International Society for River Science

RIVERINE LANDSCAPES AS COUPLED SOCIO-ECOLOGICAL SYSTEMS

6TH BIENNIAL SYMPOSIUM OF THE INTERNATIONAL SOCIETY FOR RIVER SCIENCE

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6th biennial Symposium of the International Society for River Science

BOOK OF ABSTRACTS

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The 2019 edition of the biennial symposium of the International Society for River Science is hosted by the Institute of Hydrobiology and Aquatic Ecosystem Management at the University of Natural Resources and Life Sciences (BOKU) in cooperation with the International Association for Danube Research (IAD), the I.S. Rivers conference (Integrative sciences and sustainable development of rivers) and the International Conference on the Status and Future of the World's Large Rivers.

"Riverine landscapes as coupled socio-ecological systems"

This years symposium emphasizes research related to the use and protection of water resources with a focus on complex and large river systems as well as highly modified riverine landscapes.

The event incorporates research at different trophic, temporal and spatial scales to serve as a wide platform for the exchange of ideas and experiences between science and practice. Building bridges between ecology, geomorphology, hydrology, biogeochemistry, social sciences, environmental engineering, technology and economics.

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Special sessions

SP01: **River rehabilitation and floodplain restoration: methods and measures for sustainable success**
Convenors: Bernd Cyffka (CU Eichstaett-Ingolstadt/Floodplain Institute Neuburg, Germany), Ian Fuller (Massey University, New Zealand)
Worldwide, rivers and floodplains have been changed to suit human society. Often rivers were regarded as conduits for water, and managers ignored river morphology, sediment transport and other aspects of this complex ecosystem. Today we try to rehabilitate rivers and restore floodplains. But to what? And are we restoring resilient ecosystems? What methods and measures are necessary to turn back time, and is that even possible? There are only a few promising examples of genuine restoration in the world, but many unresolved cases and problems. In some major rivers like the Danube in Europe, the EU has tried to regulate issues by the Water Framework Directive, but other parts of the world (e.g. New Zealand) lack such targeted legislation. The session aims at presenting modern examples of river and floodplain restoration, and invites contributions representing both successes and failures, from which we will identify the key requirements for sustainable success.

SP02: Fish Ecology in Rivers: ecosystem functions and impacts

Convenors: Hubert Keckeis (Univ. Vienna, Austria), Paul Humphries (Charles Sturt University, Australia)

Fish assemblages are strongly affected by human alterations and water extraction from rivers. In this session the underlying mechanisms associated with anthropogenic alteration to river ecosystems and how they affect assemblage structure and biodiversity of riverine fish communities will be considered. Topics can include bottom-up and top-down control, food web analyses and trophic relationships, productivity and production, resource partitioning, abiotic conditions and biotic interactions. We would like to explore our knowledge of which ecosystem functions and processes drive the occurrence, abundance and spatio-temporal distribution patterns of riverine fishes.

SP03: Freshwater biodiversity: networks, monitoring, data compilation and publishing

Convenors: Astrid Schmidt-Kloiber (Boku Vienna, Austria), Sonja Jähnig (IGB Berlin, Germany), Aaike De Wever (INBO, Belgium), Koen Martens (RBINS, Belgium), Daniel Hering (UDE, Germany

Global pressures on freshwater ecosystems are high and rising. Viewed primarily as a resource for humans, current land use and water management practice have led to catastrophic declines in freshwater species and the degradation of freshwater ecosystems, including rivers and floodplains. It is essential to close existing knowledge gaps like the distribution and status of freshwater biodiversity at all spatial and temporal scales as well as the question which data are needed to balance human needs while sustaining biodiversity. Recently formed multidisciplinary freshwater networks as the Alliance for Freshwater Life or Freshwater BON are intended to mobilize knowledge and data, to harmonise monitoring and to foster outreach and funding. We welcome contributions from all freshwater research networks as well as individually working scientists in the field of freshwater biodiversity, monitoring, data mobilisation, compilation and publishing.

SP04: The environmental flow and water management nexus: implementation challenges, strategies, and outcomes of environmental flow programs

Convenors: Sarah Yarnell (University of California Davis, USA), Robert Lusardi (University of California Davis, USA)

Integrating environmental flows in water management decision-making is critical to sustaining at-risk freshwater ecosystems. New modeling tools and frameworks for managing environmental water are emerging to address this need within distinct scientific, legal, social, and management contexts. The success of environmental flow programs depends on our understanding of ecosystem processes, how such understanding is expressed in modeling tools, and how environmental water needs are integrated in existing management frameworks. This session will highlight successes and challenges associated with the implementation of environmental flow programs from around the world. Talks will include: technical approaches that advance scientific understanding of river functioning; the development, implementation, and transferability of decision-support tools to guide management; examples of interdisciplinary collaboration and stakeholder engagement; and approaches for monitoring program effectiveness.

SP05: Role of aquatic plants in river biogeochemistry from source to mouth

Convenors: Jonas Schoelynck (University of Antwerp, Belgium), Stefan Preiner (BOKU Vienna, Austria)

Output of organic matter and inorganic nutrients from rivers have impacted the trophic state of the estuarine and coastal sea ecosystems globally. The quality and quantity of the nutrient loading is determined by upstream processes in the river basin. Not only because here a substantial part of the input takes place, but also because geomorphological, hydraulic, geochemical and ecological processes lead to retention, transformation or removal of materials. In-stream macrophytes are playing an important role in organic matter production and nutrient cycling though they have obtained less attention in literature. This session focusses on plant scale, patch scale, and reach scale effects of macrophytes on carbon and nutrient cycling. Research on direct impacts like metabolism and nutrient uptake studies, as well as on indirect effects considering macrophytes as ecosystem engineers, which controls flow and sedimentation are included.

SP06: Riverine landscapes under pressure - how much complexity is needed to perform integrative research?

Convenors: Bernhard Pucher (BOKU Vienna, Austria), Lena Simperler (BOKU Vienna, Austria), Matthias Pucher (BOKU Vienna, Austria), Peter Flödl (BOKU Vienna, Austria), Thomas Hein (BOKU Vienna, Austria)

Riverine landscapes are complex systems providing a variety of ecosystem services. Among others, pressures from land use change, energy procurement and urbanisation lead to heavily modified systems. To address drivers of change within socio-ecological systems at different spatial and/or temporal scales integrative approaches are necessary. This can open up methodological "black boxes" between different disciplines and thereby lead to a deeper understanding of the tight, but complex interactions between society and environment. Integrating more disciplines however leads to higher complexity (e.g. concepts, methods), raising the question of the optimal degree of complexity. In this interactive session, the approaches to integrative research and its implications on society and environment, policies and management options of riverine landscapes shall be discussed by oral and poster presentations.

