BOOK OF ABSTRACTS

I. SESSION DESCRIPTION

ID: T4a

Integrating ecological and legal approaches to mapping and assessment of ecosystem services vulnerability, resilience, and restoration

Hosts:

	Name	Organisation	E-mail
Host:	Francesca Leucci Philip Roche	Wageningen University & Research INRAE	francesca.leucci@wur.nl philip.roche@inrae.fr
Co-host(s):	Alexandra Aragão Sylvie Campagne	University of Coimbra Biological Research Station Roscoff	aaragao@fd.uc.pt scampagne@sb-roscoff.fr

Abstract:

'Environmental damage' may be either the direct and imminent result of polluting activities or the long-term effect of multiple and diffuse anthropogenic sources cumulating and commingling. Whatever the cause is, environmental damages are disturbances of ecosystems that could lead to a strong loss of ecosystem services. This raises the question of how to bring the environment back to the state of nature before the disturbance while taking into consideration the notion of ecosystem vulnerability as assessment of exposition and sensitivity of ecosystem services as well as ecosystem resilience dynamics.

According to the EU Commission (SWD EU guidance on integrating ecosystems and their services into decision-making, 2019), the ecosystem service framework can be a useful instrument and could be used in two moments: first, to map and assess the extent and severity of the environmental damage at the local, national or global level; secondly, to envision the type of restoration activity needed to bring the environment back to the previous state and to improve its conservation status. In the first moment, the question is: which ecosystem services have been lost as imminent or long-term result of a degradation/deterioration/disturbing event? In the

second moment, the question is: which ecosystem services, where and how should they be restored?

Goals and objectives of the session:

This session aims to create a synergistic dialogue between ecological science and legal science to deepen our understanding and enhance methodologies in assessing and managing ecosystem service vulnerability and resilience. Scholars and practitioners either from the scientific or from the legal field are invited to explore and present a broad spectrum of studies and tools that aim to evaluate the vulnerability and resilience of ecosystem services in the face of environmental disturbances, with a strong emphasis on the implications for legal standards and restoration practices.

From an ecological viewpoint, this session aims to discuss methodologies ranging from quantitative models and spatial analysis to innovative approaches like dynamic modeling, GIS-based tools, remote sensing applications, systems dynamics, and machine learning. These methods provide critical insights into the ecological pressures such as climate change, habitat degradation, and overexploitation, and how they can be systematically assessed and managed.

From a legal perspective, the session will focus on how environmental liability, as outlined in directives such as the EU Directive on Environmental Liability, interacts with ecosystem service frameworks. This includes understanding how laws enforce the assessment and restoration of environmental damage and how these practices are implemented on the ground following significant ecological events, such as oil spills or large-scale deforestation.

Key discussions will also revolve around the real-world applications and case studies, highlighting how various regions and biomes across the globe are applying these frameworks to assess damage and plan effective restoration strategies. Additionally, the session will tackle the intrinsic challenges such as dynamic environmental baselines, complex data requirements, the need for sophisticated ecosystem models, and the trade-offs among various restoration options.

Session format:

Here some examples of topics that could be covered:

1. Theoretical and Methodological Frameworks: Expanding on conceptual frameworks for assessing ecosystem service vulnerability, including discussions on exposure, sensitivity, adaptive capacity, resilience, and resistance metrics.
2. Technological Advances in Assessment: Showcasing the role of technological innovations in enhancing ecosystem service evaluations.

3. Legal and Social Dimensions: Exploring how legal requirements influence the assessment and restoration of ecosystem services, emphasizing the integration of ecosystem services into environmental legislation.
4. Case Studies and Practical Applications: Presenting detailed case studies from different global contexts that demonstrate the application of these assessments in real-world scenarios.
5. Challenges and Solutions in Ecosystem Assessments: Addressing the technical and legislative challenges in ecosystem service assessments, focusing on solutions that facilitate better decision-making for long-term environmental and societal benefits.

Building on common challenges, synergies and overlaps between the scientific and the legal domain, the final aim of this session is to come up with some guidelines for public authorities, regulators, judges and experts to systematically incorporate ES considerations in the assessment of environmental damages and the practice of ecological restoration in order to take into account the ecosystem services vulnerability.

