BOOK OF ABSTRACTS

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I. SESSION DESCRIPTION

ID: T5a

Ecosystem Services Modelling for Nature-based Solutions

Hosts:

	Title	Name	Organisation	E-mail
Host:		Bart De Knegt	WUR	bart.deknegt@wur.nl
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	Prof.	Rob Alkemade	Netherlands Environmental Assessment Agency (PBL), The Netherlands	rob.alkemade@pbl.nl
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	Dr.	Thomas Elliot	École de Technologie Supérieure, Canada	thomas.elliot@etsmtl.ca

Abstract:

"Nature-based solutions (NbS) are defined by the IUCN as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (Cohen-Shacham et al., 2016). NbS could be used to enhance Ecosystem Services (ES) to solve particular societal challenges, through targeting the provision of multiple social, economic and environmental co-benefits. For example, NbS can contribute to 1) better use of ecosystems; 2) sustainable and multifunctional management of ecosystems; and 3) design and management of new ecosystems. Applying NbS requires an integrated understanding of the environmental, economic and social systems and their interactions.

So far, modelling studies of ES and NbS have predominantly focused on the urban environment. For instance, different scenarios of green and blue infrastructure in cities have been modelled for their impact on ES to achieve urban cooling and flood abatement while also storing carbon, reducing air pollution, improving biodiversity and providing recreation and health benefits (Seddon, 2020). NbS in agricultural or natural landscapes are less commonly described, but nevertheless can address key challenges in landscape management. An example is the restoration of natural forests in upper catchment areas in order to supply multiple ES that help protect downstream communities from flooding while increasing carbon sequestration and protecting biodiversity. Still, modelling how NbS can

increase ES on landscape level is challenging and rarely operationalised, since it requires an integral modelling approach.

Modelling the negative environmental impact of NbS that focus on a specific ES is also underrepresented. For example, the implementation of a NbS aimed at carbon sequestration may require the use of materials and energy that generate an overall net gain in greenhouse gas emissions throughout their supply chains and therefore shifted negative environmental impact. As such, modellers at the interface between industrial ecologies (e.g. Life Cycle Assessment) and ecosystem services must acknowledge the indirect impact of processes on the challenges that an NbS aims to remediate.

NbS, by enhancing ES, seem to be a promising concept to solve societal challenges and policy targets simultaneously and sustainably. Modelling of ES to assess NbS can help decision makers to mainstream NbS in policy and practice. However, a better understanding of how best to model this and how to assess the synergies and trade-offs between different goals is needed.

This session specifically focusses on modelling of how ES modelling can help to assess NbS. How can ES models help us to identify these solutions and help solve societal challenges? How can scenario studies inform us to assess how and where NbS could be applied most effective? How can models be used to quantify the benefits and trade-offs? What are the uncertainties of the predictions? And in general: what are the benefits and barriers to use ES models on NbS within environmental management and planning practice?

We invite speakers to present advancements in modelling ES for NbS in relation to:

- Application of ES models for NbS in real world case studies with stakeholders and end-users
- Linking ES with NbS and societal challenges through models
- Modelling the interactions between the biophysical, economic and the social system
- Good and bad practices in the development and application of ES models for NbS
- Multiscale modelling of ES for NbS (from cities to landscapes) —the impacts of local NbS on landscape scale
- Modelling to inform practices for robust policy-making and sustainable development
- Modelling impact of NbS implementation and trade-off analysis with other/conventional solution

Goals and objectives of the session:

This session is organized by ESP's Thematic Working Group on Modelling (TWG5) and has two main goals:

- to showcase recent advancements and developments in applications of ES models for NbS by the European ES community;
- to initiate a discussion on how to proceed in the development of these models in real life and to learn from each other's experience.

Planned output / Deliverables:

This session will be used to further develop collaboration and a research agenda within the Thematic Working Group on Modelling.