SP07: Ecosystem services along rivers and floodplains - an integrative tool to assess and optimize river and floodplain management

Convenors: Barbara Stammel (KU Eichstaett-Ingolstadt, Floodplain Institute Neuburg, Germany), Mathias Scholz (UFZ, Germany), Christine Fischer (UFZ, Germany)

In the last centuries, most rivers and floodplains have been severely modified to optimize for human use, resulting in a decrease in the ecological status and relating ecosystems services. Management plans today have to be integrative regarding many aspects from different disciplines. The assessment of multiple ecosystem services (ES) across ecosystems (from aquatic to terrestrial) combines methods from different scientific disciplines (e.g. hydrology, biology, agriculture and land use, landscape planning). Here, the concept of ES offers a new approach to solve this complex decision-making process by enabling a comparison of management options across disciplines. In the session, we want to give a platform to different methods of ES evaluation and their joint analysis. Presentation can deal with ES assessments in rivers and floodplains, with the analysis of synergies and trade-offs of ES, or ES as communication tool in decision-making processes.

SP08: Towards the integration of interdisciplinary research networks in restoration projects for riverine landscapes

Convenors: Christiane Schulz-Zunkel (UFZ, Germany), Mario Brauns (UFZ, Germany), Carolin Seele (Uni. Leipzig, Germany)

Near-natural rivers and their floodplains are biodiversity hotspots and provide numerous ecosystem services. However, riverine landscapes are faced with multiple pressures that dramatically change its functioning. Restoration creates more natural flooding areas and protects and improves the condition of riverine landscapes. It is important to accompany restoration projects with an interdisciplinary research network (IRN) in order to interpret and reflect on its effects in a scientifically sound way. This session aims at exchange on methods, results and applications in order to the successful integration and interpretation of field and laboratory data gathered from various restoration projects in riverine landscapes. It should also address the challenges and lessons to be learnt. Thus it gives the possibility to present work relevant for restoration in riverine landscapes across different countries related to biodiversity and ecosystem services.

SP09: eDNA, an emerging tool for river assessment, biodiversity research and conservation

Convenors: Point Didier (BOKU Vienna, Austria)

Since its first application to macroorganisms, environmental DNA (eDNA) has increasingly appeared to be a promising non-invasive method for improving aquatic biodiversity monitoring. With the emergence of next-generation sequencing platforms and the use of universal PCR priers (eDNA metabarcoding), large collections of taxa can be identified via a single analysis. This not only offers the possibility to detect rare or evasive species but also allows the rapid biodiversity assessment of large aquatic communities. In the case of water samples collected in rivers, eDNA contains both intra-organism DNA (e.g., small planktonic organisms) and extra-organism DNA (e.g., from fish) which can be cellular or extracellular and degraded. For macroinvertebrates, eDNA is mainly extracted from bulk samples. The use of this technic is now the subject of many works demonstrating its great interest but also the problems raised by its application in river system (e.g. eDNA detection distance).

SP10: Links between thermal dynamics, hydromorphology and freshwater ecology

Convenors: Davide Vanzo (EAWAG, Switzerland), Roser Casas-Mulet (TU Munich, Germany), Stephen Dugdale (University of Nottingham, UK), Kate Mathers (EAWAG, Switzerland)

Ongoing pervasive anthropogenic pressures result in alterations in hydrological, thermal and sediment river regimes. Such alterations will potentially be exacerbated by the forecast of prolonged durations of warmer periods driven by climate change. Such unprecedented global changes in aquatic systems call for immediate actions to develop effective climate adaptation strategies. Understanding the interactive links and the feedbacks between temperature, hydromorphology and freshwater ecology, is therefore a key task for both scientists and river managers. In this context, we solicit contributions on river temperature research and its links to river hydromorphology and/or ecology. Potential topics of interest are, but not limited to, sediment and thermal effects on river biota, hydro-morphological drivers of thermal heterogeneity and temperature integration in river habitat modelling.

SP11: Rivers in the industrial era

Convenors: Gertrud Haidvogl (Boku Vienna, Austria), Goncalo Duarte (University of Lisbon, Portugal)

During the late 19. and 20th century, societal imprint on rivers increased at an unprecedented pace and intensity. The industrialization of rivers weakened the century long relationship between societies and their local and regional rivers. For example, power grids supported the transfer of electricity to consumers far away from production. Heavy machinery driven by fossil fuels enabled systematic river channelization for shipping and flood protection. Fish often lost its importance as local food resource because supply shifted to resources imported by steam ships or railways. On a global scale, freshwater biodiversity changed and rivers became ecologically degraded. These general trends exhibited local and regional differences, depending on diverse and intertwined environmental and societal processes. Investigating such trajectories can help to better understand different developments of river systems and their present status.

SP12: Saving Large Rivers as Ecological Corridors - Management and Restoration

Convenors: Thomas Hein (Boku Vienna, Austria), Paul Meulenbroek (Boku Vienna, Austria), Daniel Trauner (Boku Vienna, Austria)

Large river systems are lifelines connecting a multitude of countries and bioregions, characterizing landscapes, providing resources, and habitat for flora and fauna. They represent a historic, economic and natural heritage of human society. One of their natural characteristic is to act as a migration route and thus, as ecological corridor for biota along their watercourses and the adjacent wetlands. Especially fish are excellent bio-indicators for the functionality of ecological corridors. Their populations have suffered substantially from overfishing, pollution, habitat destruction and disruption of their migration routes. To counteract the destruction of these corridors concerted transnational investigations, management plans and actions for their restoration as well as supportive conservation measures are highly needed.

SP13: Emerging challenges for wild fish populations and their implications in the context of fisheries management

Convenors: Günther Unfer (Boku Vienna, Austria), Florian Borgwardt (Boku Vienna, Austria), Kurt Pinter (Boku Vienna, Austria)

Human activities that negatively affect habitat quality of fish through a variety of pressures such as hydro-morphological alterations resemble the major problem for wild fish populations. Next to these, unsustainable fisheries use, the reestablishment of (formerly) endangered piscivorous predators (e.g., cormorants, otters), and the spreading of invasive fish species represent threats to wild fish populations challenging their management. Emerging issues such as chemical and parasitological problems associated with climate change impacts raise additional challenges and cause substantial problems for natural fish stocks. This session will focus on the emerging issues and will provide a dialogue platform for researchers working on these heterogeneous topics, conjointly dealing with the ecology and future management of wild fish populations.