II. SESSION PROGRAM

Room: Expert Street 8

Date of session: 21st of November 2024
Time of session: 11:00-12:30 & 13:30-15:30

Timetable speakers

Part1

Time	First name	Surname	Organization	Title of presentation
11:00 - 11:03	Introduction to the morning session "Measuring, mapping and assessing ES for resilience"			
11:03 - 11:15	Philip	Roche	French National Institute for Agriculture, Food, and Environment (INRAE)	Post-Fire Recovery and Resilience of Ecosystem Services in Mediterranean-Type Ecosystems
11:16 - 11:28	Pavel	Cudlín	Czech Academy of Sciences	Vulnerability and resilience of selected ecosystem services in Central European Uplands
11:29 - 11:41	Lori	Giagnacovo	VITO Remote Sensing, Belgium	Detecting early-warning signals of resilience loss in ecosystems to

Time	First name	Surname	Organization	Title of presentation
				avoid regime shifts and loss of ecosystem services
11:42 – 11:54	Elena	Todorova	Bulgarian Academy of Sciences	Using Driver-Pressures-State-Impacts-Responses framework to form forest management solutions that foster resilience
11:55 – 12:07	Anna Lilian	Gardossi	Udine University, Italy	Remote Sensing-Based Mapping of Hedgerows: Enhancing Ecosystem Services
12:08 – 12:20	Zahra	Asadolahi	Lorestan University, Iran	Monetary valuation of ecosystem services: As a way to protect Iran's middle Zagros protected areas
12:21 – 12:30	Wrap-up of the morning session by the hosts			

Part 2

Time	First name	Surname	Organization	Title of presentation
13:30 – 13:32	Introduction to the afternoon session "Measuring, mapping and assessing ES for restoration"			
13:33 – 13:45	Hendrik	Schoukens	Ghent University, Belgium	The Environmental Damage Directive and wetlands: What lessons can be learned from the CJEU's 2020 German Drainage decision?
13:46 – 13:58	Giedrius	Dabasinskas	Vytautas Magnus University	Impact of peatland restoration on the value of ecosystem services provided by wetland ecosystems in Lithuania
13:59 – 14:11	Ifigenia	Kagalou	Democritus University of Thrace, Greece	Regulating Ecosystem Services (RES) impacted by hydro-morphological alterations in Mediterranean Lakes: a national assessment
14:12 – 14:24	Ioannis P.	Kokkoris	University of Patras, Greece	Geodiversity: steps towards the MAES implementation in Greece

Time	First name	Surname	Organization	Title of presentation
14:25 – 14:37	Vahid	Amini Parsa	University of Lodz, Poland	Which landscape metrics support soil retention ecosystem service? Identifying the thresholds of patch shape for sustainable soil retention in forests
14:38 – 14:50	Francesca	Leucci	Wageningen University, Netherlands	The ES approach to damage valuation: costs, benefits and improved deterrence
14:51 – 15:03	Alexandra	Aragão	Coimbra University, Portugal	Cultural ecosystem services and human rights laws: improving the Rosetta Stone effect
15:04 – 15:16	Ehsan	Pashanejad	University of British Columbia, Canada	Balancing Ecosystem Services and Agriculture in the Canadian Prairies: A Spatial Decision-Making Approach for Sustainable Policy Implementation
15:17 – 15:30	Wrap-up of the whole session by the hosts			

III.ABSTRACTS

The first author is the presenting author unless indicated otherwise.

1. Which landscape metrics support soil retention ecosystem service? Identifying the thresholds of patch shape for sustainable soil retention in forests

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Forests play a crucial role in mitigating soil erosion by providing Soil Retention Ecosystem Services (SRES), which are increasingly threatened by modifications to forest landscape structure. Understanding the relationship between forest landscape structural shape and SRES is essential for managing forest landscapes effectively to sustain SRES. This research provides novel insights into how thresholds in forest patch shapes affect SRES across diverse forest types.

