

## BOOK OF ABSTRACTS

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### I. SESSION DESCRIPTION

#### ID: T4c

Innovation in ES mapping: Sharing experiences from spatial analysis, visualization, communication and user engagement

#### Hosts:

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Hosts:	Msc.	Miguel Villoslada	Estonian University of Life Sciences	mpecina@emu.ee
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#### Abstract:

Many of us use or produce maps. Geographic Information Science has experienced an innovation boom in recent years, unfolding a realm of possibilities for analysis, visualization, sharing and communication. Cloud-based GIS, big spatial data, co-production, and interactive and dynamic visualization tools are becoming more accessible, while knowledge about what makes spatial information “usable” stands at the core of Geo-Information science. This geo-spatial “hype” starts now entering the field of ecosystem services, with all its inherent challenges and uncertainties. This session will address three questions:

How can (or already does) the ecosystem services community benefit from these advances in geoinformation science? We welcome examples on the use of innovative mapping and visualization products, methods and tools for mapping ecosystem services, and on the efficiency of such approaches to communicate the results to varying audiences (e.g., decision-makers, practitioners, researchers, general public, etc.).

How has your mapmaking process changed over the years? The craft of map-making and spatial analysis is a dynamic process, as we continuously incorporate new knowledge and skills. We encourage presenters to share their experiences in the process of map-making for ecosystem services science and communication. You are welcome to share your “dos-and-don’ts” (from software tips, to design flaws) share your skills and lessons learnt.

How can we ensure the appropriate use of maps? Who defines what are the appropriate uses of ES maps? Sometimes technical tools can entail risks, as maps may become end products rather than instruments. We welcome approaches aimed at the development of user engagement mechanisms for the use of ecosystem services spatial information.

### Goals and objectives of the session:

This session is framed as a dynamic knowledge-sharing space, where ideas are exchanged amongst our map-making community. In order to keep a lively atmosphere, we will mix short presentations with demonstrations of software, tools and novel approaches and facilitate discussions. For presenters who might want to use this session as a space for testing their developed approaches, please indicate that in your abstract, so that we organize a “testing” session.

### Planned output / Deliverables:

A potential open access publication (depending on the material available from the session).

### Related to ESP Working Group/National Network:

Thematic working group: TWG 4 – Mapping ES

## II. SESSION PROGRAM

**Date of session:** Thursday, 10 June 2021

**Time of session:** 9:30 – 15:00

### Timetable speakers

Time	First name	Surname	Organization	Title of presentation
9:30 9:45	Améline	Vallet	AgroParisTech	Assessing and mapping ecosystem services with local knowledge and Bayesian networks: Medicinal plants in Peru
9:45 10:00	Marko	Lovric	European Forest Institute	Combining survey input and GIS data to map forest ecosystem services across Europe
10:00 10:15	Alexandra	Tisma	PBL Netherlands Environmental Assessment Agency	Modelling landscape aesthetic quality on global scale: GLOBIO ES-LAQ
10:15 10:30				Discussion
11:00 11:15	Linus	Agbleze	United Nations University and University of Bonn	The science and art of mapping ecosystem services: A look at spatial indicators, tools and geoprocessing techniques for ecosystem services assessment

# 3rd ESP EUROPE CONFERENCE

Tartu, Estonia

2021 7-10 June

Ecosystem Services Science,  
Policy and Practice in the  
face of Global Changes