SP14: Mitigating ecological impacts in a flow-altered world

Convenors: Daniel Hayes (University of Lisbon, Portugal), Miguel Moreira (University of Lisbon, Portugal), Alban Kuriqi (University of Lisbon, Portugal), Lisa Schülting (Boku Vienna, Austria), Stefan Auer (Boku Vienna, Austria), Franz Greimel (Boku Vienna, Austria)

The growing demand for water resources has disrupted the natural flow regime and associated hydro-morphological processes, resulting in heavily regulated river systems. Diverse riverine organism groups serve as valuable indicators for diagnosing aquatic ecosystem health, as they respond well to hydrological alterations occurring from inter-annual (e.g., environmental flow) to sub-daily (e.g., hydropeaking) time scales. Thus, biota can be used for the assessment of flow alteration impacts as well as defining ecological rehabilitation or restoration measures. Although a significant amount of research has studied hydro-ecological relationships, many knowledge gaps remain, especially regarding the efficiency of mitigation measures which also incorporate the trade-offs between ecology, economy and other stakeholders. This session aims to advance the assessment of environmental impacts of water resources infrastructure, develop creative mitigation measures, and restore riverine ecosystems.

SP15: Natural small water retention measures: can we asses impacts on a catchment scale? (Interreg CE Projekt FramWat)

Convenors: Tomasz Okruszko (Warsaw university of Life Science, Poland), Primoz Banovec (University of Ljubljana, Slovenia), Mateja Skrejanec (University of Ljubljana, Slovenia), Eva Feldbacher (WCL, Austria), Damiano Baldan (WCL, Austria)

Natural Small Water Retention Measures (NSWRMs) can retain water in the landscape and release it gradually, thus affecting key riverine-provided ecosystem services. Those provisions may improve river ecological status and decrease risk of droughts and floods. However, a discrepancy exist between the local, single measure functioning and the interactions between multiple sets of measures at catchment scale. Therefore, River Basin Management Plans and other relevant policy document are hardly considering NSWRMs as valuable options in the planning process. GIS-based technology and distributed hydrological models can be the useful tools to bridge this knowledge gap, providing the policy makers valuable supporting information on effectiveness at the catchment scale. During this session we will exchange so far achieved results and share important questions for incorporation of NSWRM into the river basin planning practice, and provide insights into the ongoing Interreg CE project FramWat (Framework for improving water balance and nutrient mitigation by applying natural small water retention measures).

SP16: Rivers: from Source to Sea

Convenors: Chris Bradley (University of Birmingham, UK)

This session aims to span the River - Sea continuum bringing together interdisciplinary studies that span the physical, chemical, and biological sciences linking river catchments and transitional zones to the coastal sea. These dynamic environments are changing rapidly and experiencing multiple pressures: through climate change, rising sea level, river regulation, and changing catchment land use and management. In responding to these pressures, more research is required to understand how these systems are evolving. For example, what are the impacts of catchment dynamics on marine and transitional systems downstream (and vice versa)? The session aims to provide a platform for exchange of findings from research that provides a perspective on the wider River - Sea continuum and hence advance our understanding of system functioning from a transboundary perspective to provide the science that can underpin better-informed and holistically engaged environmental protection.

SP17: S.M.A.R.T.: Science for the Management of Rivers and their Tidal systems. Outcomes from a 9-years international doctoral programme in interdisciplinary river science

Convenors: Guido Zolezzi (University of Trento, Italy), Geraldene Wharton (Queen Mary University of London, UK), Franz Hölker (IGB Berlin, Germany), Gregorio Alejandro López Moreira Mazacotte (University of Trento, Italy), Alyssa Jennifer Serlet (University of Trento, Italy)

SMART (http://www.riverscience.it), a multidisciplinary, 9-years joint doctoral programme, has trained and awarded joint Ph.D. degrees to 38 candidates, supervised by an interdisciplinary team of nearly 30 supervisors, encompassing engineering, fluid mechanics, hydrology, geomorphology, ecology, physiology to biogeochemistry. It aimed to move the field of river science forward by developing research through three main cross-cutting areas: (A) Ecosystem resilience to stressors; (B) Natural functioning; (C) Rehabilitation of function. The aims of the session are (1) to present and share with a broader community key research outcomes from SMART, (2) to share lessons learned in training young interdisciplinary researchers, and (3) to reinforce the worldwide network initiated within SMART, encouraging involvement of interested researchers. Contributions are primarily welcomed from SMART Alumni, but they are also open to other researchers proposing contributions fully within the spirit of the session

SP18: Ecological and social landscape-scale drivers of freshwater biodiversity: Novel findings and future challenges

Convenors: Rafaela Schinegger (Boku Vienna, Austria), Dana M. Infante (Michigan State University, USA)

Understanding of landscape influences on freshwaters and their inhabiting organisms has advanced substantially due to greater availability of large-scale ecological datasets, innovations in analytics, new data management technologies, and many important studies that have tested and applied the landscape approach in different systems globally. Additionally, research is beginning to occur that couples ecological knowledge with knowledge of socioeconomic factors also important to freshwater biodiversity. This session showcases advances to this understanding by offering insights into multi-scale landscape drivers influencing aquatic biodiversity within single river basins, through entire regions, and by cross-continental comparisons, along with novel analytical techniques for addressing hierarchical relationships among influences. Results represent state-of-the-knowledge on (multiple) landscape drivers on freshwater biodiversity, offer new strategies for protection and restoration of habitats, and point to critical management gaps and data needs, including critical information on a diverse array of social processes that could aid in efforts to conserve freshwater biodiversity.

SP19: Characterising riparian vegetation status and pressures

Convenors: Marta Gonzalez del Tanago (Universidad Politécnica de Madrid, Spain), Tenna Riis (Aarhus University, Denmark), Tomasz Okruszko (Warsaw University of Life Sciences, Poland)

Riparian vegetation is a critical component of riverine landscape and thus its structure and change provide useful information on the underlying changes in the fluvial system. Throughout history, riparian areas have been heavily managed and have consequently experienced widespread degradation. Recognizing the importance of riparian vegetation has resulted in much research and their structure and change provide useful information on the underlying changes in the fluvial system. This session invites studies on riparian vegetation, notably on the tools to assess status (i.e. structure, function and of related ecosystem services), pressures and changes, across all spatial and temporal scales using different methodological approaches (field, modelling, remote sensing, etc.) in a variety of geographic settings.

SP20: Riparian ecosystems management and restoration

Convenors: Ragnhildur Sigurdardottir (Reykjavik Academy, Iceland), Roland Jansson (Umeå University, Sweden)

Riparian ecosystems comprise the physical environment and biological communities that lay at the interface of freshwater and terrestrial systems. They are recognised as ecosystems that are highly diverse and contain specialist ecological communities, as well as providers of multiple ecosystem services. Riparian ecosystems have been heavily managed and have consequently experienced widespread modification over the last centuries. Recognizing of the importance of riparian ecosystems in providing ecosystem service has resulted in many efforts to develop a wide variety of management practices. This session invites presentations on riparian ecosystem management through different issues: current management, legislation, restoration measures, genetic conservation, applied tools and indicators, public and stakeholders' inclusion, development of innovative management plan and financial instruments, etc.

