# BOOK OF ABSTRACTS



## I. SESSION DESCRIPTION

### ID: B10

Designing Resilient Cities through Ecosystem Service Mapping

### Hosts:



| | Title | Name | Organisation | E-mail |
|---|---|---|---|---|
| Host: | | Stefano Salata | Department of City and Regional Planning, Faculty of Architecture, Izmir Institute of Technlology | ssalata1983@gmail.com |
| Co-host(s): | | Silvia Ronchi | Department of Architecture and Urban Studies, Politecnico di Milano | silvia.ronchi@polimi.it |
| | | Sabrina Lai | Department of Civil and Environmental Engineering, and Architecture, Università di Cagliari | sabrinalai@unica.it |
| | | Sila Özkavaf-Şenalp | Department of City and Regional Planning, Faculty of Architecture, Izmir Institute of Technlology, Campus Gülbahçe 35430 Urla Smirne Turchia | silaozkavaf@iyte.edu.tr |



### Abstract:

"The paradigms of ecological planning are widely discussed in the scientific community; nevertheless, their practical operationalization through spatial maps, indicators and an ecosystem assessment for community benefits is less common in practice and far from being achieved.

ESs are often mentioned or referred to in plans and projects but without operationalising the concept and a full integration in the planning process has not been achieved so far to effectively support decision-making process, partly due to lack of knowledge and awareness to represent the spatial distribution of ES biophysical values across the landscape.

Recent studies advocate that multi-functional Green Infrastructures (GI), a tool traditionally adopted and used in spatial planning, can act as a suitable concept for “translating” the complex topic of ESs into plan-making processes, contents, and provisions, as well as in their strategic environmental assessments.

Therefore, understanding the spatial context is a key issue for planning, which would benefit from ES spatial assessment and GI design. GIS models can assist, inform, and help assess biophysical ES provisions and its spatial distribution in a spatially explicit manner while also considering the interaction between threats and source elements through high-resolution assessments."

## Goals and objectives of the session:

We aim to discuss the possibilities and difficulties in integrating ES in the planning process using spatial explicit mapping and assessment. Within this Session, we welcome innovative studies, research advancements, and practitioners' experiences in the "operationalization of the ES framework" in spatial planning and for broader planning purposes. We encourage contributions that address case studies, exemplary applications, theoretical frameworks and perspectives, as well as proposals of innovative planning processes, methods, and tools to answer the following research questions:

1. To what extent are ESs spatially evaluated and integrated within plans and projects?
2. How have ES mapping and assessments affected planning processes?
3. How have ESs supported the definition of resilience strategies for cities?
4. To what extent is the demand of ESs incorporated in performance-based assessments?
5. How can the biophysical characterization of the land be used to support the design phase, i.e., defining potential alternatives, selecting viable choices, and determining decisions within planning processes?
6. What is the most performative scale of ES assessments useful for planning?

## Planned output / Deliverables:

"Abstracts/Papers are invited to contribute to a Special Issue on "Designing Resilient Cities by Ecosystem Service Mapping" in Sustainability (MDPI) (deadline for paper submission: January 2023).
https://www.mdpi.com/journal/sustainability/special_issues/Resilient_Cities_Ecosystem"

## Session format:

Standard session (presentations)

## Voluntary contributions accepted:

Yes, I allow any abstract to be submitted to my session for review

## Related to ESP Working Group/National Network:

Biome Working Groups: BWG 10 – Urban systems

# II. SESSION PROGRAM

**Date of session:** Wednesday, 12 October 2022
**Time of session:** 2 slots: 11:00–13:00 / 16:00–18:00

## Timetable speakers

Co-host in presence Chiara Cortinovis

| Time | First name | Surname | Organization | Title of presentation |
|---|---|---|---|---|
| 11.00 | Stefano<br>Sabrina | Salata | DAStU -Politecnico di Milano | Introduction |

| Time | First name | Surname | Organization | Title of presentation |
|---|---|---|---|---|
| | | Lai | Department of Civil and Environmental Engineering, and Architecture, Università di Cagliari | |
| 11.10 | Solen | Le Clec'h | Environmental Systems Analysis, Wageningen University | Maintaining urban ecosystem services provided by green infrastructure at times of climate change via spatial design |
| 11.20 | Federico | Falasca | University of L'Aquila | Urban ecosystem services and sustainable development: An indispensable planning dualism |
| 11.30 | Chiara | Cortinovis | Humboldt-Universität zu Berlin | A novel remote-sensing algorithm to analyze vegetation dynamics in support of urban greening initiatives |
| 11.40 | Roland | Kraemer | Geography Department, Humboldt-Universität zu Berlin, Berlin, Germany | Air Temperature Regulation of Urban Green Spaces Under Conditions of Drought and Summer Heat |
| 11.50 | Francisco | de la Barrera | Universidad de Concepcion | Urban ecosystem services in myriad of green spaces covering a long latitudinal gradient |
| 12.00 | Vahid | Amini Parsa | University of Lodz, Faculty of Economics and Sociology, Department of Regional Economics and Environment, Social-Ecological Systems Analysis Lab, Lodz, Poland | Urban trees and hydrological ecosystem service: the relationship between landscape structure and runoff reduction |
| 12.10 | Vilém | Pechanec | Department of Geoinformatics, Faculty of Science, Palacký University Olomouc, Olomouc, Czech Republic | The assessment of the resilience of selected urban ecosystem services |
| 12.20 | Fabrizio | Ungaro | Institute of BioEconomy - CNR IBE | From SOS4LIFE project to the general urban plan of the Municipality of Forlì (NE Italy): an application of studies on soil ecosystem services. |
| 12.30 | Sylwia | Kulczyk | The University of Warsaw | Cultural ecosystem services potential in the planning and management of urban areas. Case study of Poznań, Poland. |
| 12.40 | Oleksandra | Nenko | University of Turku, TIAS | Participatory Mapping of Cultural Ecosystem Services of Kaliningrad Urban Green Spaces |

| Time | First name | Surname | Organization | Title of presentation |
|---|---|---|---|---|
| 12.50 | Stefano<br>Sabrina | Salata<br>Lai | DAStU -Politecnico di Milano<br>Department of Civil and Environmental Engineering, and Architecture, Università di Cagliari | Wrap up |