Our aim is to analyze the intricate relationship between forest landscape structure and SRES, emphasizing the critical role of identified thresholds for sustainable SRES provision. We analyzed the relationship between forest landscape shape and SRES across 401 catchments in Poland, focusing on three forest types: broad-leaved, coniferous, and mixed forests. In particular, we assessed forest landscape shape using diverse landscape metrics (e.g., shape index, fractal dimension, contiguity, perimeter-area ratio) computed via FRAGSTATS. Soil erosion rates were estimated using slope, rainfall, organic carbon, water content, and clay ratio. Generalized Additive Models (GAMs) were employed to quantify the influence of these metrics on SRES, identifying significant thresholds ($p<0.05$) impacting SRES provision.

The results indicated that SRES provision by different forest types could be predicted using landscape shape metrics: coniferous forests ($80.5 \leq r2 \leq 81.1$), broad-leaved forests ($79.1 \leq r2 \leq 80.1$), and mixed forests ($80.9 \leq r2 \leq 81.4$). Specifically, in broad-leaved forests, three thresholds in the shape index distinctly influenced soil erosion rates. Coniferous forests exhibited nonlinear relationships with soil erosion rates, influenced by thresholds in the perimeter-area ratio, related circumscribing circles, and contiguity indexes. Mixed forests demonstrated varying impacts on soil erosion rates, with two thresholds in related circumscribing circles and one in fractal dimension. These insights could be essential for forest managers to enhance sustainable forest management practices and ensure the continued supply of SRES.

Keywords: Threshold, Critical Point, Patch, Shape, Landscape, Ecosystem Service, Soil Retention ecosystem service

2. Impact of peatland restoration on the value of ecosystem services provided by wetland ecosystems in Lithuania

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The loss of most of the world's wetlands has highlighted the importance of the services they provide. The purpose of the study is to assess spatial and temporal changes in the economic values of ecosystem services (ES) provided by Lithuanian peatlands and to assess the benefits of restoring drained bogs in comparison to costs. Lithuania has lost about 75% of its peatlands, most of which are drained fens (74%), and most of which remain intact were raised bogs (65%). Forestry and agriculture were the main drivers of peatland loss. The main ecosystem services provided by undrained wetlands, compared to drained ones, were mainly related to climate and water flow regulation, waste management, biodiversity and recreation. Currently, the value of intact peat ecosystem services is $1.336 million per year. The double-drained peatland area has even lower ESV than the undrained area. If these drained peatlands were restored by 2050, they would account for $4006 million per year. A cost-benefit analysis has shown that the benefits outweigh the costs, making restoration efforts economically justifiable. More effective management measures could achieve a balance between the use of these ecosystems and the benefits they provide to human well-being.

Keywords: ESV; land use; peatland; benefit/cost ratio; restoration

3. Regulating Ecosystem Services (RES) impacted by hydro-morphological alterations in Mediterranean Lakes: a national assessment

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Under the term "water related ecosystem services" there is a plethora of valuable services provided by aquatic ecosystems that are strongly linked with their health/status. The deviation from natural hydro-morphological (HyMo) condition reflects the gap from ecosystem proper functioning, a fundamental pillar providing numerous ecosystem services and societal benefits. As acknowledged by the Directive 2000/60/EC (WFD), HyMo pressures influence Biological Quality Elements (BQEs) through processes that affect habitat quality and structure, with riparian vegetation typically playing a significant role.

Using an ecosystem service approach can further advance our understanding of the impacts of HyMo changes on aquatic ecosystems and how future changes might change the availability of aquatic ecosystem services. The Regulating Ecosystem Services (RES) mainly emerge from the ecosystem functioning which, in turn, is supported by "a healthy" condition. The WFD ecological status expresses the quality of the structure and functioning of the aquatic ecosystems directly contributing to the RES.

Our aim is: a) to explore the RES affected by HyMo changes in a conceptual model, across the natural Greek lakes and b) to support the implementation of the WFD and the associated River Basin Management Plans (RBMP) by opening the dialogue on the use of the ecosystem service approach in Integrated Water Resource Management (IWRM).