SP21: Educated future: teaching about rivers and its implications for sustainable river management

Convenors: Joanna Zawiejska (Pedagogical University of Cracow, Poland), Lorenzo Picco (University of Padova, Italy)

As implementing river restoration projects and sustainable river management require public acceptance and stakeholder participation it has become evident that social perceptions of rivers and river processes are an important element in the success of such efforts. With many perception studies focused on adult members of the public, it is interesting to explore how perceptions and attitudes towards rivers are shaped and influenced by the formal education systems in different countries. From pre-school to university levels, all students are instructed directly and indirectly about rivers, their dynamics as well as their role and significance to society. The content, consistency and contexts of the messages that are delivered through curricula and syllabi across subjects and disciplines to a large proportion of the public are likely to effectively shape young people's knowledge and attitude towards rivers, and influence their future behaviours. This session invites contributions on how river science is taught (including examples of both successes and failures), river perceptions by students and teachers, and the implications of the current formal education about rivers for the river environment and the society in the future.

SP22: River resilience and the Anthropocene

Convenors: David Gilvear (University of Plymouth, UK), Andy Large (Newcastle University, UK), Martin Thoms (University of New England, Australia)

This session will explore the concept or river resilience and the usefulness of the concept for managing rivers in the Anthropocene. It will explore river resilience in terms of hydro-geomorphological, ecological and social systems. Issues to be discussed will include resilience of what river system components and to what disturbances and whether resilience offers a new paradigm or is just a reframing of existing concepts.

SP23: "Future visions" for large rivers

Convenors: Clifford A Ochs (Oxford University, Mississippi); Mike Delong (Winona State University), Andrea Funk (Boku Vienna)

To "future vision" is to imagine possibilities. In this session, we seek to imagine what is possible in a future world under alternative trajectories or scenarios for the state of large river systems. What realistic visions of future large river system conditions should we consider, and then aim to avoid or try to produce? How should these visions inform research directions, planning, and management? In a social-ecological context, how can and should alternative stakeholder or community perspectives be included in the visioning process? For this session, we invite contributed talks that explore alternative visions for future states of large river systems, under different premises and weighing different potentialities.

SP25: **Nature-based solutions at different scales in urban and rural river basins**

Convenors: Jochen Hack (TU Darmstadt, Germany), Barbara Schröter (Leibniz Centre for Agricultural Landscape Research, Germany)

Nature-based solutions are actions to protect, sustainably manage, and restore natural or modified ecosystems. They often address societal challenges more effectively and adaptively than merely technical solutions, while simultaneously providing human well-being and biodiversity benefits. Nature-based solutions (NBS) to socio-ecological problems in urban and rural riverscapes are presented and discussed. 3-4 introductory talks by international experts are followed by a world cafe in order to interactively discuss and gain key insights from inter- and transdisciplinary research and practice. NBS from the local to the regional scale are addressed with regard to (ex. questions): How differs the design of NBS at different scales? Are there synergies of actions at different scales? How can integration be achieved? How to engage actors in problem definition and solution development? What are dominant ecological processes at different scales? It is aimed for a common publication as a product.

AJWI: **Austrian Joint Water Initiative**

Convenor: Robert Konecny (Umweltbundesamt – Environment Agency Austria)

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Abstracts – oral presentations

Session **GS01**

The impact of extreme hydrological conditions on zooplankton of floodplain lakes of a large river; Vistula River, Poland

Author(s): Paweł Napiórkowski & Nikola Kolàrova

Affiliation(s): Department of Hydrobiology, Kazimierz Wielki University in Bydgoszcz, Bydgoszcz, Poland

Presenting author: Paweł Napiórkowski

The acceleration of global climate change has been observed since the end of the 20th century. It has brought a rise in average temperatures and increased frequency of extreme weather events. Extreme weather events can lead to floods but can also cause drops in water levels in rivers and their floodplain lakes during droughts.

The study was conducted in different six floodplain lakes in the growing seasons from 2006 to 2015 at the lower Vistula Valley (Poland). During the studies, there were periods with very high water level and extremely low water level. These periods were taken for further consideration.

The aim of study was to evaluate the impact of climate change (drought and flood events) on the environmental conditions and zooplankton community in floodplain lakes of the lower Vistula Valley. Our research also included testing the Intermediate Disturbances Hypothesis (IDH) on zooplankton under various hydrological conditions.

Decreased water levels lead to higher water fertility and dominance of eurytopic organisms, mainly rotifers in the zooplankton. Rotifer species thrive because they can adapt to a wide range of environmental conditions. Low water level caused also decrease in species diversity.

The flood destroyed submerged plants and brought suspension, that way it changed abiotic conditions of life in the floodplain lakes. The flood caused a decrease in the number of species and rebuilt the structure of zooplankton in the reservoirs. The increase of rotifers species at the expense of crustaceans was observed at different sites. There was also a several fold increase in abundance of zooplankton.

The IDH predicts low species diversity in ecosystems exposed to high levels of disturbance. Under these conditions the survival is guaranteed only for species which can easily adapt to changing and extreme conditions or can quickly recolonize a given ecosystem (e.g. floodplain lakes after floods and during drought). According to the IDH, it was observed, that during high disturbances a few species monopolizing the resources e.g. Keratella tecta (Gosse, 1851), whose dominance at low water status reached 40% and after a very high level even 60%. The conditions after the flood and during drought promoted the development of small rotifers, feeding on suspension and bacteria.

At intermediate levels of disturbance (medium and low flooding during potamophase), species diversity should be largest because many taxa tolerate existing environmental conditions, but none can dominate in the population.

Session **GS01**

The effects of extreme water level fluctuations on aquatic vegetation in floodplain lakes along the Lower Rhine

Author(s): Gerben Van Geest (1); Lilith Kramer (1) & Edwin Peeters (2)

Affiliation(s): (1) Deltares, Utrecht, The Netherlands; (2) Wageningen University and Research, Wageningen, The Netherlands

Presenting author: Gerben Van Geest

The cover and species composition of aquatic vegetation in shallow floodplain lakes depends strongly on the amplitude of water level fluctuations in the river. Especially extreme water level fluctuations may have a strong impact. We analyzed yearly changes in vegetation structure of 70 lakes in the floodplain of the river Lower Rhine during 20 years (1999 - 2018) in relation to environmental variables related to the hydrological regime of the river (flooding, droughts), lake morphometry, and lake age. During the first 12 years (1999 - 2010), these lakes were exposed to the usual discharge pattern of the Lower Rhine in The Netherlands, with relative high river levels during spring and low levels during autumn. During 2011-2018 however, there were several years with extreme low river levels during spring, while exceptional summer floods occurred during 2013 and 2016. Our results show that especially low river levels may have a strong impact on composition and succession of aquatic vegetation. In this presentation, we will present and discuss the effects of these extreme water level fluctuations for aquatic vegetation in floodplain lakes.