Co-host in presence Claudia Dworczyk

| Time | First name | Surname | Organization | Title of presentation |
|---|---|---|---|---|
| 16.00 | Silvia<br>Sabrina | Ronchi<br>Lai | DAStU -Politecnico di Milano<br>Department of Civil and Environmental Engineering, and Architecture, Università di Cagliari | Introduction |
| 16.10 | Cristina | Montaldi | Department of Civil Construction Architectural and Environmental Engineering - University of L'Aquila - Italy | Effects of urban planning on ecosystem services. The Umbria Region seismic crater. |
| 16.20 | Luis | Inostroza | Ruhr University Bochum | How does Urban Development affect Ecosystem Services? A mapping and assessment exercise in Bogota using the IMECOGIP toolbox |
| 16.30 | Carlotta | Quagliolo | Politecnico di Torino | Hydro-economic assessment of nature-based solutions in the city of Aveiro (Portugal) |
| 16.40 | M. Susana | Orta-Ortiz | University of Trento | Simulating nature-based solutions and assessing cumulative impacts at the city scale: a case study in Las Palmas de Gran Canaria, Spain |
| 16.50 | Laurence | Jones | UK Centre for Ecology & Hydrology | Airsheds, watersheds, peoplesheds … understanding spatial relationships to plan better nature based solutions for people |
| 17.00 | Claudia | Dworczyk | Institute for Physical Geography and Landscape Ecology, Leibniz University Hannover | Mapping Ecosystem Services Supply and Demand in Urban Regions<br>Lessons learned from a research project in Germany |
| 17.10 | Sabrina | Lai | University of Cagliari, Department of Civil and Environmental Engineering, and Architecture | Investigating spatial interactions among ecosystem services to support planning policies: A case study from Sardinia, Italy |

| Time | First name | Surname | Organization | Title of presentation |
|---|---|---|---|---|
| 17.20 | Federica | Isola | Department of Civil and Environmental Engineering and Architecture, University of Cagliari | Mapping of ecological corridors as connections between protected areas: A study concerning Sardinia, Italy |
| 17.30 | Lucia | Almeida | Universidad Autonoma de Mexico | Magdalena river watershed strategic area for the resilience of Mexico City |
| 17.40 | Francisco | de la Barrera | Environmental Science Faculty, Universidad de Concepción, Chile | Megafires in Chile 2017 and the difficult recovery of the landscape and its ecosystem services. |
| 17.50 | Stefano | Salata | DAStU -Politecnico di Milano | Wrap up |

## 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*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Magdalena river watershed strategic area for the resilience of Mexico City

*Presenting author: lucia Almeida*

*Other author(s):* Julieta Jujnovsky Orlandini, Monserrat Moysen Carbajal, Raiza González Gómez, Karla Guadarrama, , ,

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Mexico City is situated in a basin at 2,200 m asl, surrounded by volcanoes and lakes as part of the Trans-Mexican Volcanic Belt. These conditions explain their biodiversity. This place is currently one of the largest metropolitan areas in the world. The Magdalena river watershed, located in Mexico City's Conservation Land, is a good example of an important region that provides essential ecosystem services to the city. It has one of the last permanent runoffs of the Mexico Basin, used as a source of drinking water supply for the city, as well as the best preserved temperate forests in central Mexico, and significant cultural heritage. The goal of this work is to present a strategy for the comprehensive management of ecosystem services provided by the watershed. To propose solutions to complex socio-environmental problems,

caused by the accelerated growth of urban sprawl, which has resulted in a decrease and deterioration in its vegetation cover. It was conceived from a perspective of socio-ecosystems, which integrates ecological variables (units of water and forest resources) and social variables (actors and governance) that interrelate and interact. The strategy was developed based on the review, analysis, and diagnosis of academic studies previously carried out in this basin, as well as from the knowledge and perspectives of the authorities, residents, and visitors, obtained from interviews and focus groups. Taking into account the legal and institutional framework, it contains a strategic proposal based on six axes, with specific objectives and lines of action. The target is to address the main challenges within the basin and come up with elements that lead to decision-making and policy-making, using reliable and timely data and information about the territory. This case study is a good example of a community that has taken care of its environment making the city more resilient.

*Keywords*: Mexico City's Conservation Land, strategy for management, local actors, decision and policy-making, legal and institutional framework

*2. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

A novel remote-sensing algorithm to analyze vegetation dynamics in support of urban greening initiatives

*Presenting author: Chiara Cortinovis*
*Other author(s):* Dagmar, Haase, Davide, Geneletti
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Mapping and assessing urban ecosystem services can provide an invaluable support to designing and monitoring the effectiveness of greening initiatives, including those recently promoted by the EU Biodiversity Strategy to 2030. The Strategy aims at "promoting the systematic integration of healthy ecosystems, green infrastructure and nature-based solutions into all forms of urban planning". To this aim, all European cities with more than 20,000 inhabitants are expected to draft an Urban Greening Plan including measures to mainstream urban greening initiatives into decision-making, and foster citizens' engagement.