Time	First name	Surname	Organization	Title of presentation
11:15 11:30	Jan	Staes	University of Antwerp	A LIDAR/DEM based method for Spatial prioritisation of Ecosystem based Adaptation measures
11:30 11:45	Milan	Loreti	Netherlands Environmental Assessment Agency	A comparative analysis of spatial assessment methodologies for urban ecosystem services
11:45 12:00	Matilde Silvia	Schirru	Institute for BioEconomy - National Research Council	Same place, different stakeholder communities: ecosystem perspective caleidoscopes?
12:00 12:15	Maria Marta	Tonda	University of Girona	Linking Cultural Ecosystem Services, common good and landscape perspective as an alternative tool for drylands management
12:15 12:30				Discussion
13:30 13:45	Hristina	Prodanova	National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences	Uncertainty analysis in expert-based ecosystem services mapping
13:45 14:00	Raul	Sampaio De Lima	Estonian University of Life Sciences	The role and potential of UAVs for vegetation measurement and ecosystem services valuation
14:00 14:15	Ashutosh	Pathal	TERI School of Advanced Studies	Total Economic Valuation of Ecosystem Services provided by Soor Sarovar Bird Sanctuary, Agra, India
14:15 14:30	Bumsuk	Seo	Karlsruhe Institute of Technology	Habitat mapping and conservation area planning using camera-trap photos, computer vision, and network analysis: a case study of Yellow-throated marten in DMZ, South Korea
14:30 14:45	Kremana	Gocheva	Bulgarian Academy of Sciences	From big to bigger data: combining long - term remote sensing and climate data reanalysis to augment the condition assessment of High-

Time	First name	Surname	Organization	Title of presentation
				Mountain Ecosystems (HME) in Rila Mountain, Bulgaria
14:45				Discussion
15:00				

Each 15 minutes block includes 10 minutes presentation + 5 minutes questions/discussion

### III. ABSTRACTS

*Abstracts are ordered based on the session program. The first author is the presenting author unless indicated otherwise.*

#### 1. Type of submission: Abstract

T. Thematic Working Group sessions: T4c – Innovation in ES mapping: sharing experiences from spatial analysis, visualization, communication and user engagement

### Assessing and mapping ecosystem services with local knowledge and Bayesian networks: Medicinal plants in Peru

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Ecosystem service assessments and mapping initiatives often overlook some categories of ecosystem services, such as natural products collected for medicinal and aromatic purposes. However, in developing countries, their use is widespread and their contributions to human well-being is large. The high cost and limited availability of formal health care systems explains the use of alternative medicine and medicinal plants. In addition, people may also prefer traditional medicine for cultural, religious or spiritual reasons. Plant collectors are often rural dwellers that are economically marginalized, such as women or landless people. Using semi-structured interviews and participatory workshops, we identified the most used wild medicinal plants in two watersheds of Apurimac region, Peru. We analyzed their distribution and harvesting patterns to produce maps of ecosystem service supply and use. The mapping was based on Bayesian belief



networks fueled with local plant collectors' knowledge. Probabilities for the Bayesian belief network were elicited using serious games based on crop seeds and pictures describing different ecological conditions within the study site. Results showed that the most important medicinal plants are mainly located in the highlands and are partially found in a natural protected area, which reduce overexploitation risks but also restrict livelihood opportunities of plant harvesters. These restrictions can cause problems to harvesters, given that more than 80% of interviewed harvesters had a strong to medium economic dependence to plant harvesting. This study shows that it is possible to integrate different sources of knowledge into ecosystem services spatial modeling tools. This can be particularly useful in areas where ecological data are scarce.

*Keywords:* local knowledge, ES mapping, medicinal plants

*2. Type of submission: Abstract*

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## **Combining survey input and GIS data to map forest ecosystem services across Europe**

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Mapping Forest Ecosystem Services (FES) is a growing field of research. One of its current frontiers is to map their entire range on a large geographical scale with a high spatial resolution. This study possesses all the stated characteristics – on the case of Europe's forests. We collected data on supply, demand, income and profitability of FES from forest owners and managers with a reference to a specific point–location in their forest. We then compiled a 1 x 1 km data set of more than fifty forest descriptors for all the forests in Europe. We then matched the two data sets, and used the forest descriptors (e.g. growing stock, distance to the city, tree species composition) to assess the above stated FES variables. This estimation was then extrapolated to



1.45 million square kilometers of forests. We then focused on areas where the demand and supply are not matched, and identify forest descriptors that have largest positive and negative marginal effects on FES supply and demand. Variables related to FES income and profitability reveal dichotomization of forests in Europe; one group that focuses on provisioning and another one that focuses on regulating and cultural FES. This finding points to a lack of providing a financial basis for a truly multi-functional and sustainable model of forest management on the level of individual micro-locations in Europe.