Session **GS01**

Effects of drying and re-wetting on biofilm processes in temperate headwater streams

Author(s): Gabriele Weigelhofer (1); Lisa-Marie Ziegler (2); Manuela Waberer (2); Daniel Von Schiller (3); Michael Mutz (4) & Michael Tritthart (1)

Affiliation(s): (1) University of Natural Resources and Life Sciences Vienna, Austria; (2) WasserCluster Lunz -Biological Station GmbH, Austria; (3) University of the Basque Country, Spain; (4) Brandenburg University of Technology, Germany

Presenting author: Gabriele Weigelhofer

Over the past decades, the frequency and duration of droughts has increased across Europe, causing perennial streams to shift to intermittency even in temperate regions. Our study aims to investigate the short- and long-term effects of periodic drying and re-wetting on different biogeochemical processes in temperate streams in Austria located along a land use and pollution gradient.

In the project PURIFY (2018-21), we have selected 10 intermittent and 10 perennial headwater reaches in Burgenland, Styria, Carinthia and Lower Austria, covering a gradient from oligotrophic to eutrophic conditions. Water and sediments from the benthic and the hyporheic zone are sampled repeatedly before and during the dry phase and are analysed as to nutrient and organic matter concentrations and the biomass and activity of biofilms (amongst others, bacterial abundances, chlorophyll-a, EPS, respiration, activities of extracellular enzymes, and photosynthetic light curves). To extend these results, we are analysing the effects of desiccation on the uptake of nutrients and dissolved organic matter at the sediment surface and in the hyporheic zone via experimental flumes and sediment perfusion cores under controlled lab conditions. Preliminary results from 2018 indicate that shading by riparian trees can buffer the impacts of desiccation on biofilms through maintaining a high water content in the dry stream sediments. Down to a water content of 10-15%, which was common in most of our study streams during summer, benthic sediments of intermittent reaches did not differ in CO_2 production, enzymatic activities and bacterial abundances from those of perennial reaches. Only in sun-exposed gravel streams with a water content of 1-2%, benthic respiration was significantly reduced. Receding water levels in both perennial and intermittent reaches resulted in high seasonal variations of DOC and nutrient concentrations in the water column.

Session **GS01**

Climate change as driver of multiple stressors in riverine ecosystems: interactions of thermal regimes and emerging pathogens stressing brown trout populations in the future

Author(s): Florian Borgwardt (1); Thomas Bechter (1); Stefan Auer (1); Karoline Waldner (2); Mansour El-Matbouli (2) & Günther Unfer (1)

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Presenting author: Florian Borgwardt

Water temperature is one of the most important drivers in in river ecosystems affecting biota directly and indirectly. Fish as ectothermic organisms rely on their thermal environment and prefer specific temperature ranges. Some fish are dependent on cold-water environments such as brown trout (Salmo trutta). However, higher water temperatures can also trigger other problems such as outbreaks of proliferative kidney disease (PKD), an emerging parasitic disease affecting salmonid fishes. In Switzerland PKD was considered as one of the major reasons for the decline of brown trout populations. In turn, forecasts predict temperature increases due to climate change, and recent investigations of long-term water temperature data underline that the increasing trends for water temperature in rivers are already discernible today.

Based on a literature review we defined temperature thresholds that promote the occurrence of PKD on the one hand and indicate thermal stress for brown trout on the other. We then used these thresholds to firstly analyze temperature data of more than 300 gauging stations across Austria starting from the year 2000 characterizing the current conditions in Austrian rivers. Secondly, we used this data to model the future developments of these critical thresholds across Austrian rivers to highlight the increasing stress related to higher temperatures and the probably related outbreaks of PKD.

The analyses showed that at 57.4% of the gauging stations passed the threshold for a possible PKD outbreak (more than 13 consecutive days with a water temperature above 13°C) at least once in the period from 2000-2015. In 29.2% of all sites, 50% of the temperature values exceeded the threshold for PKD related mortality of brown trout (more than 26 consecutive days with a water temperature above 18°C) within this period. Not affected river sites were mainly restricted to alpine areas (mean altitude of 802 m). The water temperature model predicted a possible outbreak in 33-38% (RCP 4.5 - 8.5) of the analyzed river segments across Austria in the near future (2050s), and for 41 - 63% (RCP 4.5 - 8.5) of the segments in the far future (2070s), compared to the status quo (2000-2011) of 19%.

The results clearly show the severe changes that riverine ecosystems and their biota will face in the future due to climate change. This underlines that the anticipation of future changes has to consider the complex interplay of all relevant factors for a timely development of management measures and conservation strategies.

Session **GS01**

Future hydropower dams threaten freshwater megafauna species worldwide

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Presenting author: Christiane Zarfl

The development of hydropower dams to cope with the increasing electricity demand while mitigating climate change will transform the global map. Since the technologically feasible hydropower potential is already exploited in most European and North American countries, an unprecedented rush in dam building activity is expected in emerging economies in Africa, South America and Southeast Asia. Dams involve, however, a number of consequences for freshwater ecosystems, which include changes in river connectivity, sediment, flow and thermal regimes. It leads to the loss of habitat types, restricts dispersal pathways of aquatic organisms, alters biodiversity, and impacts ecosystem processes and services. While only 2.3% of the earth's terrestrial surface is covered by rivers, lakes and reservoirs, freshwaters harbour 9.5% of all described animal species and thus represent the most diverse ecosystems of the earth. Freshwater megafauna species (>= 30 kg) serve as surrogates for the overall freshwater biodiversity; consequently, the loss of these charismatic species indicates a loss of co-occurring smaller, less visible species. Indeed, the impact of dams is reported as one of the biggest pressures on freshwater megafauna. The aims of this study are to identify (1) to what extent future hydropower dams affect the distribution ranges of freshwater megafauna at the global scale, (2) in which river basins the threat to megafauna species by future dams will be greatest and (3) if those sub-catchments supporting the highest species richness and numbers of threatened megafauna species will be disproportionately affected by future hydropower dam constructions. Therefore, we spatially overlapped, at global extent, 6862 existing and 3682 planned locations for (hydropower) dams with the contemporary distribution of 207 freshwater megafauna species under consideration of their respective threat status. Hydropower development will especially affect megafauna-rich areas with up to 23 species in South America, South and East Asia, and the Balkan region. Sub-catchments with a high proportion of threatened species are considered as most vulnerable. These are located in Central America, Southeast Asia and in the region of the Black and Caspian Sea. At a catchment scale, dam locations can be identified that will overlap with the highest catchment-specific species richness and the largest share in threatened species - or the other way around. In this way, our results provide an approach to classify planned dam locations according to their potential impact on freshwater megafauna species at different spatial scales, raise attention on potential conflicts between climate mitigation and biodiversity conservation, and help setting priorities for freshwater management.