Key requirements for indicators to inform this planning effort are the ability to capture changes at high spatial and temporal resolution, and the capacity to describe conditions and dynamics affecting not only public, but also private green areas, which constitute the largest part of urban ecosystem service suppliers. Indicators based on remote sensing, such as NDVI, meet both requirements. However, methods to analyze NDVI temporal series

developed for non-urban contexts are not fully suitable to urban applications. Such methods primarily focus on trends in plant phenology, while abrupt changes due to man-made greening or browning interventions (e.g., tree planting, green roof installation, soil sealing) are difficult to capture.

We developed an algorithm for the analysis of NDVI temporal series from Sentinel data specifically suited to urban areas. The algorithm works on the annual 'greenest' composite and combines the analysis of trends related to vegetation growth with the identification of multiple break points in the series, thus revealing and dating positive and negative changes due to human activity. We present the rationale of the approach, and its application and validation in Berlin. The results provide key spatially-explicit information on urban vegetation dynamics and their causes. The automatized analysis process can be adopted as a routine monitoring tool for local plans and policies related to greening interventions.

*Keywords*: NDVI, urban vegetation, remote sensing, urban greening, planning

*3. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

## Hydro-economic assessment of nature-based solutions in the city of Aveiro (Portugal)

*Presenting author: Carlotta Quagliolo*
*Other author(s):* Peter Roebeling, Alessandro Pezzoli, Elena Comino
*Affiliation*: Politecnico di Torino, Italy
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Cities are highly vulnerable to extreme weather events, about 43% of disasters will occur in urban areas due to climate change enhanced flood risk, which is the major impact across most of European cities. Changes in precipitation patterns and a high level of impervious surfaces in urban areas are increasing their sensitivity to runoff production. At the same time, projected global sea-level rise may further increase the frequency of compound flooding due to simultaneous storm surge, sea-level rise and pluvial runoff that cause vast-socio-economic and ecological impacts for coastal cities. Consequently, climate and flood risk adaptation should be flexible and multifunctional because of higher uncertainty of impacts, especially considering local spatial variability within the urban environment. In this context, over the last decade the role of Nature-Based Solutions (NBS) has been recognised to support climate change adaptation by delineating ideas of multi-functionality, non-linearity and heterogeneity in urban design. This study develops a spatial hydro-economic assessment of NBS implementation to reduce the pluvial flood on the coastal lagoon city of Aveiro (Portugal). Through the employment of an integrated evaluation method based on InVEST modelling and GIS tools, simulations of specific NBS in base and future climate change scenarios have been developed. Specifically, the Urban Flood Risk Mitigation model

has been used to assess the biophysical effects of NBS while a Cost-benefit (CBA) analysis has been integrated to develop the economic evaluation of such solutions. The main findings of this study show the importance to estimate the net benefit value of NBS to aid decision making process in adaptation planning. By spatially quantifying the potential flood mitigation impacts and benefits of NBS, could encourage a greater integration of NBS into urban planning.

*Keywords*: Nature-Based Solutions, Pluvial flood risk, Coastal lagoon city, InVEST modelling, Cost-benefit (CBA) analysis

*4. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Urban ecosystem services and sustainable development: An indispensable planning dualism

*Presenting author: Federico Falasca*
*Other author(s):* Lorena Fiorini, Lucia Saganeiti, Alessandro Marucci, , , ,
*Affiliation*: University of L'Aquila, Italy
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The concept of ecosystem services (ES) associated with spatial planning is well deepened in the scientific literature, thanks to the variety of approaches currently available. Nevertheless, over a long period of time, none of them can define a standard analytical procedure in the management of the related territorial dynamics, despite the richness of criteria that take place in their governance process.

On the other hand, sustainable development can't be regardless the benefits that the exploitation of technologies based on the semi automatized recognition of uneven portions of the territory, and with high analytical potentialities, bring both to the urban context and the neighboring natural environment.

Furthermore, the Goals fixed at international level, such as those of the agenda 2030, emphasize the strict correlation between these elements, also entailing the necessity of a joint management. In this sense, territorial profiling exploiting the ES concept represents a way to address the fundamental task of changing the paradigms on which planning policies are based.

The present study proposes the characterization and association of areas with similar properties in the case study of the province of L'Aquila. It will provide a first application field, comparing empirically fragile areas with the relative analytical elaborations. Finally, recurring patterns between the analysis of the criticalities of the urban settlement and the quantitative assessment of the annexed ESs will be highlighted.

This approach will provide a measure of the necessary actions to protect fragile urban contexts, representing a first step for a decision support system that introduces ESs concept management inside the urban settlement.

*Keywords*: SDG11, Sustainable planning, Ecosystem Services, Urban settlement, Urban planning

*5. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

The assessment of the resilience of selected urban ecosystem services

*Presenting author: Marcela Prokopova*
*Other author(s):* Lenka Štěrbová, Marcela Prokopová, Renata Včeláková, Ahmed Mohammed Ahmed Alhuseen, Jan Purkyt, Ondřej Cudlín, Pavel Cudlín
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The importance of ecosystem services (ES) provided by urban and peri-urban areas is increasing, especially those that mitigate the impacts of ongoing climate change. We present a relatively simple method for assessing the performance of three ecosystem services (most important under climate change conditions) and their application in the cadastral area of Liberec, a Czech foothill city. ESs are quantified by the performance levels of key ecosystem functions (EFs) associated with habitat types, indicating their ability to provide ES (environmental cooling through evapotranspiration, climate change mitigation through carbon storage, and habitat provision through species and habitat diversity). A gradient analysis was used to visualize the spatial distribution of ESs.