Having correlated HyMo parameters with major BQEs from 18 Natural lakes, reflecting specific human pressures and lakes' functions, we attempt to link them with ecological functioning, affected ES and RES indicators from CICES (5.1). Findings suggest that natural lakes' RES are interlinked and simultaneously affect, and are being affected by the HyMo alterations, recommending an integrated approach for their conservation. Yet, the complexity of the Mediterranean ecosystems, under the light of climate crisis, need adaptive water policy instruments based on the ES approach.

Keywords: Water policy, hydro-morphology, Ecosystem Services Approach

4. Enhancing our understanding of resilience and vulnerability to address global change in forests

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Resilience and vulnerability are not new concepts to address the recent disturbances that caused unprecedented high levels of forest damage, threatening the provision of ecosystem services. Both are important concepts to understand, anticipate, and manage global change impacts on forest ecosystems. However, they are often used confusingly and inconsistently, hampering a synthetic understanding of global change, and impeding communication with managers and policy-makers.

Here, we synthesize the similarities and differences of resilience and vulnerability in forest social-ecological systems, aiming to better define their scope in improving our understanding of forest responses to global change. In particular, we address the following questions: (i) What are the commonalities and differences between resilience and vulnerability, their respective contexts, and uses?; (ii) What are the particular strengths of each concept for addressing forest change?; and (iii) What can we learn from past studies on resilience and vulnerability for the next generation of global change assessments in forest social-ecological systems? Resilience and vulnerability are powerful concepts with complementary strengths, having different histories, methodological approaches, components, and spatiotemporal focus. Resilience assessments address the temporal response to disturbance and the mechanisms driving it. Vulnerability assessments focus on spatial patterns of exposure and susceptibility, and explicitly address adaptive capacity and stakeholder preferences. We suggest applying the distinct concepts of resilience and vulnerability where they provide particular leverage, and deduce some lessons learned to facilitate the next generation of global change assessments.

Keywords: resilience, vulnerability, forests

5. The ES approach to damage valuation: costs, benefits and improved deterrence

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The potential of liability laws of preventing environmental accidents is often underestimated due to various issues that might hinder both their efficiency and their effectiveness. Among them, the uncertain level of monetary damages to be paid in litigation is likely not to induce polluters to invest adequate money on prevention. The aim of this presentation is therefore threefold. First, it wishes to shed a light on the current legal system of environmental liability at the EU level (at regional and national level), based on the American model. Secondly, it highlights advantages and pitfalls of specific methods to calculate ecological damages in the courtroom (contingent valuation, HEA, travel cost method, etc.). While judges have been employing for decades stated-preferences and revealed-preferences methods, they seem more at ease with the restoration-cost method. Yet, this approach cannot pass the efficiency test due to many reasons (e.g., uncertainties regarding baseline conditions or the real remediation of impaired sites). From an economic standpoint, inaccuracy in the assessment of damages can provide polluters with efficient incentives to avoid accidents only in case of small accidents. But large accidents would need to be assessed through more accurate methods in order to make sure that future potential polluters will receive adequate incentives to avoid their occurrence. Apparently, the ecosystem services approach would provide a possible way forward to make liability laws more efficient and effective. Courts have discussed its application is some recent cases (e.g., the Deepwater Horizon or the Costa Rica case) and many issues of validity have been raised. After identifying the specific bottlenecks in the judicial decision-making, the last aim of the author is to investigate how the ES approach (e.g., what types of classifications) could enhance the likelihood of judges of introducing it in litigation, hence raising the deterrent effect of environmental liability laws.

Keywords: liability, accidents, courts, environmental damage assessment, ecosystem services approach

6. Post-Fire Recovery and Resilience of Ecosystem Services in Mediterranean-Type Ecosystems

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Forest fires are a significant disturbance in Mediterranean ecosystems, profoundly affecting the capacity of these landscapes to provide essential ecosystem services (ES). This study examines the post-fire recovery dynamics and resilience of ES, focusing on the differences between seeder and resprouter-dominated systems. Utilizing an integrated approach that combines ecosystem service capacity matrices with transition models, we explore the temporal recovery patterns of ES under varying fire intensities in southern France's Mediterranean-type ecosystems.