Session **GS01**

Effects of short duration exposure of different salinity levels on Ceratophyllum demersum

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Presenting author: Hiranya Jayasanka Senavirathna

The global warming leaded sea level rise is causing river water salinization in every part of the world. Rivers flowing into the sea over low-lying lands will be facing more river floods than usual sometimes up to several kilometers. Further, the places where the river flow and discharge reduced during dry spells and droughts (climate change led prolong droughts than usual) facilitates the deeper intrusion of seawater. The increased salinity in the river water is affecting negatively on the freshwater ecosystems of rivers. Especially, aquatic plants will face a significant impact over animals as animals have the migration option. To investigate the possible impacts (sublethal and lethal) of salinity on freshwater macrophytes, we studied the morphological and physiochemical responses of Ceratophyllum demersum for short duration (5 days) exposure of different salinity levels (0.0 ppt (control), 1.5 ppt, 2.5 ppt, 5.0 ppt, and 10 ppt). Experiments were conducted in a laboratory under controlled conditions (80 µmol/m²/s photosynthetically active radiation, 12/12 light period and 25 °C continuous temperature). The C. demersum cuttings were fixed to nutrients washed river sand in glass tanks which containing 5% Hoagland solution (each tank with four cuttings and triplicate per each salinity level). After five days of acclimation, plants were introduced to salinity and upon five days of salinity exposure plants were harvested after recording elongation. The exposure of salinity over 1.5ppt caused plant growth rate to be reduced with the increasing salinity. The 5 ppt and 10 ppt exposure caused significant reductions in plant growth. The photosynthetic pigments (Chlorophyll a, b and carotenoids) were reduced in 1.5 ppt and increased significantly in high salinity (2.5 ppt, 5 ppt, and 10 ppt) and the 5 ppt and 10 ppt exhibited around 2-fold increase from the control. The exact opposite trend was shown for the Anthocyanin contents. The tissue H_2O_2 production and peroxidase activity (POD) of 10 ppt exposure were reduced over control while around 3-fold increment recorded in 5 ppt. However, along with the salinity, the H_2O_2 content and POD activity have not followed a trend. The catalase (CAT) activity was increased in all the salinity levels while 1.5 and 10 ppt showed significant change over control. Accordingly, it is expected that under different salinity C. demersum will be responded differently, probably due to various physiological adjustments for each salinity. Further, on the first day of salinity exposure, the 10 ppt exposed plants folded the leaf blades and remained until harvested. This indicates that under 10 ppt exposure, plants were responded swiftly, and morphology was almost stagnant.

Session **GS02**

Can land use predict particulate organic matter in New Zealand rivers and its influence on turbidity and suspended sediment relationships?

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Presenting author: Sarah Mager

It is well established that land use disturbance disproportionately affects suspended sediment yield in rivers. Suspended sediment yields are one of the main threats to global water quality, however, its measurement is rarely observed, rather environmental management and monitoring are focused on quantifying sediment yields through the use of proxy variables, e.g., nephelometric turbidity. Sediment is only one component of eroded material transported through the fluvial environment due to land disturbance; organic material is transported concomitantly with inorganic sediments by passive parallel transport or cohesive forces with fine sediments. Typically, it is the inorganic portion that is quantified, and the organic influence on water clarity and turbidity is often overlooked, yet organic and inorganic material are optically distinct and behave differently with nephelometric turbidimeters. In this paper we consider the influence of the organic portion of suspended material and its affect on river turbidity measurements, and the effect this has on establishing turbidity-suspended-sediment relationships. Under low flow conditions, when most environmental monitoring occurs, we find that particulate organic matter dominates the suspended load, particularly in pastoral-dominated catchments or in environments with rich-organic matter sources; the non-homogeneity of the suspended load creates variability in turbidity-suspended sediment relationships. Under event flow, suspended load is mostly inorganic material; but the portions of organic-inorganic material in suspension are highly variable depending on intrinsic and extrinsic catchment characteristics. Here we examine a series of catchments with different land use from southern New Zealand to explore the effects of pastoralisation on organic suspended load, compared to indigenous forest and grasslands, and the implications this may have for monitoring turbidity and suspended sediment.

Session **GS02**

Effects of agricultural land use on the quality of dissolved organic matter in streams and its degradation by benthic microorganisms

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Presenting author: Gabriele Weigelhofer

Agriculture delivers significant amounts of dissolved organic matter (DOM) to streams, thereby changing basic biogeochemical processes at the water-sediment interface. The project ORCA aims to investigate the influence of agriculture on the quantity and quality of DOM in headwater streams and to clarify the effects of different DOM sources on the in-stream organic carbon uptake in predominantly heterotrophic and autotrophic biofilms.

We analyzed streams along a land use gradient regarding DOC quantity and DOM quality (absorbance and excitation-emission fluorescence indices) and performed laboratory flume experiments with leachates from different sources to study the effects of DOM quality on microbial abundances, benthic respiration, DOC degradation, and activities of extracellular enzymes. Via two different light intensities in the flumes, we addressed the question whether the presence of algae in the biofilms affected the DOM degradation.

Our results showed increasing freshness and fluorescence indices from forest to cropland streams, indicating an increased influence of microbial derived DOM. Leachates of untreated forest and grassland soils were better degraded than those of cropland or fertilized grassland soils, despite lower nutrient concentrations. DOM degradation was enhanced in the flumes in the presence of benthic filamentous algae. Besides, we observed positive effects of the DOM on the algae due to the phosphorus added with the DOM.

Session **GS02**

Growth and water relations of riparian poplar forests in Central Asia

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Presenting author: Frank M. Thomas

The riparian forests along the endorheic rivers of Central Asia are mainly composed of poplar species (Populus euphratica, P. pruinosa). In the arid to hyper-arid climate of the region, the trees generally are phreatophytes, which - for survival and growth - rely on access to groundwater. Fundamental ecosystem functions (ESF) such as matter flux and biomass production are the basis of ecosystem services (ESS) that are essential for the local and regional population. These ESS comprise supporting (e.g. biomass production), provisioning (e.g. construction wood, fodder, medicinal plants), regulating (e.g. protection from soil erosion and sand drift) and cultural services (e.g. recreation, sacred sites). The persistence of these ESS is being challenged by political and socio-economic transformation processes, by a rapidly growing human population and by the pressure to produce cash crops for a global market. Thus, the ESF and ESS of the riparian forests are threatened by overuse, by a continuous decrease in the groundwater level, and by salinization. In the Tarim Basin of Xinjiang, NW China, and other Central-Asian regions, excessive use of water for agricultural areas has led to a drastic drop of the groundwater level and to soil degradation and desertification, and resulted in a severe reduction of the poplar forest area during the past decades. Increase in the distances of poplar trees to the groundwater generally results in reduced biomass production and impairs the regeneration of the poplar forests.