In addition to assessing the current provision of EF /ES, we also propose a method for evaluating its 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 assessment and its future projection, (ii) the preconditions for resilience estimated by assessing biodiversity, habitat connectivity (distance to nature), and habitat heterogeneity, and (iii) the level of landscape protection, an important indicator that provides insight into the future existence of habitats that, if not adequately protected, are threatened by urban development. The paper also discusses the results from the application for the broader area of the city of Liberec at the habitat level on a scale of 1:10,000.

The method can serve as a useful tool to quickly identify significant ES providers and their resilience, expressing their sustainability for the future. It can also help to identify places with low ES values or places with high ES value but low resilience. These areas should be the focus of urban adaptation strategies to global climate change.

*Keywords*: Resilience of selected urban ecosystem services, Urban and peri-urban areas, Impacts of climate change, Assessment of biodiversity and connectivity

*6. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# Mapping of ecological corridors as connections between protected areas: A study concerning Sardinia, Italy

*Presenting author: Federica Leone*
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According to the European Commission, green infrastructure (GI) and spatial connectivity concerning the provision of ecosystem services (ESs) are strictly related to the conceptual category of ecological networks. Regional and urban planning processes should adequately manage, improve and monitor the effectiveness of GIs as ecological networks which provide ESs and the spatial connectivity of such systems. Building on a methodological approach defined in previous studies, this study aims at defining and implementing a methodology to identify ecological corridors (ECs) as edges of spatial networks whose nodes are represented by areal units which provide a wide range of ecosystem services. The approach is implemented with reference to a network of protected areas located in the spatial context of Sardinia, an Italian insular region. Finally, the study discusses the relation between ECs and the spatial taxonomy of the landscape components featured by environmental relevance (LCFERs), identified by the Regional Landscape Plan, through multiple linear regression analysis, in order to assess if, and to what extent, the present regional spatial zoning code can be used as a basis to implement regulations aimed at protecting ECs.

Although the regression results put in evidence that all the LCFERs are correlated to increases in the eligibility of a patch to be included in an EC, woodlands and cork and chestnut woods are the most suitable. Planning measures should focus on transition from agricultural to forest land uses, supported by financial grants. On the other hand, since the nodes of the networking spatial structure of the regional GI are identified with the system of the regional protected areas, whose protection regime implies conservation and enhancement of habitat quality, ecological integrity and ESs, strengthening such spatial structure entails the establishment and implementation of planning policies aimed at extending to ECs the protection regime related to protected areas.

*Keywords*: ecological corridors, protected areas, landscape components, least-cost path model, multiple linear regression analysis

*7. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# Air Temperature Regulation of Urban Green Spaces Under Conditions of Drought and Summer Heat

*Presenting author: Roland Kraemer*
*Other author(s):* Nadja Kabisch, Paul Remmler, Jan Bumberger, , , ,
*Affiliation*: Humboldt-Universität zu Berlin, Germany
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In times of urbanisation and climate change, urban green spaces and their ecosystem services are central to adapting to extreme weather events such as heat and drought. But what happens to the provision of ecosystem services when green spaces themselves are affected by heat and drought? In this study, we investigated the regulation of air temperature in and around two structurally different inner-city parks in Leipzig, Germany, which were strongly affected by the heat and drought periods in 2018 and 2019. We used a dense network of in situ measurements and machine learning to generate spatially explicit maps of air temperature distribution at a fine-scale neighbourhood level for a 24-hour period during the summer 2019 heatwave. The results showed that the larger, tree-dominated park maintained relatively cool spaces at all times, while the other, more open, grass-dominated park was highly heated during the day but delivered relatively cool air at night and in the early morning. We found a maximum spatially averaged cooling effect of green spaces compared to the built environment of 1.1°C in the morning. However, in the afternoon, when air temperatures reached a peak of almost 40°C, cooling was limited to shaded areas, resulting in average differences between green spaces and the built environment of less than 1°C. Our spatially explicit maps showed that the "cooling distances" of green spaces, i.e. the cooling effects that extend beyond the boundaries of a park, are negligible in dry and hot conditions. We conclude that vegetation structure, particularly the arrangement of trees, is key to designing heat and drought resilient green spaces and thus maintaining the provision of ecosystem services under the challenges of climate change. Urban planning needs to consider larger green spaces complemented by decentralised, well-distributed, small-scale green infrastructure that intersperses the built infrastructure such as roadside greenery and green backyards.

*Keywords*: urban green spaces, ecosystem services, microclimate regulation, heat, drought

*8. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# Megafires in Chile 2017 and the difficult recovery of the landscape and its ecosystem services.

*Presenting author: Francisco de la Barrera*
*Other author(s):* Diana Mancilla, Francisca Koch, Sergio Gonzalez
*Contact*: fdelabarrera@gmail.com

Assessing the environmental damage caused by large and mega-fires by quantifying changes in the landscape and its changing effects on the provision of ecosystem services is necessary, both to contribute to the diagnosis of landscape restoration needs and to determine its resilience capacity. In this work, the changes in the landscape in three micro-basins affected by the 2017 Chilean megafire are analyzed. These areas were quantified and spatialized through annual land cover classifications using Sentinel-2 images and monthly spectral indices over 6 years. In parallel, the expert-based matrix was integrated with spatially explicit models for soil and surface water regulation services, applying RUSLE and OpenNSPECT models. The results indicate that native forests are the largest providers of ecosystem services, having been severely affected (>50%), being resilient to fire. The landscape had low diversity and provisioning capacity, even before the megafire. After the fire, the service provision capacity decreased by half, and the most affected ecosystem services were regulation and cultural services. Four years later, the low provision is still present at 54%, showing a slow recovery. The effect on soil regulation services and runoff in the study area increase the mean annual erosion rates (+252%) and increases in surfaces exposed to extreme erosion processes (> 200 tons/ha/year, +900%). Likewise, the increase in runoff values (30-50%), conditions the security of the water supply and productive soils for the development of the local population. The evolution of the landscape accounts for its resilience and the environmental damage caused, requiring restoration actions. This knowledge allows not only to show the damage but also the need to implement actions that contribute to the resilience of the landscape, since, without proper management, a landscape that provides few ecosystem services is perpetuated.