Our findings reveal distinct recovery trajectories between seeder and resprouter systems. Seeder-dominated environments exhibit a gradual recovery, with critical services such as carbon sequestration and soil quality taking up to 87 years to return to 90% of their pre-fire capacity after high-intensity fires. In contrast, resprouter-dominated systems show a faster recovery, with similar services rebounding within 23 years under the same conditions. Notably, pollination and wild plant services demonstrate high resilience, recovering within 2 years regardless of fire severity, while provisioning services such as game provision exhibit lower resilience, taking up to 67 years to recover.

Cultural services, which embody the symbolic and emblematic values of the landscape, show varied resilience, recovering over 3 to 51 years. This study underscores the importance of understanding vegetation types and succession patterns in predicting ES recovery post-fire, offering insights into ecosystem recovery and resilience in fire-prone Mediterranean landscapes. By employing a transition matrix approach to simulate two distinct post-fire vegetation dynamics, we assessed how different recovery rates affect the provision of crucial services. The integration of slow and rapid recovery models, combined with varying fire intensity scenarios, provides a comprehensive understanding of potential ecosystem recovery trajectories.

Keywords: vulnerability, forest, transition, dynamics

7. The Environmental Damage Directive and wetlands: What lessons can be learned from the CJEU's 2020 German Drainage decision?

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When adopted in 2004, the Environmental Damage Directive (ELD) was hailed as a very innovative piece of environmental legislation, with the potential of prompting more comprehensive ecological restoration efforts in the context of environmental accidents and massive degradation. These high hopes seems justified by the impressive set of compensation criteria included in its anexes, which appear to focus on the effective restoration of 'pure' ecological damage. However, after two decades of application, the ELD's track-record appears mixed, to say the least. Very few cases exist where the ELD was instrumental in achieving a proper and effective restoration in cases of ecological degradation. A potent illustration of its shortcomings appears to be offered a 2020 ruling on the legality of the existing water level management and draining on the Eiderstedt Peninsula in Germany. Whereas the area was in 2006 designated as a protected area under the EU Birds Directive, the protection of the Black Tern requires relatively wet conditions, to be found in marshlands and extensively used pastures. A German NGO therefore challenged the continued drainage activities in light of the ELD, requesting the competent authorities to adopt measures to remedy the damage. However, as the requests were rejected by several local courts, the court case ended up in Luxembourg, where the Court of Justice of the EU was questioned on whether the existing drainage activities are set to constitute 'normal' management and could therefore be exempted from the scope of application of the ELD. In my paper, the CJEU's decision of 9 July 2020 is critically assessed, in light of the premises of the ELD and, more generally, the EU's Green Deal and recently adopted EU Nature Restoration Law.

Keywords: wetlands, drainage, restoration, Environmental Damage Directive, EU Nature Restoration Law

8. Cultural ecosystem services and human rights laws: improving the Rosetta Stone effect

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Ecosystem Services (ES) have been presented as "A Rosetta Stone for nature's benefits to people" (1). However, decision makers are not using the Stone as much as it should. The European Court of Human Rights' case Kyrtatos v. Greece, illustrates the judicial inability to consider immaterial benefits.

To overcome this, a direct correspondence between the classes of Cultural ES (CES) in the Common International Classification of ES (https://cices.eu/) and human rights catalogues is feasible. Using the CES as an interpretation key it is possible to establish a correspondence between CICES and the Charter of Fundamental Rights of the EU (CFREU).

• CICES scientific and educational services, can be protected via freedom of expression and information (art.11); freedom of arts and sciences (art.13); and right to education (art.14);

• CICES experimental and physical services, can be conserved through the prohibition of degrading treatment (art.4); the right to wellbeing of the child (art.24 n.1); the protection of the environment (art.37); the right to daily and weekly rest (art.31 n.2), the freedom of peaceful assembly (art.12), and the right to liberty and security (art.6);

• CICES heritage and existence services, can be secured through the respect for physical and mental integrity (art.3 n.1), prohibition of degrading treatment (art.4), respect of cultural diversity (art.22) and right to reconcile family and professional life (art.33);

• CICES sacred and symbolic services, can be defended while safeguarding cultural and religious diversity (art.22), the right to daily and weekly rest (art.31 n.2), and the right to reconcile family and professional life (art.33).