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:

Thematic Working Groups: TWG 13 – Role of ES in Ecosystem restoration

II. SESSION PROGRAM

Date of session: Friday 14 Octobert
Time of session: 11:00–12:30

Timetable speakers

Time	First name	Surname	Organization	Title of presentation
11:00	Hosts	Click here to enter text.	TWG5	Introduction
11:15	Clara	Veerkamp	PBL Netherlands Environmental Assessment Agency	Modelling multiple ecosystem services in 707 European urban areas
11:30	Lucie	Allart	University of Clermont-Auvergne, INRAE, VetAgro Sup,	STRUCTURAL EQUATION MODELLING TO UNDERSTAND THE COMBINED EFFECTS OF CLIMATE, FERTILISATION AND BIODIVERSITY ON GRASSLAND MULTIFUNCTIONALITY
11:45	Michael	Villoslada	University of Eastern Finland	Arctic shrubification: Unveiling the role of reindeer husbandry as a Natured-based solution in tundra ecosystems.
12:00	Stoyan	Nedkov	National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences	Modelling of water-related ecosystem services for nature-based solutions in river basin management
12:15	Ondrej	Cudlin	Global Change Research Institute of the Czech Academy of Sciences	Application of integrated modelling platform IMALBES for Nature Based Solutions in the forest-agricultural landscape

Time of session: 13:30–15:30

Timetable speakers

Time	First name	Surname	Organization	Title of presentation
13:30	Edna	Cabecinca	University of Trás-os-Montes and Alto Douro (UTAD)/CITAB; Commission on Ecosystem Management, International Union for the Conservation of Nature (IUCN)	An integrated modelling approach accounting for biodiversity and ecosystem services through NbS and tackle climate change: The ALICE project
13:50	Solen	Le Clech'	Wageningen University	Modelling the effect of field margins on Ecosystem services – an ex ante analysis of agri-environmental climate measures
14:10	Thea	Wubbelmann	Climate Service Center Germany (GERICS), Helmholtz-Zentrum Hereon; Institute for Physical Geography and Landscape Ecology, Leibniz University Hannover	Urban Ecosystems and heavy rainfall. Estimating the benefits of Nature-Based Solutions under changing climate conditions
14:30	Hosts and all participants	Click here to enter text.	TWG5	Discussion and outlook

III. ABSTRACTS

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

1. Type of submission: Abstract

T. Thematic Working Group sessions: T5a – Ecosystem Services Modelling for Nature-based Solutions

STRUCTURAL EQUATION MODELLING TO UNDERSTAND THE COMBINED EFFECTS OF CLIMATE, FERTILISATION AND BIODIVERSITY ON GRASSLAND MULTIFUNCTIONALITY

Presenting author: Lucie Allart

Other author(s): Frédéric Joly, Claire Mosnier

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Grassland ecosystems are affected by different global change drivers (GCDs) including land use intensification and climate change that impact biodiversity and associated ecosystem services (ES). The ability of grassland ecosystems to deliver multiple ES simultaneously, referred to as multifunctionality, largely depends on plant diversity. We used multiple regression models and structural equation modelling (SEM) to understand how climate and land use intensification impact grasslands' plant diversity and multifunctionality.

We used field data from French Massif Central – the largest European grassland – that offers an open-sky lab to disentangle the effects of climate and land use intensification, thanks to mechanizable high plateaux, and therefore to study the effects of GCDs by using space-for-time substitution.

By building multiple regression models accounting for site-differences in soil, climate, land use and local plant diversity, we found that species richness was the main driver of multifunctionality (R2=0,40, species richness and its interactions accounted for 63% of the explained variability). It shows that species richness largely interacts with the fertilisation level and mean annual temperature (averaged on 20 years), which suggests that the effect of GCDs on multifunctionality are modulated by plant diversity levels. Then, SEM revealed that GCDs indirectly impacts multifunctionality by modifying species richness level, making species richness a pivot variable.

Our results helped describe the complex relationships between plant species richness, climate, fertilisation and multifunctionality at local scale. It shows that preserving multifunctional grasslands in spite of global change implies preserving species richness, which constitutes a pivot and a modulator in GCDs effects on multifunctionality. Therefore monitoring plant species richness may be a way to assess how GCDs dynamically impact grasslands' multifunctionality. Our analyses show how structural modeling could help in guiding the implementation of nature-based solutions, aiming at the preservation of biodiverse and multifunctional grassland ecosystems.