*Keywords*: ES matrix, RUSLE model, OpenNSPECT model, landscape restoration, forestry

*9. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Urban ecosystem services in myriad of green spaces covering a long latitudinal gradient

*Presenting author: Francisco de la Barrera*
*Other author(s):* Ricardo Truffello, Sergio Gonzalez, Valentina Salinas, Helen de la Fuente
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Urban green spaces contain different amounts and proportions of vegetation cover that contribute to providing ecosystem services, including carbon sequestration and temperature buffering. In this work, a supervised object-based classification is applied in the Google Earth Engine platform using Sentinel 2 multispectral images in all the parks and squares (11,340) of 7 cities in Chile, covering a wide latitudinal range (18.5°S - 53.0°S). Together with obtaining the vegetation cover of each plaza and park, the carbon storage per pixel (10m/pixel) was calculated using a model based on the Enhanced vegetation index. In addition, the surface soil temperature (LST) was derived from the atmospherically corrected thermal band 10 in together with the choice of a downscaling method (DS) resulting from the combination of Landsat 8 and Sentinel-2 data. The results show that the proportion of grass and trees increases from north to south (from drier to rainier cities), with contrasting results in extreme cities, where the driest city has more trees) and the southernmost city has fewer trees. The carbon stored increases from north to south, with some exceptions. Similarly, the maximum and average temperatures decrease from north to south, with some exceptions in the south. There are differences in share of grass and trees between squares and parks, as well as in carbon storage and expression of temperatures. The results make it possible to identify that the squares and parks with the least provision of ecosystem services are located in socio-materially vulnerable neighborhoods, regardless of geographic position, allowing the feeding of planning processes and management of ecosystem services in urban spaces and the vegetation that provides them.

*Keywords*: object-based classification, local parks, plazas, land temperature, carbon sequestration

*10. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Effects of urban planning on ecosystem services. The Umbria Region seismic crater.

*Presenting author: cristina montaldi*
*Other author(s):* Francesco Zullo, Chiara Cattani, Gianni Di Pietro
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The earthquake in central Italy in 2016 led to a profound transformation of the urban and natural landscape. The effects that are still visible and the processes of physical and economic reconstruction are still far from being completed. The role of territorial planning in this kind of situation is extremely important because it allows to orient future settlement choices through appropriate interpretative keys of the existing territorial dynamics. This is especially true in a context of several fragilities, where natural shocks have further exacerbated the pre-existing phenomena of demographic decline and job losses.

This work aims to analyze the effects of the planning choices made in the post-earthquake period in the seismic crater municipalities of the Umbria Region. Using the InVEST models, these assessments will address the effects on ecosystem services such as the quality of habitats and carbon storage of the current plans, and the comparison of them with the transformative scenarios designed in urban planning tools in force at the time of the earthquake. The data about the mosaics of the municipal urban planning tools in the two periods investigated, derive from specific actions produced under two LIFE projects (SUNLIFE and IMAGINE) one of which is still ongoing. The comparison makes it possible to identify how and to what extent the transformative scenarios, linked to the new condition, change the spatial planning compared to the previous one and the effects on the provision of ecosystem services. The knowledge of the latter aspect, together with land use, energy and emissions, is also fundamental in terms of improving the environmental performance of the urban development tool. It allows to optimize the methods of urban transformation that will be implemented. Moreover, this process of optimizing the provision of essential ecosystem services could certainly play a key role in the enhancement and economic recovery of these areas.

*Keywords*: ecosystem services, spatial planning, performance-based planning

*11. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Maintaining urban ecosystem services provided by green infrastructure at times of climate change via spatial design

*Presenting author: Solen Clec'h*
*Other author(s):* João Cortesão, Sitong Luo, Jana Verboom
*Affiliation*: Wageningen University, Netherlands
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Climate change is leading to ecological shifts that affect green infrastructure (GI) and the ecosystem services it provides. Such ecological shifts affect the way GI should be employed in spatial design to keep providing a wide range of urban ecosystem services (UES). A broad understanding of these impacts and their effect on the creation and support of resilient urban climates are still lacking.

We aim at expanding on preliminary considerations on the implications that climate-change-driven ecological shifts are likely to have on UES provided by GI and, consequently, on climate-responsive spatial design. To this end, we conducted a systematic literature review of scientific peer-reviewed papers to reveal potential effects of climate change on urban UES. Then, we discussed the possibilities for spatial design to tackle the impacts of climate change on UES, with a group of experts.

We observe that, first, the influence of climate change on urban UES provided by GI is still understudied. Second, climate change significantly and increasingly impacts the distribution, composition and condition of GI. Such impacts should, in turn, affect the provision of multiple UES. Third, we identified two main trends for climate-responsive spatial design: implementing nature-based solutions using species or genotypes currently endogenous of other areas, or designing urban spaces in ways that enable the health and resilience of trees to phenomena such as drought or extreme heat, for example, larger tree pits with the capacity to hold rainwater or species-rich GI whose high trait diversity would imply high response diversity.