Our studies on sustainable use, biomass production and water relations of riparian poplar forests over two decades have shown that - with regard to biomass production - the wood of the forests may be sustainably used through a moderate harvesting intensity. The growth of trees close to the river is immediately linked to the river's water supply. Rejuvenation of the forests from seeds is only possible after thorough wetting of the soil surface upon flooding and at relatively short distances to the groundwater. At sites with larger distances to the groundwater, trees can only regenerate vegetatively through root suckers emerging from underground root spacers. Measurements and calculations have shown that the water transport capacity of such spacers is large enough to supply even large trees with sufficient amounts of water. Vegetative regeneration also seems to be the only functional mechanism at sites with high salt concentrations in the topsoil. Due to the dwindling regeneration ability with increasing distance from the water table, the stands become older and sparser and, ultimately, are doomed to die off, although individual well-established old trees can grow vigorously even at larger distance to the groundwater. Our results may contribute to develop suitable management schemes for the conservation and protection of Central Asia's riparian forests.

Session **GS02**

Studying the effect of urban development on Varuna River at Varanasi, India- a case study

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Presenting author: Ankit Tewari

The contribution of rapidly increasing population and urbanization can be directly reflected upon the amount of pollution it has caused to the environment in India or any part of the world. Rivers flowing through these urbanized centers are facing the consequences of such uncontrolled and un-sustainable expansion to their point of extinction, as they carry little to zero dissolved oxygen (DO), no biota and is majorly dominated by effluent from wastewater treatment plants, among other anthropogenic pollutants. River Varuna, a small tributary of the mighty Ganga river, at Varanasi is one such a river where it receives sewage from twenty-two municipal drainages located on both sides of its 15-km-long passage through the city. In addition to this, there is also inputs from agricultural and industrial sector. The main objective of this paper is to study the impact of urbanization, around Varanasi area, on river Varuna and to see if it has the Urban Stream Syndrome". The symptoms of the urban stream syndrome include a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species. These findings can help one better understand the mechanisms that drive such symptoms and also help to set better mitigation plans for ecological restoration of urban rivers."

Session **GS04/06**

Different stressor gradient portions affect detection and identification of stressor interactions in river basins

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Presenting author: Pedro Segurado

Effective management measures are dependent on adequate identification of stressors hierarchy and joint effects characterization of multiple stressors acting on the several components of river ecological status. This is often accomplished with regression-based modelling techniques based on the ever-increasing river biomonitoring data.

Several studies carried out at large geographical scale revealed that different catchments show very distinct patterns of response to the same stressor combinations. We hypothesize that this is in great measure a consequence of only part of the stressor gradients being covered by each target basin. To support this idea, we simulated a pool of sites showing four types of responses of indicators to two co-occurring virtual stressors: additive, synergistic, antagonistic and complex antagonistic effects. We then simulated several sampling constraints that covered different portions of each stressor's gradient. To illustrate and confirm if predictions from our simulations showed any adherence to reality, a biomonitoring fish database from 39 river basins of Southwest Europe was used as a case study.

The present work shows that datasets not fully capturing the whole stressor gradients will limit our ability to completely unveil the overall underlying multiple stressor patterns to an extent that depends on the percentage of stressor gradient coverage. The stressor gradient coverage length showed a very strong influence in the detection of single stressor effects, the correct interaction type classification, the stressor significance and the goodness-of-fit. The trends found for the case study were in accordance with the general trends derived from simulations.

Our results may help to improve our understanding of the statistical consequences of capturing only portions of stressor gradients and their potential implications for the management of aquatic ecosystems. A main management paradox arises from these results: on one hand, because only covering part of stressor potential gradients, each basin will show a very particular multiple stressor behaviour and therefore should be treated as an independent management identity; on the other hand, because certain patterns only arise when basins are analysed altogether, management actions should follow more general rules, i.e. transversal to all river basins.

Session **GS04/06**

A first description of the effects of hydropeaking on the population of cyprinid fishes in Austrian rivers

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Presenting author: Daniel S. Hayes

Hydropower is a renewable energy source which can be effectively used to store water, thereby providing the advantage to release water and generate electricity in quick response to market demands. However, the sub-daily flow pulses generated by this regime have detrimental implications for riverine ecosystems. This operation scheme, known as hydropeaking, is identified as a severe threat to fish populations. So far, hydropeaking studies have focused on salmonid fish and have mostly been restricted to singular fluvial systems with non-comparative assessment of multiple pressures. The more numerous cyprinid species in Austria have not yet been thoroughly studied in the context of hydropeaking operations. To fill this knowledge gap, this study aimed to assess impacts of hydropeaking on selected cyprinid species through a multi-stressor comparative framework. We used an Austrian-wide database containing biological, hydrological, and morphological data to assess the status of cyprinid populations in reference rivers and those exhibiting sub-daily flow fluctuations. Thereby, this study is the first of its kind to conduct large-scale analyses on changes in cyprinid population metrics such as biomass or abundance.

Session **GS04/06**

The effects of multiple stressors on fish in temperate river systems of central Chile: community responses

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Presenting author: Konrad Górski

River systems are highly complex and dynamic ecosystems. At the same time they are among the most impacted ecosystems on the planet due to contamination, water extraction, flow regulation and other factors such as rapid proliferation of non-native species. Still, our understanding of the synergistic and additive effects of multiple human-induced stressors on fish communities in river systems is rudimentary in many parts of the world. Chile is presently undergoing fast economic growth and rapid increase of stressors that impact its river systems. Various industrial and urban contamination sources already exist in central Chile, and multiple new hydropower projects are proposed or under construction in addition to ones that already exist. Furthermore, most of Chilean river systems accommodate at least two non-native fish species. Still, the effects of combined impacts of these multiple stressors have not been assessed up to date. In this study we analysed trends in fish community data in four seasons to assess the ecological impact of these stressors. We sampled 6 sites in each of the two central-Chilean river systems (Biobío River and Valdivia River) that are subjected to urban and industrial (pulp mill) contamination as well as presence of non-native species. Furthermore, the flow of the Biobío River is altered by hydropower dams, whereas Valdivia is free of dams up to date. The study design considered two reference condition sites, two sites with urban contamination and two sites with urban and industrial contamination in each system. We found significant differences in fish community between reference and contaminated sites in both river systems. In the Valdivia River contaminated sites were dominated by puye Galaxias maculatus and darter Percilia gillissi, whereas reference sites were characterised also by presence of catfish species such as Trichomycterus aerolatus and Diplomystes camponsensis associated with good water quality. Similarly to the Valdivia River, contaminated sites in the Biobío were characterised by higher abundances of darter Percilia irwini. In contrast to the Valdivia River, however, we reported low numbers or absence of puye Galaxias maculatus in these sites. This is probably a result of combined effects of contamination and hydropeaking that have affected this floodplain associated species. Furthermore, in the Biobío River the effects of contamination were superimposed by non-native invasive species such as Gambusia holbrooki that often dominated contaminated sites. Consequently, our results suggest additive and/or synergistic responses of fish community to multiple stressors. This response is principally driven by combined industrial and urban contamination at interplay with flow regulation and non-native species.