*Keywords:* forest ecosystem services, mapping, machine learning, Europe

*3. Type of submission: Abstract*

[T. Thematic Working Group sessions: T4c – Innovation in ES mapping: sharing experiences from spatial analysis, visualization, communication and user engagement](#)

## **Modelling landscape aesthetic quality on global scale: GLOBIO ES-LAQ**

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This paper presents the first version of the model for assessing landscape aesthetic quality (LAQ) in the context of the GLOBIO-ES model suite. LAQ provides the backdrop and physical precondition for many nature-related recreation and tourism activities. Standardized approaches for assessing and monitoring landscape aesthetics are missing, and therefore LAQ is often omitted in ecosystem services studies and in global environmental assessments. Lower LAQ can lead to a decrease in ecosystem services for tourism and recreation. Hence assessing LAQ can provide better insights on the economic and social consequences of its change, and help guide environmental policies and/or spatial plans. In literature two different methodological approaches are mentioned for LAQ assessment: objective (user independent) and subjective (user dependent). Both approaches serve different purposes and can be combined for the best results. We derive LAQ from landscape indicators and metrics deduced from literature, referring to a core



set of basic common landscape preferences of people. This 'objective assessment' will be supplemented with subjective approaches that show local users' perception and preferences in a given area. In this contribution we present a model for LAQ consisting of a set of landscape indicators and metrics. Three indicators are selected based on literature review and availability of data on the global level: scenic beauty, visual diversity and tranquility. The results have shown that the vast majority of the terrestrial part of the earth has moderate or above moderate scenic beauty, and next to that high tranquility. Due to the complexity of landscape aesthetics and the global scale of this research LAQ can be calculated as inputs to recreation and tourism, but not as a single global value. The suggestion is to relate contribution of each of the three indicators to recreation and tourism separately, depending on the types of activities envisaged.

*Keywords:* landscape aesthetic, ecosystem services, GLOBIO, modelling, mapping

*4. Type of submission: Abstract*

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## **The science and art of mapping ecosystem services: A look at spatial indicators, tools and geoprocessing techniques for ecosystem services assessment**

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Recent development in remote sensing and Geographic Information System (GIS) have led to their use in mapping and spatial assessment of ecosystem services while remaining an area of high research paucity that needs to be prioritized. The main utility of GIS for such an exercise lies in data provision and techniques of geospatial analysis and this was explored in this paper. Thus, this paper aims to undertake a comprehensive mapping of several ecosystem services in France. This resulted in assessment of more than 30 ecosystem service indicators. Indicators were identified and selected based on their ability to communicate ecosystem service information to policy makers, and spatially assessed to expand the scope of existing ecosystem services



mapped. The potentials of open source data such as Open Street Map (OSM) which is less expensive and easily accessible to the mapping community have been explored particularly for cultural services which are more difficult to assess spatially. Tools used for data analysis and visualization included ArcGIS and QGIS. Several preprocessing techniques and geospatial analysis such as kernel density estimation, aggregation of maps, weighted sum overlay, correlation analysis among others were employed in the analysis. Choosing the right parameter to reflect the prevailing conditions in ecosystem service mapping was demonstrated as an issue of importance. The results illustrated a distribution where high concentration of economic ecosystem services are captured in South Eastern France. Moreover, high concentration of ecological ecosystem services covered a greater area of France as compared to economic ecosystem services. High concentration of social ecosystem services were captured in Northern France which was not the case for economic and ecological services. A synergy is noted between economic and ecological ecosystem services while a trade-off is assessed between social ecosystem services and both economic and ecological ecosystem services.