Knowledge on the impacts of climate change-driven ecological shifts on UES and on the level and identity of UES provided by potential climate-resilient nature-based solutions is critical to prevent short-term, unsuitable, ill-argued, or incomplete climate-responsive spatial design strategies. Such solutions would in turn lead to inefficient and suboptimal management outcomes.

*Keywords*: Urban ecosystem services, Climate change, Urban climate resilience, Climate-responsive design, Climate adaptation

*12. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# Urban trees and hydrological ecosystem service: the relationship between landscape structure and runoff reduction

*Presenting author: Vahid Amini Parsa*
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The importance of providing runoff reduction ecosystem service by trees (RRES) to mitigate urban stormwater runoff increases with further urbanization and climate change. The sustainability of RRES is disturbed by urban landscape modification. However, studies on the relationships between landscape structural pattern and RRES are limited. In this case, improving our knowledge on the linkage between the landscape structure and RRES is crucial to effectively manage urban landscapes and to maintain and enhance the sustainable supply of RRES. This study attempts to bridge this gap by analyzing the relationship between the landscape structural pattern and the RRES in Tabriz, Iran. The provision of RRES was estimated using the i-Tree Eco model. Landscape metrics (shape, fractal dimension, contiguity, related circumscribing circle, and perimeter-area ratio indexes) of land use and cover (LULC) were derived with the use of FRAGSTATS to quantify the landscape structure. Landscape metrics were then introduced as independent variables into stepwise regression analysis (through linear, power, logarithmic, and exponential modeling methods) to assess whether landscape structure metrics could explain the provision of RRES. The results indicate that throughout the city the trees prevented 196854.15 m3 of runoff annually. Regression models ($p \leq 0.05$) suggested that the provision of RRES could be predicted using the measures of the related circumscribing circle ($0.889 \leq r2 \leq 0.954$) and the shape index ($r2 = 0.983$). The findings also revealed that the regularity or irregularity of the shape of the given LULC patches (i.e., residential area, green spaces, agricultural land and transportation, and commercial land) can impact the functions of the patches, which, in turn, affects the provision of RRES in the city. The landscape metrics through the regression models (as proxies) can contribute to explicitly predicting the capacity of trees for potential RRES. This helps to allocate suitable LULC through optimizing landscape metrics and management guidance to sustain RRES.

*Keywords*: Regulating ecosystem services, Ecosystem service modeling, Green infrastructure, Landscape ecology, Landscape metrics

*13. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Mapping Ecosystem Services Supply and Demand in Urban Regions- Lessons learned from a research project in Germany

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The OESKKIP research project investigated the integration potential of the ecosystem service (ES) approach into urban and regional planning and governance processes in Germany. For this purpose, two urban regions, Rostock and Munich, were selected as case study areas. In

both urban regions, dynamic urbanization processes take place across the administrative boundaries and threaten the supply of ES. At the same time, the growing number of urban dwellers and visitors increases the demand for different ES.

In the research project, indicators and methods with different levels of complexity for quantifying ES supply and demand were tested. However, data unavailability/inaccessibility and the lack of suitable indicators, especially for ES demand, resulted in difficulties mapping all selected ES at the targeted regional scale. Despite these challenges, the resulting maps were helpful for communication with local stakeholders. The discussions with stakeholders provided valuable insights into the future needs for ES research and identified existing barriers and challenges. The barriers and challenges are, among other things, related to understanding problems of ES terminology, the unclear added value of ES assessments, and the needed spatial scale of ES mapping. We want to share and summarize our experiences and provide recommendations for future research on mapping ES supply and demand in urban areas.

*Keywords*: Mapping ecosystem services supply and demand; indicators; regional scale; stakeholder involvement

*14. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Airsheds, watersheds, peoplesheds … understanding spatial relationships to plan better nature based solutions for people

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Cities are highly complex, inter-connected social-ecological systems, encompassing social, built and natural/semi-natural components. They interact with their surrounding extra-urban areas at varying scales, from peri-urban and rural to global. In most instances, city planners tend to think about interventions only within cities and rarely about the wider connected domains outside. Yet, considering the wider spatial context, making use of the space outside the city footprints or boundaries can open up opportunities to achieve substantially greater benefit for city residents without sacrificing valuable space, leading to more sustainable city design for people and the environment.

We discuss the intra-extra-urban flows which connect cities to their wider airsheds, watersheds, biodiversitysheds and resourcesheds, which in turn interact with their peoplesheds. For each domain, we illustrate the processes and the scales they operate at, and discuss the implications for optimum location of nature-based solutions (NBS) to address urban challenges. We suggest that integrating knowledge about these multiple

sheds can inform holistic design of NBS to deliver greater benefit for city residents. This takes into account the synergies and multi-functional co-benefits which arise from a careful consideration of place and people, while minimising potential disbenefits and trade-offs.

