affiliation, Country: 2CITAB, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal

ALICE, Improving the management of Atlantic Landscapes: accounting for biodiversity and ecosystem services, will develop a comprehensive package of new methods, tools and procedures to identify barriers to the delivery of benefits from Blue and Green Infrastructures (BGI) implementation and to improve the characterization of biodiversity and the valuation of ecosystem services (ES) across four Atlantic case studies (CS; Portugal, Spain, France and UK-Ireland). One of the key objectives of ALICE is developing a full-package of new methods,



tools and procedures to assist with coastal and inland landscape management, based on participative learning and modelling by incorporating socioeconomic and climate change scenarios. Therefore, biophysical models will develop to link coastal and riverine environs and test scenarios to assess impacts on target ecosystem components. A fully harmonised biomonitoring spatial database will be created on the ALICE platform. Water runoff, sediment transport and water quality models will be developed and linked through a simulation platform. A Virtual Watershed, will be created for each CS, providing a geospatial riverine landscape unit coupling a digital elevation model and synthetic hydrography for analyses of landforms, processes, and human interactions. A Stochastic Dynamic Methodology (StDM) will be used to assess how different catchment configurations and scenarios affect coastal, riverine and soil characteristics. This project is an integrative technological approach by identifying the ES benefits delivered by BGI and explore the economic and social barriers to the delivery of ES. This innovative foundation sets ALICE complementing other programs (CLIMSAVE, VOLANTE, BESAFE, OPERAs, OpenNESS, IMPRESSIONS, PlanSmart) by integrating social, economic and environmental analytical tools and models at the basin scale.

Keywords: Modelling, Climate change, Ecosystem services, Blue and Green infrastructures

4. Type of submission: **Abstract**

T. Thematic Working Group sessions: [T5a Models for integrated ecosystem services assessments and future scenarios](#)

Prioritizing sites for ecological restoration based on ecosystem services

First author: María R. Felipe-Lucia

Other author(s): Francisco A. Comín, Beatriz Miranda, Ricardo Sorando, Juan J. Jiménez, Enrique Navarro

Affiliation, Country: University of Bern, Switzerland

Ecosystem services (ES) are increasingly used as a tool to approach the challenges of restoring ecosystems multifunctionality while integrating both ecological and social values. However, there are still some critical issues that hinder the implementation of the ES approach at large scales, as required in ecological restoration, including the disparity in the spatial scale of data available to assess ES, difficulties to integrate the assessment of multiple ES and uncertainty about the spatial scales relevant to ES management. Although the assessment of ES has been already applied to guide land management scenarios, an approach integrating the valuation of multiple ES at larger scales, which are often more



meaningful for land management, is still underdeveloped. Given economic resources to undertake ecological restoration at large scales are often scarce, a tool to effectively prioritize sites for ecological restoration and enhance multiple ES supply and human well-being is critical. We present the Relative Aggregated Value of Ecosystem Services (RAVES) index, to prioritize sites for ecological restoration based on the assessment of multiple ES. We tested the spatial heterogeneity of ES to identify the relevant scale to managing ES and to apply the RAVES index using a local case study (the River Piedra catchment). We also used the RAVES index to compare three alternative restoration scenarios to enhance ES based on the availability of socio-economic resources. Our results show that the RAVES index can effectively be used to hierarchically prioritize sites for ecological restoration across large spatial scales. The RAVES index integrates both ecological information and societal values by weighting ES via a multicriteria analysis and was successfully to identify optimal management scenarios. Our work highlights the importance of analysing the spatial heterogeneity of ES to identify the most relevant scale to applying the RAVES index and to managing ES via ecological restoration.