*Keywords:* ecosystem services, ecosystem service mapping, ecosystem service indicators, spatial assessment, multicriteria analysis

*5. Type of submission: Abstract*

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## **A LIDAR/DEM based method for Spatial prioritisation of Ecosystem based Adaptation measures**

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Although the principles of Ecosystem Based Adaptation (EbA) may be clear on a conceptual level, it remains a struggle to implement these principles in a practical context. To limit the complexity, we focus on the restoration of infiltration and retention (ecosystem functions) as a means to increase resilience to local climate change. Randomly implementing restoration measures is





generally not the most efficient. Especially in intensively used areas where available space is limited it is important to take efficient measures. The application of principles and associated measures requires a thorough understanding of the hydrological (dis)functioning of catchments. Indicators can be useful for the spatial and thematic prioritization and optimization of restoration measures at landscape-level. A spatial prioritisation method for EbA-measures was developed to provide guidance on where to implement particular infiltration/retentions measures to have the greatest benefit in terms of reducing drought risk per unit surface area. With evolutions in LiDAR technology, digital elevation maps have become one of the most widespread data that is available on large spatial scales and at fine resolution. This opens opportunities for the development of topography-derived indices as a basis for SPM's at the catchment level. The development of several open-source tools for topographic analysis has led to a wide user-audience, including users with and without geomorphometric expertise. The method allows to map hydrological pathways from field scale to catchment scale. A smart representation resulted in very insightful maps that can be used by non-experts. Based on the results of the validation in three countries, we conclude that the presented method is highly transferable and has a high accuracy in predicting hydrological flows on different spatial scales in surface water dominated catchments (south-east UK) and in sandy catchments with permeable soils (e.g. validation sites in the Netherlands and Belgium).

*Keywords:* adaptation, climate change, topographic position index, digital elevation model, ecosystem-based adaptation

*6. Type of submission: Abstract*

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## **A comparative analysis of spatial assessment methodologies for urban ecosystem services**

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It is increasingly recognized that green and blue infrastructure (GBI) may contribute towards mitigating environmental and social issues in urban areas, judged from an ever-growing amount of scientific publications as well as actual policy implementations. Spatially explicit assessments incorporating a multitude of urban ecosystem service (ES) models portray one popular way to open up assessment possibilities of urban GBI for a multitude of stakeholders. Despite their growing popularity, comparative analyses of results remain limited, leading to comparability issues among studies and cities and creating uncertainty in the assessment of the effectiveness of urban nature in tackling specific sustainability challenges. In this study we will identify uncertainties in model outcomes and research gaps in urban ES assessments by applying a model inter-comparison approach, assessing the supply of a set of ES for the city of The Hague (NL). We apply a scenario-based modelling approach to quantify multiple urban ES (e.g. Urban Heat Island effect mitigation, urban flood risk mitigation). By employing different modelling frameworks (e.g. InVEST (US) & Natural Capital tool (NL)) and scenarios, model uncertainty is quantified based on the changes in ES between different scenarios, while simultaneously highlighting distinct model particularities. Subsequently, quantitative results from analogue models are being compared to each other in relation to their respective modelling methodologies as well relevant model characteristics for assessing benefits of urban GBI. In this presentation, we will show the interim results of two urban ES arising from two different ES models for the city of The Hague. Differences in outcomes and methodologies will be elaborated on, as well as possible implications that varying results for seemingly analogous models can have.

*Keywords:* comparative analysis, spatial assessment, green and blue infrastructure, ecosystem services, cities

*7. Type of submission: Abstract*

*T. Thematic Working Group sessions: T4c – Innovation in ES mapping: sharing experiences from spatial analysis, visualization, communication and user engagement*