*Keywords*: green infrastructure, ecosystem services, cities, urban metabolism

*15. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

Simulating nature-based solutions and assessing cumulative impacts at the city scale: a case study in Las Palmas de Gran Canaria, Spain

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City-scale strategies aimed at implementing multiple nature-based solutions (NbS) can improve the supply of ecosystem services (ES), representing a promising opportunity to tackle environmental and social resilience in cities. These strategies are characterized by a vast stock of urban sites where different NbS types can be implemented. However, how these strategies should be designed and the extent to which they contribute to urban challenges remain open questions in the NbS research and constitute a barrier to fully mainstreaming NbS and related ES in cities. This study aims twofold: (i) to simulate the implementation of multiple NbS and (ii) to quantify their cumulative impacts in terms of ES supply and beneficiaries. The NbS simulations were guided by a method that prioritizes different NbS types in available sites and determines the most advantageous chronological sequence of implementation. It combines spatial data on ES demand, ES supply by NbS type, and biophysical characteristics of sites. GIS tools and some InVEST models supported the assessment of cumulative impacts. The study was conducted in Las Palmas de Gran Canaria (Spain), focusing on urban forests, urban parks, community gardens, infiltration ponds, and five ES, including runoff mitigation, stormwater treatment, soil erosion control, recreation, and food supply. Overall, 179 NbS were simulated stepwise in 130 sites heterogeneously distributed in the city. Urban forests, urban parks, and community gardens predominated at specific stages of the simulation process. Overall, the findings showed a net increment in the ES supply and the number of beneficiaries at the city scale. However, the cumulative impact assessment showed a non-linear relationship between NbS simulations and impacts, including constant, positive, and negative trends. Finally, we discussed several ways the proposed prioritization method and cumulative impact assessment can support planners in designing advantageous city-scale NbS strategies.

*Keywords*: nature-based solutions, ecosystem services, city-scale implementation, GIS simulations, cumulative impacts

*16. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# Investigating spatial interactions among ecosystem services to support planning policies: A case study from Sardinia, Italy

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A fundamental characteristic of green infrastructure, as per the definition provided in 2013 by the European Commission, is multifunctionality, understood as the delivery of multiple ecosystem services (ES) which flow from ecosystems to humans. Consequently, green infrastructures are regarded as win-win solutions to environmental, social, and economics problems because they combine nature conservation with maintenance of ESs. However, while some ESs are synergic, spatial interactions between ESs can be negative and result in trade-offs.

By building on spatially explicit assessments of seven ESs previously carried out by the author, this study aims at identifying areas of territorial specialization that can support planning policies by investigating multifunctionality in ES supply. Sardinia is chosen as a case study because its low residential density, low infrastructure endowment, and persistence of traditional farming practices have preserved good levels of naturalness, prerequisite for the delivery of ESs. The scale is that of municipalities, the administrative tier responsible for land-use planning in Italy, as land-use change is the most important factor affecting ES provision.

Following Raudsepp-Hearne et al. (2009), the methodological approach comprises three steps: i., spatial pattern investigation through autocorrelation and hotspot/coldspot analysis; ii., correlation analysis between couples of ESs; iii., PCA and cluster analysis to map groups of municipalities whose in-group similarity is higher than between-group dissimilarities.

Five groups of municipalities providing similar bundles of ESs were identified, whose spatial distribution reflects both ecological and socio-economic patterns. Moreover, the analysis showed that agricultural productivity and carbon storage and sequestration compete with other ESs, hence plan-making processes should carefully assess such trade-offs, as actions aiming at their enhancement can be detrimental to other ES. Future research could include a larger number of ESs, to better assess sensitivity and stability of the clusters, and socio-economic control variables.

*Keywords*: ecosystem services, multifunctionality, bundling, trade-offs, environmental planning

*17. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# From SOS4LIFE project to the general urban plan of the Municipality of Forlì (NE Italy): an application of studies on soil ecosystem services.

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The LIFE15 ENV/IT/000225 SOS4LIFE project tried to demonstrate the feasibility at municipal scale of the European strategy "no net land take" to 2050.

The Institute of Bioeconomy of the National Research Council (CNR IBE) in collaboration with the Emilia-Romagna Region mapped the main soil ecosystem services (SES) for the entire territory of the partner Municipalities (Forlì, Carpi and San Lazzaro di Savena) with a focus on the ES of Carpi urban and periurban soils.

Following the request of the municipal technicians, an aggregate soil quality index was defined and mapped in order to have an additional useful tool for urban planning. The SES maps and the Soil Quality Index map (which are available through a specific Web-GIS) are tools to support decisions in urban planning, as they serve to more consciously direct any residual transformations (which cannot find an answer in urban regeneration) on soils of poorer quality and to safeguard the best soils in terms of ecosystem service supply.

In addition, the general urban plan of Forlì will use the aforementioned maps to manage a compensation system that aims to restore at least part of the SES that are lost with the new urbanizations. The compensation consists in the desealing of waterproofed areas and in the subsequent restoration to greenery or for agricultural use. The municipality of Forlì, in order to increase the level of detail of the existing Maps, has entrusted the CNR with a survey campaign of urban and peri-urban soils together with the drafting of a maps of the vulnerability climatic index during a heat wave. The latter will make it possible to address the desealing and green restoration interventions (and also urban forestation), as a priority towards the areas that are more critical, improving urban resilience to climate change.

*Keywords*: Ecosystem services, Land take, Urban planning, Urban resilience, Urban soils

*18. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# *Cultural ecosystem services potential in the planning and management of urban areas. Case study of Poznań, Poland.*

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Cultural ecosystem services (CES) are not yet frequently applied in spatial planning in Poland. Therefore, our study aims to recognize the opportunities to identify and assess CES for the planning and management of urban space, based on the Poznań case study. The research focused on identifying the approaches, needs, and preferences of two groups: practitioners (including city officials) and residents.

To acquire the perspective of practitioners, we conducted a workshop. To recognize residents' preferences regarding the spatial features of the place of residence, we applied a conditional choice experiment (DCE). Finally, we mapped selected features characterizing residential spaces in Poznań to detect the diversity of spatial conditions contributing to the CES potential of housing areas.