Keywords: landscape management, catchment-scale assessment, multiple ecosystem services index, scenario analysis, semi-arid landscape restoration

5. *Type of submission: Abstract*

T. **Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios**

Improving the accuracy of complex models: towards an universal assessment method for uncertainty in combination modelling

First author: Kremena Gocheva

Affiliation, Country: Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences, Bulgaria

The complexity of socio-ecological systems makes determining the correct indicators an iterative task. Data is collected based on top-down decisions (typically - legislation agreed between policymakers who are not specialists in the subject area); scientists face data gaps and changes of methodology that make available data incompatible. Modelling is widespread and hundreds of approaches, many of them - underpinned with software - are used to close the gaps. Some of the key performance metrics rigorously addressed in deterministic models are accuracy, precision and recall. In manufactured systems with finite states or known outcomes, measuring these metrics is relatively straightforward. Not so in ecological



modelling where the system is not controlled by the modellers and is open to external influence. Modelling also has methodological compatibility issues. Firstly, assessing the accuracy after one modelling instance is done with high quality data but assessing the overall accuracy when one or more derivative datasets are used as inputs in other models is not addressed systematically. Secondly, technological advancements provide new opportunities for improving modelling quality. However, to assess the rate of improvement, a rigorous measurement of some base metrics is also necessary across running different instances of the same model with new/improved data. We attempt the application of the error analysis technique to derivative datasets using data from the mapping and assessment of Bulgarian ecosystems outside Natura 2000. The accuracy, precision and recall metrics is calculated for two parameters of EU level datasets: topological accuracy and thematic accuracy. We analyse the model biases using a model agnostic, qualitative diagnostic method. It allows for improved compatibility between datasets across modelling techniques, forward and backward compatibility of processing inhomogeneous time series, and may be extended to other ecosystem metrics. It is therefore well suited for assessing the modelling accuracy of new, higher resolution remote sensing and ground data.

Keywords: Modelling accuracy, cumulative error, derivative datasets, error analysis, ecosystem type thematic accuracy

6. *Type of submission:* **Abstract**

T. [Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios](#)

Future uncertainty in scenarios of ecosystem services provision: Linking differences among narratives and outcomes

First author: Zuzana V.Harmáčková

Other author(s): D. Vačkář

Affiliation, Country: Stockholm Resilience Centre, Sweden

Future provision of ecosystem services (ES) has been increasingly analysed through the scenario approach, widely recognized as a tool to address uncertainties and to communicate them to stakeholders and decision-makers. Multiple uncertainty-related aspects of the scenario approach have been discussed in the recent literature, e.g. how uncertainty emerges from and is accounted for in ES modelling processes. However, this contribution aims to address yet another uncertainty-related aspect of scenario analysis, exploring the



relationship between the diversity of qualitative scenario narratives on the one hand and the diversity of their respective quantitative outcomes on the other, and how these differences inform decision-makers about the inherent stochastic uncertainty of the system. In this contribution, we build on an illustrative local-scale case study carried out in a UNESCO Biosphere Reserve in the Czech Republic, and create an array of ES provision scenarios to 2050 by combining participatory scenario planning and ES modelling through multiple spatially explicit approaches. Based on the scenarios, we present a feasible semi-quantitative approach to compare the differences among scenario narratives and outcomes, including a qualitative comparison of storylines and a quantitative comparison of resulting ES provision maps in both spatial and aggregated terms. Our results show that substantially different scenario narratives may lead to similar levels of modelled ES provision, and vice versa, that similar narratives may result in contrasting scenario outcomes. Consequently, we discuss the implications of these findings for robust strategies of landscape management, recognising future uncertainties. In addition, we discuss the influence of selected comparing approaches on potential interpretations of results by stakeholders and decision-makers.

Keywords: ecosystem services modelling, scenarios, uncertainty, participatory scenario planning, map comparison

7. *Type of submission:* **Abstract**

T. **Thematic Working Group sessions:** T5a Models for integrated ecosystem services assessments and future scenarios

Assessing future interactions between nature and society using scenarios and integrated models: experiences from IPBES

First author: Paula Harrison

Other author(s): Jennifer Hauck, Lluís Brotons, Matthew Cantele, Joachim Claudet, Christine Fürst, Antoine Guisan, Christian Rixen, Fernando Santos-Martín, Martin Schlaepfer, Cosimo Solidoro, Zharas Takenov, Jozef Turok, Zuzana Harmáčková, Robert Dunford, Kasper Kok, Anastasia Lobanova, Alejandra Morán-Ordóñez, Anthony Sonrel, Armağan Aloe Karabulut, Mark Rounsevell