Keywords: climate change, land use intensification, plant diversity, nature-based solutions

2. Type of submission: Abstract

T. Thematic Working Group sessions: T5a - Ecosystem Services Modelling for Nature-based Solutions

Modeling of water-related ecosystem services for nature-based solutions in river basin management

Presenting author: Stoyan Nedkov

Other author(s): Hristina Prodanova, Vanya Stoycheva

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The water-related ecosystem services (WRES) are all ES obtained from ecosystems reliant on water, including both provisioning and regulating. The river basins' availability with good water quality is vital for the health and survival of mankind and living organisms. Therefore, the assessment of ecosystem condition and water-related ecosystem services mapping is key to improving the knowledge, monitoring, and river basins management. And since nature is a climate regulator, the development of nature-based solutions in river basin management would contribute also to accomplishing the sustainable development goals. The modeling of WRES is a key technique to provide data for different aspects of the water cycle that are usually not available through direct or indirect measurements. There is a great variety of models and modeling approaches that deal with water regulation and each of them has its specifications, advantages, and disadvantages, the field of application and limitations, as well as specific data requirements. In this paper, we intend to provide the first results from a research project focused on the development of a methodological framework for mapping, modeling, and evaluation of water-related ecosystem services in order to implement nature-based solutions (NBS) in river basins management. The main role of the ES models is to quantify the implementation of NBS for activities such as flood risk management, erosion, climate change mitigation and adaptation, etc. The modeling is applied in the case study of the Ogosta river basin located in the northwestern part of Bulgaria. We developed an approach that employs a combination of hydrologic modeling through ArcSWAT tool, GIS-based techniques, and the matrix approach. The preliminary results are obtained for the flood regulation ES that enables to define the service providing areas (SPA) and service demanding areas (SDA).

Keywords: Hydrological modeling, ArcSWAT, flood regulation, GIS

3. Type of submission: Abstract

T. Thematic Working Group sessions: T5a – Ecosystem Services Modelling for Nature-based Solutions

Modelling the effect of field margins on Ecosystem services – an ex ante analysis of agri-environmental climate measures

Presenting author: Solen Clec'h
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Linear landscape elements, such as field margins, are nature-based solutions whose adoption is supported by agri-environmental climate measures (AECMs). AECMs are meant to improve ecological conditions on farms and surrounding areas for biodiversity conservation and ecosystem services (ESs). The effectiveness of AECMs is heavily debated and evidence for increased ESs supply is still scarce and context-dependent. Knowledge on trade-offs and synergies among ESs under different AECMs is also lacking. We aimed at assessing the potential of AECMs to provide high levels of multiple ES in three contrasting European agricultural landscapes.

We assessed potential effects of linear field margins (woody, grassy and flower) on seven ESs (agricultural yield, pollination, pest control, habitat maintenance, water quality, climate sequestration and aesthetics). We first allocated linear field margins on land use maps along the edges of existing parcels, varying their share of the total agricultural used area, ranging from 0% to 15%. Next we used the spatially explicit Natural Capital Model that combine data on land use, management characteristics and various environmental characteristics to estimate the average provision of the seven ES under different scenarios (share and type of field margins). Finally, we analyzed trade-offs and synergies between ESs at the landscape level.

While AECMs lead to overall higher ESs level, the type of AECMs, its share within the whole landscape and its location result in specific trade-offs and synergies. Our analyses give insights on the efficiency of AECMs on multiple environmental targets. Our approach is a first step towards a general framework for an ex-ante integrated analysis of AECMs that can be used to design policies. From a more practical perspective, our results can form a basis for additional payments for AECMs, for example in the form of carbon credits, and could help optimizing the supply of multiple ESs in agricultural landscapes.

Keywords: small-scale agriculture, buffer strips, trade-offs, nature-based solutions, linear field margins

4. Type of submission: Abstract

T. Thematic Working Group sessions: T5a - Ecosystem Services Modelling for Nature-based Solutions

Modelling multiple ecosystem services in 707 European urban areas

Presenting author: Clara Veerkamp
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Nature-based solutions (NbS) emphasizing ecosystem's multi-functionality i.e., address societal challenges by delivering multiple ecosystem services (ES) simultaneously. Several cities have taken up NbS as a strategy to foster sustainable urbanization and to cope with impacts of climate change, loss of biodiversity and pressures on human health. Quantitative assessments can play an important role to evaluate the extent to which NbS actually deliver on this promise. Although there is a growing body of such assessments, these are typically geographically bound or spatially restricted (e.g., single city, neighborhood or street) which makes it difficult to compare the effectiveness of NbS across different cities or regions. Moreover, urban ES assessments predominately focus on the capacity of urban ecosystems to deliver ES, while societal demands for these ES are hardly quantified. Hence, the extent to which nature offer relevant solutions to particular challenges is widely unknow to decision-makers.