The results showed that practitioners considered the use of nature for recreation, the aesthetic value, and the importance of nature for future generations as priority CES. However, they regarded the space in a holistic way. The results of the residents' survey concerning features of the preferred housing areas (based on 263 questionnaires) showed that the respondents appreciated the openness of the landscape the most, preferred trees over low vegetation, and the presence of infrastructure for active recreation over its absence. The distance to the parking lot or public transport stop was only in fourth place in the hierarchy of importance of spatial features. In contrast, it was not important whether the greenery in the neighborhood was well organized or unmaintained. The spatial analysis revealed differentiation of the features such as share of tree crown area and share of the built-up area in the vicinity of buildings between and within the housing estates showing existing conditions and their diverse potential for providing CES. The DCE and spatial analysis results inform stakeholders about future needs in planning residential areas and indicate areas for revitalization towards higher ES potential.

*Keywords*: urban space, discreet choice experiment, residential areas, spatial features, trees

*19. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# Participatory Mapping of Cultural Ecosystem Services of Kaliningrad Urban Green Spaces

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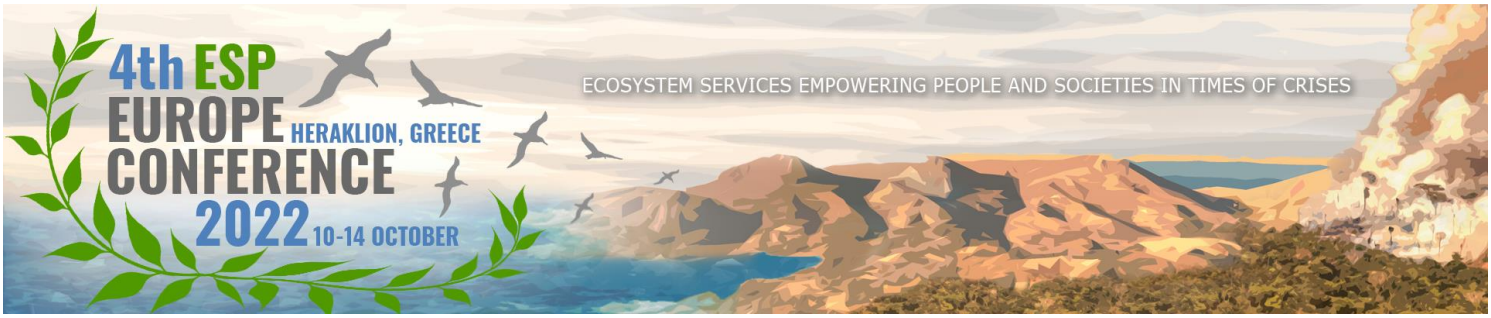
The paper presents a study on CESs of UGSs in Kaliningrad conducted along with participatory mapping approach using PPGIS tool Mapsurvey; a first massive PPGIS survey of CESs in the region. The final sample made up 1148 respondents (aged over 18). Before the mapping, triangulated selection of 16 urban green spaces was made based on the maximum variation of their morphological, normative, environmental and historic characteristics, as well as on the UGS rating, involving 100 experts. Participatory mapping design contained collecting respondents' markers on: (a) familiar and visited UGS, (b) 10 kinds of cultural ecosystem services and 2 kinds of disservices in the UGS, (c) new UGS to be developed, (d) 5-point rating of the current condition of the UGS, (e) socio-demographic section. The classification of CESs was elaborated based on the current literature, as well as on the contextual expert knowledge of the authors. In particular, 2 CESs - reviving personal/family stories, memories and feeling comfortable, out of control - were formulated, specific for the study. 2 disservices included encountering unpleasant environmental items and experiencing irrelevant practices in UGSs. The rating of the CESs was compiled; experiencing the beauty, live nature and cultural heritage were the most mentioned ones, providing new knowledge - the least mentioned. UGSs leading in CESs and devoid of them were defined and their environmental features described (e.g. the Central Park, the Zoo and the Kant Island became leaders - central, filled with infrastructure and activities, historically vibrant). Meanwhile UGSs with prominent natural and historical potential however poor CESs were allocated. Prevalence of the "passive" CESs (not demanding specific managerial efforts) over "active" CESs was detected. The overall lack of the multifunctionality of CESs in the UGS notwithstanding their objective capacity was determined. The share of disservices in mapping turned out to be comparable with the services.

*Keywords*: cultural ecosystem services, urban green spaces, participatory mapping, PPGIS




*20. Type of submission: Abstract*

B. Biome Working Group sessions: B10 - Designing Resilient Cities through Ecosystem Service Mapping

# How does Urban Development affect Ecosystem Services? A mapping and assessment exercise in Bogota using the IMECOGIP toolbox

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Urban development trends can have profound impacts on the provision of Ecosystem Services to urbanites. While cities expand at very fast rates all over the world, in many cases such urban development is unplanned and dominated by underlying market forces shaping urban environments. Against such trends, urban planning aims to provide strategies that better integrate social, economic and environmental considerations. How does planned urban development affect the delivery of ES? In this presentation, we introduce the IMECOGIP toolbox, a GIS add-in developed to assess the provision of ES in an urban planning context. The toolbox allows the assessment of 6 ES that are quantified on the basis of biophysical variables and are depicted spatially explicit in maps. To show the advantages of our toolbox, we use the northern area of Bogota, Colombia, as a case study. Here, the local authorities have promoted a master plan of 1.800 hectares to accommodate the city's growing population while simultaneously controlling the systematic and unplanned urban development process. The master plan aims to provide a sustainable urban structure in terms of land use, transport, and blue-green infrastructure. However, to what extent this master plan will affect the provision of ES is an open question that we aim to answer using our toolbox.

*Keywords*: Urban planning, GIS, ES mapping