Affiliation, Country: Centre for Ecology & Hydrology, United Kingdom

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services reviewed and synthesised findings from scenario and modelling studies in its Regional Assessment for Europe and Central Asia. Two linked reviews were undertaken to gather



evidence on: (i) exploratory scenarios, which examine a range of plausible futures based on assumptions about a range of trajectories of indirect and direct drivers; and (ii) modelling studies, which translate the driver assumptions in exploratory scenarios into projected consequences for biodiversity, ecosystem services and human well-being. The review of modelling studies focused on integrated modelling approaches that combine modelling of multiple environmental, social and economic system components and their interactions. Such approaches provide essential support to guide planning and decision-making by highlighting critical interdependencies and potential synergies and trade-offs between ecosystem services under different plausible futures. This presentation will provide a summary of the findings from this IPBES assessment showing that scenario and integrated modelling studies for Europe and Central Asia show trade-offs between different ecosystem services with implications for biodiversity. Political and societal value judgements embedded within scenarios will determine how these trade-offs are resolved. Scenarios that assume proactive, environmental decision-making; promote environmental management approaches that support multifunctionality; and mainstream environmental issues across sectors, can mitigate undesirable trade-offs. Moreover, scenarios that assume cooperation between countries or regions are more effective in mitigating negative impacts across geographic scales. Such scenarios project more positive impacts across a broad range of indicators of biodiversity, ecosystem service and human wellbeing than others. Results from the CLIMSAVE Integrated Assessment Platform (a coupled-component modelling approach combining models for six sectors: urban, agriculture, water, forestry, fluvial/coastal flooding, and biodiversity) will be used to illustrate specific findings. Finally, the findings are related to policy goals and targets to assess the extent to which the Sustainable Development Goals and the Aichi targets are expected to be achieved under the different scenario archetypes (albeit under a different timeframe).

Keywords: Scenario archetypes, integrated models, ecosystem services, biodiversity, science-policy interface



8. *Type of submission: Abstract*

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

An integrated strategy for the assessment of multiple freshwater-related ecosystem services under global change conditions

First author: Dídac Jorda-Capdevila

Other author(s): Vicenç Acuña, Carme Font, Sergi Sabater

Affiliation, Country: Catalan Institute for Water Research (ICRA), Spain

Mediterranean societies are changing as much as their environment. The expansion of urban and irrigated areas and the increase of extreme events related to precipitation – droughts and storms – are currently affecting the ecological status of freshwater ecosystems, as well as the social and economic benefits they provide. In this study, we attempt to develop an integrated valuation at a basin level consisting in four steps. First, a socio-cultural valuation inform us about the importance and vulnerability of different ecosystem services in the basin for different type of actors. Second, we relate multiple drivers of change to ecosystem services provision through the construction of an innovative matrix that assembles mechanistic and Bayesian models. The starting point of this is a hydrological model built with Q-SWAT, and different complements are developed with Q-GIS and R. Third, an economic valuation accounts for monetary and non-monetary values of service provision. And fourth, a participatory process with key stakeholders co-develops future scenarios in 2050 at a river basin scale and proposes multiple management practices that can be assessed to enhance decision-making. This is being done for the Algars River basin, a small subbasin (402 km²) of the Ebro River (Iberian Peninsula), which includes two typical Mediterranean landscapes: in the headwaters, forested mountains barely threatened by human pressures but becoming popular by tourists; in the lowlands, a typical agricultural landscape with the presence of few urban areas. In this basin, there are multiple intermittent streams, whose hydrology, ecology and service provision are poorly studied in the academia. The innovative integration of mechanistic and Bayesian models for the assessment of freshwater-related ecosystem services, its applicability to other river basins – including those with intermittent and ephemeral reaches –, and the playability of the scenario development process for decision-makers are the main highlights of the study.