In this study, we assessed multiple ES across major European cities, considering the ES supply and societal demands for these ES. To that end, we applied spatially explicit urban ES models (building upon urban InVEST and other available GIS methods) to 707 urban areas, and quantified five urban ES likely to be of high priority in urban planning and decision making (i.e., local temperature regulation, global climate regulation, flood protection, habitat and gene pool protection and outdoor interaction).

In this presentation, we will share the results of our large-scale assessment, focusing on the distribution of urban ES delivery across the 707 European urban areas. We will discuss hotspots of ES and relationships between ES (synergies and trade-offs) as well as illustrate explorative variables which best explain ES delivery in our analysis. Moreover, we would like to reflect on the development and application of urban ES models for NbS based on the challenges encountered in our large-scale assessment.

Keywords: nature-based solutions, cities, Europe, spatial modelling

5. Type of submission: Abstract

T. Thematic Working Group sessions: T5a - Ecosystem Services Modelling for Nature-based Solutions

An integrated approach to the assessment of biodiversity and selected ecosystem services: from vegetation status to sustainable landscape

Presenting author: Ondrej Cudlin

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The assessment of the state of biodiversity and ecosystem services in the landscape increasingly urgently requires an integrated approach at several levels: unified data sources, assessment scales, and a set of monitored functions and services that are interconnected and influence each other. The vegetation component and its diversity is a key element for the functioning of the landscape.

The presented IMALBES modelling platform is an integrated, multi-scale and multi-criteria tool that places great emphasis on the integration of information on the state of biodiversity into individual models of ecosystem functions and services. A special algorithm is implemented for each evaluated function. Individual models (algorithms) are linked in terms of process and data – they require identical input data. The calculation of several indicators takes place in one step, the partial results of one model are required by the following model in order to ensure the procedural and logical integrity of the entire process.

Detailed mapping and assessment of vegetation (naturalness, connectivity and resilience) at the habitat level represents the initial step of the entire model. This layer, created at a scale of 1:10,000, enters individual models of ecosystem functions and services as a basic geospatial matrix. This is followed by an analysis of selected provisioning and regulating services for which vegetation is directly responsible (habitat services, carbon sequestration, soil protection). Habitat services are then analyzed in interaction with other functions (e.g. evapotranspiration and water retention). The last step are comprehensive analyzes of the sensitivity of biodiversity to multiple pressures and driving forces and analysis of the land degradation. The model allows, thanks to the advanced use of satellite data, to assess the state of biodiversity and the sustainable use of natural resources in the present and in the future. Case studies from locations in the Czech Republic will be presented.

Keywords: Integrated modelling, Ecosystem functions and services, Biodiversity assessment, Forest-agricultural landscape, Sustainable landscape

6. Type of submission: Abstract

T. Thematic Working Group sessions: T5a - Ecosystem Services Modelling for Nature-based Solutions

An integrated modelling approach accounting for biodiversity and ecosystem services through NbS and tackle climate change: The ALICE project

Presenting author: Edna Cabecinha
Other author(s): André Fonseca, Simone Varandas
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Over the last decades, an increasing number of ES modelling applications from local to global scales have been created. ALICE project aimed to improve Atlantic Landscapes management accounting for biodiversity and ecosystem services (ES) by developing a comprehensive package of new methods, tools, and procedures to identify barriers to the delivery of benefits from NbS implementation across Atlantic case studies (Portugal, Spain, France, and UK-Ireland). This integrative modelling tool was supported by a participatory approach incorporating socioeconomic and climate change scenarios, identifying the ES benefits delivered by NbS, and exploring the economic and social barriers to NbS implementation.

The increasing anthropogenic pressure (climate and land-use changes) has a major impact on ES and biodiversity. NbS protect, manage, and restore natural or modified ecosystems, addressing societal challenges, providing ES and biodiversity benefits, and promoting human well-being.