The reinterpretation of fundamental rights in the light of CES can be a sharp instrument for effective justice.

Reference:

Díaz, Sandra et all (2015) A Rosetta Stone for Nature's Benefits to People, PLoS Biology 13(1) https://doi.org/10.1371/journal.pbio.1002040

Keywords: Cultural Ecosystem Services, immaterial benefits, human rights, Charter of Fundamental rights of EU.

9. Vulnerability and resilience of selected ecosystem services in Central European Uplands

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The assessment of the vulnerability and resilience of selected ecosystem services (ESs) in the landscape increasingly requires information about the landscape vulnerability to land degradation, rate of ecosystem service provision and their resilience to climate change and land use change under contemporary preservation by nature protection laws.

We present a method for assessing the provision of ecosystem services (most important under climate change conditions) at the habitat level on a scale of 1:10,000 in the cadastral area of Černovice town, situated in the Czech-Moravian Upland. ESs are quantified by the indicator rate of key ecosystem functions, associated with habitat types using look-up-table method, indicating their ability to provide ESs (environmental cooling through evapotranspiration, climate change mitigation through carbon storage, regulation of extreme events through water retention and habitat provision through species and habitat diversity).

The next step consists in analysing and evaluating their resilience under climate change conditions. It is based on indicators related to resilience that represent (i) the degree of disturbance represented by the climate change future projection and future land use intensification estimation, (ii) the preconditions for resilience estimated by assessing biodiversity, habitat connectivity (distance to nature), and habitat heterogeneity, and (iii) the level of landscape protection due nature preservation laws.

This approach will be complemented by the computation of the Environmental Sensitive Area Index (ESAI), defining sensitivity level to land degradation, based on combinations of 16 drivers,

grouped into four environmental groups related to climate, soil, vegetation and land use quality, human pressure and land management.

On the basis of all mentioned parts, the main risk factors in the landscape on a local scale are identified and typical measures to minimize their potential negative impact (resilience support) are proposed.

Keywords: Provision and resilience of selected ecosystem services, Vulnerability to land degradation, Impacts of climate change, Mitigation and adaptation measures

10. Detecting early-warning signals of resilience loss in ecosystems to avoid regime shifts and loss of ecosystem services

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Ecosystems worldwide are under threat by anthropogenic impacts and climate change, and risk losing their ecosystem services and biodiversity. These intrinsic changes have a major impact on the ecosystem structure and functioning, and will lead to degradation of the initial state. When drivers of change become too intense and/or frequent, the resilience of the ecosystem decreases and may no longer be able to withstand the disturbances. Once a critical threshold in resilience loss is reached, the system may shift into an alternative stable state, better known as a regime shift. Research has shown that ecosystems exhibit early-warning signals of resilience loss when being pushed towards the tipping point, that can be detected by time series analyses. In a tropical dry woodland in Zambia, called Miombo, we recently investigated critical slowdown of the ecosystem's response to increased fire frequency as an early warning signal for a regime shift. Identifying a transition in ecosystem state and the actual driver(s) of change is crucial in planning effective interventions for conservation or restoration. In the OBSGESSION projects, we aim at setting up a standardized detection-attribution-modelling (DAM) framework to harmonize change detection and attribution in ecosystems and biodiversity in Europe. Our study in Zambia pointed out that the detection of an actual regime shift requires not only changes in ecosystem structure, but also ecosystem functioning. As biodiversity is a crucial element in supporting and maintaining the ecosystem functioning, we will create and analyze time series of essential biodiversity variables (EBVs) in relation to associated negative

disturbances in areas of interest. The goal of the DAM framework is to provide a useful reference guide for conservation and restoration practitioners on evaluating where, when and how to intervene in areas at risk for regime shifts and to support resilience in ecosystem services.