Keywords: Integrated valuation; intermittent rivers; stakeholder engagement; socio-environmental modelling; global change



9. *Type of submission: Abstract*

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Assessing the role of coral reefs and mangroves for coastal flood protection under climate change scenarios

First author: Pelayo Menéndez Fernández

Other author(s): Iñigo J. Losada, Michael W. Beck, Borja G. Reguero

Affiliation, Country: IH Cantabria, Spain

Coral reefs and mangroves are well-known additional obstacles to coastal hazards and, particularly, cost-efficient alternatives for flood protection. These ecosystems mitigate coastal flooding impact by reducing wave height and storm surge. The physical processes involving wave's energy dissipation and storm surge height reduction depends on the ecosystem geometry, buoyancy, density, stiffness and spatial distribution, as well as water depth and wave climate. Most of these variables are highly sensitive to climate change scenarios. For example, coral roughness decreases if reefs are degraded, leading to lower wave energy dissipation rates and higher flood levels. This worrying and uncertain future highlights the need of improving knowledge in predicting coastal flooding scenarios under climate change conditions. We use a 1D numerical model to simulate waves and storm surge dynamics in presence of coral reefs and mangroves with the aim of testing the sensitivity of the resulting Flood Height against different values of climatic and habitat variables, potentially affected by climate change. We found that the worst consequences of climate change in coastal flooding come from the habitat side (i.e. deeper corals or lower density mangrove forest), followed by sea level rise and ocean climate worsening conditions. For instance, the partial loss of coral reefs and mangroves would be the cause of increasing Flooding Heights up to 45% with respect to nowadays scenario. However, the worst-case scenario of combined ocean hazards and the complete habitats loss, would lead to Flood Height increments over than 160%.

Keywords: Coral reefs, mangroves, flood protection, climate change



10. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Past and future assessment of ecosystem services based on land use changes to help decision making in protected areas planning

First author: Ricardo Moreno-Llorca, Domingo Alcaraz-Segura

Other author(s): Herrero J., Bonet-García F.J., Millares-Valenzuela A., Ros-Candeira, A.

Affiliation, Country: Laboratorio de Ecología (iEcolab), Instituto Interuniversitario Sistema Tierra, Universidad de Granada, Spain

Land use changes have heavy consequences on ecosystem structure, function and services they provided, decades after the human activities have occurred. These effects on ecosystem services (ES) are even more important in mountainous environments. Protected areas managers need to know how these changes affected in past stages to ES delivery and to predict how different future land use scenarios could affect the supply of ES. The ES selected in this study were crop production, pastures for livestock, aquifers recharge, flood prevention, erosion prevention and aesthetic value. The main objective of the study was to compare different methodologies in order to guide the selection of appropriate tools to decision making process. In this work, we employed several methodologies and models to assess ES based on the land use at any given time in the past and future. Accordingly, both type of models, from globally ones, as INVEST, to local process-based models as WiMMed (Watershed Integrated Model in Mediterranean Environments), were used to estimate ES. Firstly, we analyzed land use changes and the evolution on ES in different timesteps in the past (1956, 1977, 1984, 1999, and 2007) in Sierra Nevada. Secondly, we developed a Bayesian Belief Network to generate several likely land uses scenarios for the future, based on climate, socioeconomic and policies scenarios. Afterwards, we assessed the spatio temporal change in supply of ES linked to land use change patterns. This work allows us to classify the models according to several criteria like temporal and spatial accuracy, or fidelity to the real processes, data requirements, time and effort needed to get results, and degree of specialization of the model user. The analysis of ES by using different approaches allowed us to establish the strengths and weaknesses of each type of methodology in order to help decision makers in land management.

Keywords: Land use change, ecosystem services, decision making, protected areas, ecosystem modelling



11. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Biophysical models for mapping and assessment of ecosystem services

First author: Stoyan Nedkov

Other author(s): Bilyana Borisova, Svetla Bratanova–Doncheva, Petar Nikolov, Desislava Hristova

Affiliation, Country: National Institute of Geophysics, Geodesy and Geography, Bulgaria

Ecosystem services (ES) are human–derived benefits flowing from the environment and their provision and flow are dependent on the ecological structures and functions, which make up the biophysical environment. The biophysical quantification of ES is focused on measuring ecosystem structure and functioning powered by biodiversity. Biophysical methods for mapping ecosystem services are used to quantify ecosystems' capacity to deliver ecosystem services and the amount of harvested yield of such capacity for human benefit. Biophysical measures are closely related to the methods and are often used as input data to social and economic mapping methods, and form the basis for natural capital accounting. Biophysical models are an integral part of the mapping and assessment of ES as they deliver information on the relationship of biophysical characteristics and ES. The ES MERALDA (Enhancing ecoSystem sERvices mApping for poLicy and Decision mAKing) project aims to deliver a flexible methodology to provide the building blocks for pan–European and regional assessments. The biophysical part of the flexible methodology includes classification of biophysical models which is based on previous works and comprehensive review of existing methods applied throughout Europe. In this paper, we will present the main principles of the classification and practical guidance how it can be used for selection of appropriate methods.