Our study analyses the impact of land use and climate change scenarios on the spatial distribution of ES and biodiversity, between historical period (1950 – 2018) and future period (2041 – 2070), at a watershed level, over the Atlantic region, highlighting the importance of integrating at landscape level management options through NbS implementation. Based on two IPCC scenarios (RCP4.5 and RCP8.5), using a 5-model ensemble developed under the EURO-CORDEX project. A downscaling methodology was applied to increase spatial resolution from ~12 km to ~1 km in all climate variables. Land cover maps were developed using the Forecasting Landscape Scenarios Model.

Collaborative mapping was used to engage key stakeholders through participatory approaches for NbS designed by enhancing predictive capabilities with artificial intelligence algorithms and a multi-model platform.

With these results, we hope to show how ALICE can contribute to more effective and integrative management through this multidisciplinary, collaborative approach to implement NbS and improve ES and Biodiversity under Global Change.

Keywords: Modelling, Climate change, Ecosystem services, NbS, Participatory approach

7. Type of submission: Abstract

T. Thematic Working Group sessions: T5a - Ecosystem Services Modelling for Nature-based Solutions

Arctic shrubification: Unveiling the role of reindeer husbandry as a Natured-based solution in tundra ecosystems.

Presenting author: Miguel Villoslada
Other author(s): Timo Kumpula,
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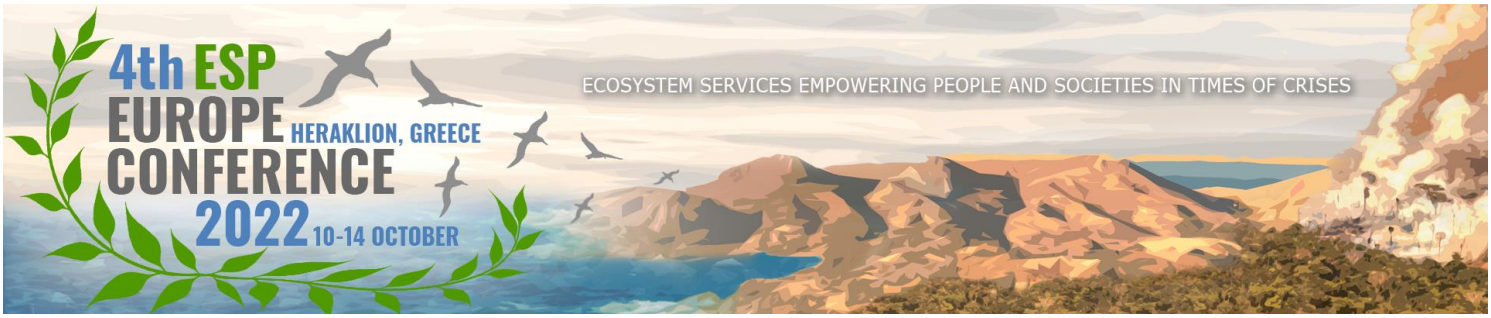
Arctic terrestrial ecosystems are undergoing a state of transition, reflected in changes in ecosystem structure, composition, functioning and the supply of essential ecosystem services. Shrub expansion induced by climate change, or shrubification, may potentially alter hydrological dynamics, carbon feedbacks and microclimate conditions. On the other hand, traditional reindeer husbandry could act as a Nature-based solution, halting shrub expansion and controlling the effects of climate change in the Arctic.

It is of upmost importance to closely monitor and model these changes in order to gain a complete understanding of their dynamics and improve the adaptive capacity of the regions under study. Although shrubification of arctic wetlands has been well-documented using traditional field ecology techniques, there is still a lack of understanding of the potential controlling effect of reindeer husbandry at the landscape scale. In this regard, satellite-based earth observation data has played a key monitoring role during past decades. However, the fine scale of these processes often renders them invisible or hazy under the eye of satellite sensors. On the other hand, the rapid growth of Unmanned Aerial Systems and sensor capabilities opens new opportunities for mapping and monitoring.

Here, we present a toolset of Unmanned Aerial Systems and Machine Learning algorithms that enables highly accurate monitoring and modelling of landcover change dynamics in the sub-arctic tundra. More importantly, this toolset reveals the controlling effect that reindeer exert on shrubification processes. We combined multispectral and photogrammetric data with an ensemble of machine learning algorithms to map the extent of woody shrubs and quantify their above-ground biomass and topsoil moisture levels at two study sites across the Finnish-Norwegian border.