## **Same place, different stakeholder communities: ecosystem perspective caeleidoscopes?**

*First author:* Matilde Silvia Schirru

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As innovative approaches emerge, the concept of Cultural Ecosystem Services (CES) is periodically revised and enhanced, presenting new value nuances. Due to their intrinsic site-specific character, CES usually call for subjective, rather than objective, perspectives. Therefore, how to assess CES through alternative, non-economic approaches, is fundamental. This issue becomes even more urgent when attempting to assess and map CES within natural protected areas, and even more so when such areas are non-inhabited, as the absence of any local communities poses additional challenges. Within this study, initiated within the framework of activities of GIREPAM (Integrated Management and Ecological Network of Marine Protected Areas) Interreg project and next developed within the NEPTUNE (Natural and cultural heritage and sustainable management of underwater recreational activities) Interreg project, the way different stakeholders (institutional managers, groups of experts, local communities and tourists) perceive CES supplied by the Asinara National Park and by the Porto Conte Regional Park in Northern Sardinia (Italy) was investigated. Interviews and questionnaires were carried on during the years 2018–2019, particularly during summer when most touristic visits occur. Also, more than 700 observations related to CES were mapped and recorded through a Participatory GIS, which allowed us to investigate whether the perception of CES supplied by a given natural protected area varies depending on the local community. Differences were recorded among heterogeneous groups of stakeholders within the same protected area and different priorities between similar CES categories emerged in the two study areas. Data showed that perceived values of a natural protected area greatly differ, depending on which is the local community engaged in recognizing the cultural values, and that this difference is statistically significant.

*Keywords:* cultural ecosystem services, Mediterranean island, protected area management, marine protected areas, Sardinia

*8. Type of submission: Abstract*

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## Linking Cultural Ecosystem Services, common good and landscape perspective as an alternative tool for drylands management

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Dryland landscapes are directly related with use and management of their natural resources and resilience capacity, both aspects generally limited, especially in a context of global environmental change. Many of these resources are considered within the common goods category, making this an added challenge to their management. In this context, the periphery of Latin American metropolitan areas represents an even greater challenge because of its inadequate growth, low efficiency in resource use and environmental functions that causes landscape degradation and loss of Ecosystem Services (ES). The link between the Cultural Ecosystem Services (CES) and the landscape as a common good opens an opportunity space for an alternative perspective of inclusive and sustainable land management. On this basis, we identify which aspects of the landscape are understood as common good and are linked to the CES, how they are perceived and recognized by people and also how they can be included as a tool for decision-making applied to land management. The Metropolitan Area of Mendoza, Argentina, inserted in a highly fragile dryland ecosystem, is presented as a representative case study of the problems exposed. The objective of this research was to analyze the CES perceived by a part of the population belonging to the study area, based on principles of citizen science and participatory mapping (PPGIS) from a landscape perspective, using the Survey 123 (ESRI ArcGIS) tool. Preliminary results show that the spatialization of the intangible values of the landscape linked to the CES most valued by the participants is feasible. As a result, different cartographic products are obtained and this is useful for inclusive and participatory decision-making. This paper proposes differential alternatives for territorial planning, based on the people's perception and the link between the CES from the perspective of the landscape as a common good.

*Keywords:* dryland landscape, cultural ecosystem services, citizen science, land management, common good



*9. Type of submission: Abstract*

T. Thematic Working Group sessions: T4c – Innovation in ES mapping: sharing experiences from spatial analysis, visualization, communication and user engagement

## **Uncertainty analysis in expert-based ecosystem services mapping**

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More than a decade the ecosystem services scientific community is familiar with matrix approach – a look-up table linking assessment of ecosystem services with spatial units. Expert-based assessment of ecosystem services via the matrix approach is the most used even if this has limitations such as those related to the subjectivity of experts. In order to receive valuable results, methodologies have been published with key steps like the selection of the right group of respondents (experts or stakeholders), and the development a guideline with informative characteristics of the spatial units and clear rules on how to assess the ecosystem services. This study presents results of ES expert-based assessment and analysis of the uncertainties in scoring the capacity of the landscapes to provide ecosystem services. 24 persons grouped in “experts” and “stakeholders” have filled a matrix of five ES: carbon sequestration, erosion regulation, habitat quality, crop production and recreation for the area of North-Central Bulgaria. We define as an expert someone knowing the area and the ES concepts, and as a stakeholder someone who lives in the area. Both groups were asked to give a confidence score in order to see how comfortable they feel about their own scores. With the evaluation scores (0–5) and the confidence one (1–3), we found out that there is very high percentage of agreement within the “experts” group compared to the non-experts (stakeholders) group. We can deduce that people who already know landscapes and ecosystem services concepts are more likely to give scores, which are more objective. In other hand, the stakeholders are people who live and know the area of interest very good, but don’t have specific knowledge about the capacity of landscapes to provide ecosystem services. Well-defined profiles of experts needed for the matrix approach is essential to have valuable ES assessment and mapping.