Keywords: Biophysical models, classification, flexible methodology, mapping



12. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Modelling tools for the prediction of driver impacts on biodiversity and ecosystem services at habitat level

First author: Vilém Pechanec, Pavel Cudlín

Other author(s): Ondřej Cudlín, Lenka Štěřbová, Jan Purkyt

Affiliation, Country: Palacký University Olomouc, Global Change Research Institute of the Czech Academy of Sciences, Czech Republic

Our approach integrates several models and data sources into a single GIS environment to predict the consequences of multiple impacts of pressures on biodiversity and selected ecosystem services (ES). The first step consists in the creation of an advanced layer of habitats, combining the Layer of Habitat Mapping provided by Nature Conservation Agency of the Czech Republic and the CORINE LC layer. The layer contains 193 habitats, divided into 5 groups according to their naturalness, and evaluated for biodiversity value, based on the Habitat Valuation Method (HVM; Seják, Cudlín 2010). To determine the multiple impacts of pressures on biodiversity, five indicators MSA (Mean Species Abundance), reflecting 5 drivers of the model GLOBIO3 (land use change, landscape fragmentation, infrastructure influence, atmospheric NO_x deposition and climate change), were computed and interpreted. The historical development of the main driver effecting biodiversity and ES provision, land cover (LC) change, was recorded using CORINE LC data in 1990, 2000 and 2012. Regarding to the incorrectness of CORINE mapping, the percent representation of 193 HVM habitats within individual CORINE LC categories was specified by the detailed land use mapping in 450 x 450 m squares, situated in the Czech Republic network 7 x 7 km in the frame of CzechTerra project. The future state of land cover was modeled by own tool CLC prediction model for year 2050 based on the use of Markov's chains, according to Business as usual scenario. Values of two selected ecosystem services were projected for 1990, 2000, 2012 and 2050 into LC categories of CORINE LC layer. Carbon sequestration (storage) was determined by the InVEST 3 algorithm using four carbon pools: above-ground biomass, below-ground biomass, necromass and soil organic carbon. These values, as well as evapotranspiration values for climate regulation for individual habitats were derived from literature and experimental measurements.

Keywords: biodiversity, ecosystem services, habitat, impacts, time period



13. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Outlook to the future: will the climatic changes alter the ecosystem services of the baltic coastal lagoon?

First author: Arturas Razinkovas–Baziukas

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The Curonian lagoon, the largest coastal lagoon in Europe is known to be highly eutrophic experiencing cyanobacteria blooms largely controlled by the ambient physical factors such as riverine discharges, wind induced intrusions of marine water and the water temperature itself. Commercial and recreational fishery as well as other recreational activities at large are widely assessed as the most important services provided by the lagoon ecosystem. We did find indications that seasonal dynamic of the water renewal time could be used as good indicator for the possibility of cyanobacteria bloom development as well as temporal patterns in summer temperatures. We did run the SHYFEM model to reproduce the hydraulic circulation of the Curonian lagoon including the spatial structure of the renewal time for years 2004–2016 to produce statistical evidence of the relationship between the hydrological and climatic characteristics as riverine loads, ambient temperature, renewal time and monitoring data during the same period. The same hydrological and climatic parameters including the water levels and extent of the flood in the Nemunas river delta were used to predict the ChIA levels, catches, CPUE and mortality of the most important commercial fish species using BBN during the same period. Using the climate scenarios RCP4.5 and RCP8.5 data downscaled to the Lithuanian coast the SHYFEM model was run to represent the hydraulic circulation of the lagoon in the years 2030–2050 and derive the parameters that could be used to predict both ChIA levels and populations of commercial fish species. Our analysis revealed a clear trend towards the enhancement of cyanobacteria blooms in the future leading to the cascading effects on the regulatory ecosystem services, while the effect on the provisional services (commercial fish catches) and cultural services linked to the fishery stocks (recreational fishery) was expected to be more complex.