We conclude that traditional reindeer husbandry constitutes a Nature-based solution, able to prevent the degradation of arctic tundra wetlands and ensure the supply of ecosystem services.

Keywords: Arctic tundra, shrubification, ecosystem condition, remote sensing, ecosystem services



8. Type of submission: Abstract

T. Thematic Working Group sessions: T5a - Ecosystem Services Modelling for Nature-based Solutions

Urban Ecosystems and heavy rainfall.
Estimating the benefits of Nature-Based Solutions under changing climate conditions

Presenting author: Thea Wübbelmann
Other author(s): Kristian Förster, Claudia Dworczyk
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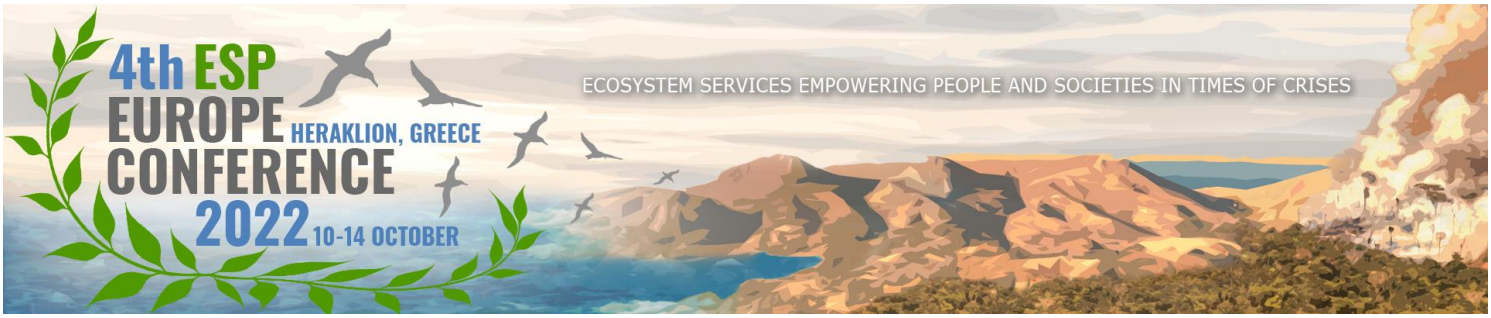
Urban areas are mostly highly sealed spaces, which often leads to large proportions of surface runoff. Simultaneously, heavy rainfall events are projected to increase in frequency and intensity with global climate change. Consequently, higher risks and damages from pluvial flooding can be expected. With Flood Regulating Ecosystem Services (FRES), the benefits from nature to people to reduce surface runoff and runoff peaks can be determined. However, urban FRES are rarely studied for heavy rainfall events under changing climate conditions. Therefore, we first estimate the functionality of urban FRES supply and demand under changing climate conditions. Secondly, we identify the impacts of Nature-based solutions (NBS) on FRES supply and demand and their potential future functionality and benefits with regard to more intensive rainfall events.

A district of the city of Rostock serves as case study area. Besides the reference conditions based on the current land use, we investigate two potential NBS: 1) an increasing number of trees; and 2) unsealing and soil improvement. Both NBS are applied for three heavy rainfall events. Besides a reference scenario, two future scenarios were developed to investigate the ecosystem service functionality, based on 21% and 28% more intense rainfall. While the potential FRES demand was held constant, we assessed the FRES supply and actual demand for all scenario combinations using the hydrological model LEAFlood. Comparing the actual demand and supply indicates the FRES-budget to identify the changes of FRES supply surplus and unmet demand.

The use of FRES indicators from hydrological models to estimate future functionality under changing climate conditions and the benefits of NBS can serve as a communication tool for decision makers to reduce future urban flood risk. In a next step, different scenarios for



flood regulation demand and other adaptation measures can be tested together with practical applications in other urban areas.

Keywords: Climate adaptation, Hydrological Modelling, LEAFlood (Landscape vEgetAtion and Flood model), Flood Regulating Ecosystem Service supply and demand, Mismatch analysis, Scenarios