Keywords: regime shift, early-warning signals, resilience loss, ecosystem functioning, DAM framework

11. Geodiversity: steps towards the MAES implementation in Greece

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In the frame of the LIFE IP 4 NATURA Project, this study seeks to facilitate the implementation of the Mapping and Assessment of Ecosystems and their Services (MAES) in Greece, through the development of an indicator tailored for abiotic attribute assessments, specifically focusing on geodiversity. This indicator serves not only to fulfill reporting requirements outlined in EU initiatives but also to pinpoint areas of significance, known as "conservation hotspots". These areas, characterized by their diverse geology, play a crucial role in supporting biodiversity and various ecosystem services. Furthermore, the identification and mapping of threats, whether from natural or human-induced factors, can inform the establishment or revision of protective environmental policies. The geodiversity indicator has been developed by integrating geological, geomorphological, climatic, pedological, and hydrological datasets, while threats to geodiversity have been produced by combining sub-indicators related to erosion, protection status, land degradation, mineral extraction activities, and the distribution of wildfire ignition points. A thematic map has been produced to highlight geodiversity "hotspots" across Greece, which tend to align with areas of high geodiversity but insufficient protection against adverse natural or anthropogenic factors, largely due to inadequate protective measures. Study findings offer a baseline for making scientifically sound decisions regarding conservation, management, and spatial planning, all while adhering to EU and national regulations and strategies concerning nature conservation and sustainable development.

Keywords: ecosystem condition, geodiversity hotspots, land use management, natural capital

12. Using Driver-Pressures-State-Impacts-Responses framework to form forest management solutions that foster resilience

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Abstract text (maximum 300 words)

The dynamic two-way interactions between human and natural systems reveals in retrospection a series of trade offs and synergies that form both the landscape and the way of life of local people. The Scots pine forests in the west Rhodopi mountain were afforested in the period 1960-1970, after the oak forests that naturally inhabited the area were destroyed. These forest plantations are located below their natural altitude diapason which results in lower resilience to disturbances. Meanwhile, many drivers and pressures are affecting the health and conditions of these forests. The local population is strongly dependent on all ecosystem services these forests provide. The present research explores policy-economics-society interaction through analysis of local development plans, statistical data and results from feedback received by local stakeholders. The obtained information is integrated in a Driver-Pressures-State-Impacts-Responses framework to form comprehensive description of the interactions between society and environment. Based on the analyzed results the multiple values of forests in rural areas and forest management solutions that would enhance the resilience of the coupled human-environment system are identified.

Keywords: ecosystem services; forests; socio-ecological resilience; DPSIR; stakeholders

13. Remote Sensing-Based Mapping of Hedgerows: Enhancing Ecosystem Services

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Hedgerows are important linear features of landscape composed of trees and/or shrubs of various species. They perform ecosystem services, as well as cultural functions, such as control of soil erosion, microclimatic effect, wood production, and other ecosystem services. In particular dense hedgerow network plays a key role in habitat connectivity for some species and thus influences the degree of fragmentation of the landscape. information on hedgerow networks is often retrieved in the field using accurate ground surveys, a very time-consuming process. Remotely sensed data offer the opportunity to map and characterize hedgerow networks at a landscape scale. Generally remote sensing images are widely used to characterize landscapes while less explored is the detection and characterization of this important linear features.

The aim of this study was to identify wooded hedgerows from remote sensing data using an object-oriented approach, in order to estimate the proportion of hedgerow network that can be automatically extracted. The investigated area is a rural-urban landscape located in the plane area of Friuli Venezia-Giulia region (North-East of Italy).

The image object-oriented classification approach was conducted with eCognition on Planet's data. It consists of a two steps method: a segmentation and a classification. Respectively the segmentation generates image objects in different resolutions (fine to coarse) while the supervised classification allows classification of objects into different landscape element types to extract wooded hedgerows. For the segmentation procedure, three parameters as size (scale parameter), homogeneity of areas (NDVI) and shape (smoothness and compactness) were used. The multitemporal data made possible to identify the target class using the RGB and Infra-red bands.

The results highlight that agricultural landscape complexity influences the classification accuracy, as the detection performance increases with hedges density. The study was complemented by the design and use of a ground truth application, thus integrating the use of crowdsourcing.

Keywords: Remote sensing, hedgerows, eCognition, Planetscope data, object oriented