Keywords: coastal lagoon, hydraulic modelling, provisional services, climate scenarios, BBN



14. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

The Natural Capital Model for the Netherlands – integrated modelling of ecosystem services and biodiversity

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The Dutch government has the ambition to make its policies more “nature-inclusive”. Nature-inclusive policy recognizes the wide range of services provided by ecosystems, aiming for their sustainable use while conserving biodiversity. Hence, an important objective of the Dutch government is to more explicitly address the effects of interventions on multiple ecosystem services and biodiversity in the decision-making processes. For decision-making, government and stakeholders are increasingly asking for robustness and consistency in ecosystem service modelling and assessment. To achieve these goals, a collaborative integrated Natural Capital Model (NCM) is being developed that provides spatiotemporal information on ecosystem services. The model incorporates a broad range of ecosystem service sub-models such as wood production, carbon sequestration, air regulation and outdoor recreation. The model uses spatial data on land use, ecosystem processes and socio-economic factors as input. Both supply and demand of ecosystem services are modelled to accurately assess ecosystem service use. The NCM is developed to facilitate multiple types of analysis, to accommodate the relevant policy questions addressed by the different institutes. The model can assess the current situation, and facilitates ex-post and ex-ante scenario analysis. Drivers, pressures and management schemes can be adjusted to assess their consequences. The model couples ecosystem service models with a spatiotemporal model for biodiversity, to enhance the understanding on linkages and to explore the impact for realizing biodiversity goals. We present the model concept, current possibilities, challenges and future developments of NCM and illustrate its functioning using case studies. First, we explore the case of adding 100.000 hectares of forest across the country, as envisioned in a national action plan. Second, we show the added value of four separate strategies within Amsterdam’s new green infrastructure plan. In both cases we highlight the integration between environmental and socio-economic conditions and ecosystem service supply and demand.



Keywords: natural capital model, integrated model, scenario analysis, spatio-temporal assessment, collaboration

15. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

An explorative modeling approach for the dynamic simulation of the provision of multiple ecosystem services

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The dynamic representation of ecosystem services (ES) is a crucial research frontier in the field of ES modelling. Here, we present a new approach for the dynamic modelling of multiple ES, based on the Petri Net modeling framework. The key features of this approach are, on one side, the inclusion of both ecological and social elements involved in the generation of multiple ES; and, on the other hand, the simulation of the dynamics of multiple ES over time, considering the interactions among ES and the effects of changing drivers on their provision. Due to its high complexity, the model should be intended as an exploratory tool, focused on the analysis of the general trends of multiple ES provision, rather than on the generation of quantitative projections. A first conceptual application of the model to the Venice lagoon, Italy, is presented, in which the model is used to simulate the trend of 13 different ES. This application shows the potential of the model in exploring the trends produced by climate change and socio-economic pressures, and the effects of a set of possible management actions. This modeling approach, although being still in its development phase, could contribute to generate new perspectives on the dynamic modeling of multiple ES and on the integrated management of social-ecological systems.

Keywords: Dynamic modeling, multiple ecosystem services, interactions, social-ecological systems



16. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Models as consensus-building tools: Collaborative modelling and the integrated assessment of ecosystem services

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Spatial and temporal models are often used as heuristic and/or predictive tools to guide policy- and decision-making, forecasting the effect of different management strategies and the impact of long-term changes - notably, climate change, upon them. Scenario building using models often provides synthetic information on such effects, which may be fed into the negotiation processes that accompany the implementation of the management strategy of choice. Unfortunately, the complexity of the information fed into such models and its development in a strictly technical realm result in stakeholder distrust - particularly when contentious or wicked problems are addressed and/or multiple types of knowledge are involved. In such cases, collaborative model results that acknowledges conflicts of interests and multiple knowledge sources at face value may represent a more robust alternative for the development of flexible management strategies supported by incremental, mutual learning. In this presentation, we present an example of collaborative modelling aimed at optimizing the management of three ecosystem services interlinked by complex ecosystem dynamics and wicked socio-political conflicts: cattle ranching, wildlife conservation (thus economically-profitable recreation), and water storage/purification. We used a combination of Bayesian Belief Networks and Dynamic Modelling to (i) identify discrepancies and synergies among the perceptions of key stakeholders, experts and decision-makers; (ii) simulate management choices under current and future conditions, based on separated vs. collective perceptions; (iii) identify specific processes that may benefit from detailed, expert-guided modelling; (iv) evaluate the contribution of such detailed models to increasing the predictive power, degree of consensus (collective choice) and technical-political uptake of updated management strategies. We discuss the advantages and limitations of this strategies, and its potential integration into more complex modelling efforts.