*Keywords:* uncertainty analysis, confidence index

*10. Type of submission: Abstract*

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## **The role and potential of UAVs for vegetation measurement and ecosystem services valuation**

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Soil moisture is an important feature that controls water–energy fluxes in natural environments and might affect several ecosystem services. Among the measurement techniques, optical remote sensing data based on soil's spectral behavior and microtopography have been widely applied to predict it at larger spatial and temporal scales. However, this technique still presents some limitations regarding the interference of environmental sources of noise. In this way, the present study aimed to assess the ability to estimate surface soil moisture using Random Forest Regression based on different optical data sets. The study area focuses on two sites within Lavassaare Nature Reserve (Pärnu County, West Estonia), where one of them was affected by a fire and disturbing approximately 87 ha of vegetation. Field measurements were conducted on 16.07, 25.09, and 02.10.2020. In each measurement, 30 samples of soil moisture at 0–10 cm profile were measured per site. UAS–data were collected using a fixed–wing eBee X equipped with a Sensor Optimized for Drone Applications (S.O.D.A.), and a Parrot Sequoia on the same dates. Based on this data, we calculated vegetation indices using reflectance maps, and point cloud–height distribution metrics using photogrammetric processing. Subsequently, we fitted the models using a Random Forest (RF) algorithm for each site and measurement date. The best model (for the first measurement in the disturbed site) explained 92.4% of the variability in the validation dataset. For this model, the heights at the 80th and 90th percentiles of height distribution and the Simple Ratio index showed greater importance than other variables. In



contrast, the worst models explained 66.6% of data variability. Also, microtopographic metrics were the most important for prediction using this model. These results indicate that vegetation status can be used as a proxy of soil moisture in more homogeneous conditions, while microtopography is more important with heterogeneous vegetation cover.

*Keywords:* drone, multispectral, structure from motion

*11. Type of submission: Abstract*

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## **Total Economic Valuation of Ecosystem Services provided by Soor Sarovar Bird Sanctuary, Agra, India**

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Peri-urban forests are among the most vulnerable ecosystems. Still, their sustainable management can be an efficient way of mitigating and adapting to climate change and increasing urban socio-ecological systems' resilience. Ecosystem services—the benefits humans derive from ecological systems offer a useful framework for incorporating nature's services into decision making. Mainstreaming ecosystem services (ESs) to national accounting and development paradigms require initiation of ESs in the national policy documents as a sustainable development goal (SDG) enabler. However, research and resource capacity on this still-evolving theme is limited. The present study is an effort to estimate terrestrial and aquatic carbon stocks, carbon sequestration and the economic value of ecosystem services in Soor Sarovar Bird Sanctuary (SSBS) located in a semi-arid area of Uttar Pradesh (UP), a tiny human-made forest ecosystem adjoining densely populated city of Agra on the highway leading to the Indian capital city of Delhi. The study tailors established transdisciplinary, integrative project management methods to primary and secondary studies and devised aquatic carbon estimation techniques through first principles and analogies. A value-driven and iterative agile project management approach was adopted to



resolve innovation complexities. Apart from a carbon stock of 1.31 million tons with an estimated value of ₹ 21 million, the total annual economic value flow of ₹ 827 million for 799 ha area has been derived from carbon sequestration, recreation, water provisioning, wastewater treatment and employment generated. Benefits from SSBS @ ₹ 10,14,442 / ha per annum compares in order of magnitude higher than the ₹ 11,186 /ha per annum estimated for Agra district's cropland ecosystem services. In conclusion, the case study utilises transdisciplinary knowledge and innovative technologies to demonstrate ESs adoption's practicality as a method of sustainable development into routine practice.