Keywords: Collaborative modelling, science-policy interface, stakeholder participation, ecosystem services, adaptive management



17. Type of submission: **Abstract**

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Spatio-temporal quantification of the impact of climate change, sea-level rise and land management on the provision of multiple coastal ecosystem services

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In the collaborative research project COMTESS (Sustainable coastal land management: Trade-offs in ecosystem services), we apply a chain of hydrological, ecological and socio-economic models to predict the impact of changing climate, sea level and land use on groundwater level and salinity, plant species composition and eventually ecosystem service (ES) provision of four study regions from 2010 to 2100. We compare four land management options (LMOs): trend (business as usual, i.e. mainly dairy farming), stakeholder-based (co-developed with local stakeholders), carbon sequestration (reduced pumping raises groundwater levels; reeds sequester carbon) and multiple land use (similar, but reed is harvested). We consider ES as vegetation-mediated or directly depending on hydrology (e.g. reduced flood risk due to retention of excess water in polders). Vegetation-mediated services are modelled via the distribution of individual plant species (statistical species distribution models). Plant traits of the resulting species community on a site are then related to ES (e.g. fodder production is related to species-specific grassland utilization indicators). Our simulations show that despite the projected precipitation decrease until 2100, rising sea levels lead to excess water that needs to be pumped into the sea to keep groundwater levels from rising in LMOs trend and stakeholder-based. While increased pumping can compensate rising groundwater levels, it cannot mitigate salinization due to higher evapotranspiration. The resulting environmental changes affect ES provision differently in alternative LMOs, e.g. forage production decreases drastically in the carbon sequestration option, less so in the trend option— although even here a negative temporal trend is visible. On the other hand, more water is retained in the carbon sequestration than in the trend option. Our spatio-temporally explicit quantification of ES provision allows analyzing trade-offs between individual services as well as comparing alternative management options over time. Eventually, we aim at providing management recommendations to local stakeholders.



Keywords: coastal services; vegetation-mediated services; trade-offs and synergies; modelling chain; spatio-temporally explicit quantification

18. Type of submission: Abstract

T. Thematic Working Group sessions: T5a Models for integrated ecosystem services assessments and future scenarios

Multi-Scenarios Simulation of Land Use for Reducing Wind Erosion in The Typical Agro-pastoral Ecotone

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Horqin Left Back Banner is located in a typical semi-arid sand area with heavy soil degradation and strong wind erosion. This study applied the Revised Wind Erosion Equation (RWEQ) model for simulating wind erosion for the case area of Horqin Left Back Banner. Three future scenarios, considering historical development, whole area administration and regional administration, were developed, based on the CA-Markov model, local wind erosion conditions and related regional planning. The Dyna-CLUE model was further used to simulate land use patterns of Horqin Left Back Banner in 2020 for each developed scenario. Modelled results suggested that: 1. The wind erosion of Horqin Left Back Banner was intense with a clear spatial heterogeneity in the year of 2010, with an average value up to 33.86t/(hm² · a). 2. The Kappa index of the simulated results for the year of 2010 was about 0.921, indicating that the Dyna-CLUE model has a good simulation performance. 3. The results for the historical development scenario suggested a serious trend of desertification and grassland degradation for Horqin Left Back Banner, and in particular the area of desert land was found to be increased by 33.76%. The whole area administration scenario indicated an effective achievement in wind erosion control. 70.30% of the unused land was reclaimed, where 32.32% and 32.52% were converted to woodland and grassland, respectively. The water and wetlands areas were also restored, with an increase in total area by 5.01%. Compared with the whole area administration scenario, the regional administration scenario suggested that the reclaimed area of unutilized land in high wind erosion areas was even larger, and meanwhile the area of arable land in low wind erosion areas was found to be increased by 4.68%.

Keywords: Dyna-CLUE; wind erosion; land use simulation; Horqin Left Back Banner