*Keywords:* peri-urban forests, innovative techniques, integrative project management, ecosystem services measurement

*12. Type of submission: Abstract*

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## **Habitat mapping and conservation area planning using camera-trap photos, computer vision, and network analysis: a case study of Yellow-throated marten in DMZ, South Korea**

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One major issue in wildlife conservation is to spatially model wildlife habitats, which often suffers from data insufficiency. Toward improved mapping of wildlife and data-driven habitat conservation, a computer vision model for mapping of wildlife habitat is presented in this talk. The recent development in Artificial Intelligence and Machine Learning, especially in image recognition techniques, showed potential for extracting information from casual photos. In our case study, we explored the potential of this innovative novel computer vision techniques in identifying animal species from camera-trap photos, by which we map habitat distributions. We collected camera-trap data using HC 600 (Reconyx) for eight years (2010–2017) in the 12 wildlife hotspots in the demilitarized zone, located at the border between South and North Korea.





Focused on Yellow-throated marten (*Martes Flavigula*), we identified animal species using a Convolutional Neural Network model based on Google's Inception v4. The model is implemented using Tensorflow and Keras libraries in Python. The resulting occurrence data was used to estimate the movement pattern of the target species. In parallel to that, the landscape is translated as a green network, and the patches' network properties were calculated. Using the green network, observed forest canopy map, and digital topography data, we estimated the habitat quality of the patches. The potential distribution of the target species was estimated by combining the camera-trap-based occurrence model and the potential habitat quality. The derived maps are provided through an interactive R shiny web application, which improves the usability of the map. We confirmed that considerable improvement in habitat mapping by utilizing the computer vision model on top of the traditional habitat modelling. By combining such novel techniques, the proposed approach may help map Ecosystem Services in protected areas and help design conservation plans.

*Keywords:* habitat mapping, camera-trap, computer vision, Yellow-throated marten, network analysis

*13. Type of submission: Abstract*

[T. Thematic Working Group sessions: T4c – Innovation in ES mapping: sharing experiences from spatial analysis, visualization, communication and user engagement](#)

## **From big to bigger data: combining long – term remote sensing and climate data reanalysis to augment the condition assessment of High– Mountain Ecosystems (HME) in Rila Mountain, Bulgaria**

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Big data from satellite remote sensing is a source of incredible possibilities for earth observation but also of a number of new challenges and uncertainties. We present the use of combined:



satellite derived vegetation indices (VI), climate reanalysis data and field data from the forest management database and other sources to determine the changes in condition and ecosystem functioning (i.e. primary production capacity) in HME throughout a period of 42 years (1977 – 2019). To our knowledge, this is the longest time series of satellite observations for Bulgarian HME to date. The study identifies a number of uncertainties: technical constraints of the sensors used in the earlier years, uniform and precise climate modelling is not available for the first years of our study period, dearth of suitable satellite images due to the shorter vegetation season and the frequent occurrence of clouds, data imbalance in remote sensing data – the last years have more and better quality, field data and research bias towards studying forest ecosystems. To partially alleviate these uncertainties and disbalances, we apply joint analysis of the data from different sources and were able to formulate hypotheses for further research. We found that combining vegetation indices, and in particular the use of Normalized Differential Greenness Index (NDGI) allow cross-checking of data both to reduce uncertainties, and to improve the understanding of the complex and dynamic development in HMEs. The systematic application of the Whole System approach to the HME is also beneficial for the uniform data processing across different ecosystem types and a landscape level understanding of ecosystem processes.

*Keywords:* remote sensing vegetation indices, whole system approach, climate data reanalysis, landscape level assessment, ecosystem condition and functioning