Session **GS04/06**

Integration of lipid profile and body condition as diagnosis tool of multi-stressor effect on a native silverside in temperate river systems of central-southern Chile

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Presenting author: Nicole Colin

The exacerbated urban expansion has generated an intense water use due to increase of ecosystem service demand. Then, strong human-stressors are originated; urban and industrial pollution, barriers by dams, hydrological alteration and invasions are the most common in river systems. Consequently, running waters are among the most threatened ecosystems worldwide by negative impacts of multiples stressors than interact and cause additive and synergic effects on living organisms. Several tools have been developed in order to detect damage intensity in biota but a high quantity is developed to sub-individual level. Specific exposed biomarkers are frequently used as a diagnosis tool, however, the ecological relevance is reduced because, usually, organism have mechanisms to repair damage and response is not exposed in superior levels. Therefore, the use of biomarkers at sub-individual and individual level could show a more acute and ecological response. Here, we used lipid profiles and Scaled Mass Index as condition measure to detect sub-lethal damage on Basilichthys microlepidotus in four seasons to assess the ecological impact of multiple stressors. The study design is confirmed by two reference condition sites, two urban polluted sites, and two urban plus industrial polluted sites in two central-southern Chilean river systems (Biobío River and Valdivia River). Both basins, Biobio and Valdivia, are exposed to urban and industrial (pulp mill) pollution as well as presence of non-native species. In addition, the flow of the Biobío River is altered by hydropower dams. The Valdivia River is free of dams up to date. We found significant alteration of the individual condition (Scaled mass index) in summer season, but with different tendencies between basins. Silverside body condition increases in the polluted zone in Valdivia River and decreased in Biobio River. This could be an effect of hydrological alterations in the Biobio River and its interplay with pollution decreasing survival of individuals with poorer body condition. Furthermore, total lipids show a marked seasonal variation in Biobio River with a strong increment in autumn at polluted sites and high intra-site variation among individuals. In contrast, in Valdivia River, we did not find marked differences in lipid concentration among sites. This reinforces the potential synergistic effects of hydrological alteration and pollution on body condition of B. microlepidotus. Combined lipid profile and body condition appeared to have a great potential as diagnosis tool of the effects of multi-stressors on river fish.

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Session **GS04/06**

Response of leaf litter decomposition to invasive plant species Fallopia japonica in streams affected by multiple stressors

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Riparian areas are terrestrial areas adjacent to aquatic ecosystems and directly affect the structure and processes in aquatic systems. Multiple stressors of anthropogenic origin introduced simultaneously by hydromorphological and land use changes impacted ecosystems worldwide. Fallopia japonica (Japanese knot-weed) are an exotic species that rapidly spread into riparian areas across Europe, including Romania. Stands of F. japonica have lower species diversity, but high above-ground production and drastically alters both riparian and aquatic habitats. Limited information is known about the stream ecosystems responses to riparian invasion by this species. Even less is known about the changes in the aquatic community structure and processes when multiple stressors occur simultaneously. Our research assessed the impact of this aggressive invader, Japanese knotweed, on leaf litter breakdown and its associated invertebrate communities in low order streams impacted in different degrees by land use changes of riparian areas and impoundments of their longitudinal and lateral connectivity. A field experiment was conducted in 30 sites in the Argeș river basin in Romania. Our results suggest that aquatic leaf litter consumers use knotweed leaf litter in streams where it is not yet present or have extremely low densities. However, the decomposition rates of invader species are significantly lower as compared to those of native alder (Alnus glutinosa) leafs. The relative contribution of macroinvertebrates and microorganisms as well as the composition and structure of the invertebrate communities on the two types of leaf litter is discussed considering that the spread of this invader species in the basin is a real threat. Alteration of stream-riparian systems by multiple stressors of increased severity could increasingly change biodiversity, ecological processes and ecological services provided by these widespread ecological systems.

Session **GS04/06**

Alien species in two tributaries of the Danube - different colonisation pathways and threats to the native communities

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Presenting author: Lucia Koskoff

In 2018 a survey on benthic invertebrates and fish was carried out in the Urfahr channel and the Mitterwasser brook, two tributaries to the River Danube near Linz, Upper Austria. Their mouths lie close to each other and are not separated by any migration barriers, but one comes from the North, incorporating brooks from granitic hills, the other from the South, being fed by two small lakes in the Danube flood plain. Hence, they differ distinctly in both water chemistry and temperature.

A total of 14 alien invertebrate and five alien fish species was detected in the project area, each showing conspicuous differences in their distribution patterns in the two watercourses: The Mysids Katamysis warpachowskyi and Limnomysis benedeni, the zebra mussel (Dreissena polymorpha), the Asian clam (Corbicula fluminea) and the Caspian mud shrimp (Chelicorophium curvispinum) occurred exclusively in the Southern tributary, whereas the Ponto-Caspian freshwater shrimp Echinogammarus ischnus and the polychaete Hypania invalida were restricted to the Northern one. While alien species were found from source to mouth in the Southern Mitterwasser brook where they accounted for up to 44.55 per cent of the community, they have only colonized the lower reaches of the Northern Urfahr channel, their share in the local community reaching just 8.11 per cent. The same pattern was observed in fish assemblages, with alien species inhabiting all of the Mitterwasser brook but occurring only in the lower reaches of the Urfahr channel. Proterorhinus marmoratus was the most abundant species in the Southern, Gasterosteus aculeatus in the Northern tributary.

The numbers of some invasive species have increased to such an extent that they interfere with or even replace native species. Dreissena polymorpha inhabits the upper reaches of the Mitterwasser brook where it has formed spatially inclusive mussel layers on top of the bottom substrate, thus imperilling one of the largest Upper Austrian populations of Unio pictorum and Unio tumidus.

Ponto-Caspian shrimps have completely eliminated native shrimps in the Mitterwasser brook and are about to replace them in the lower reaches of the Urfahr channel, whereas assemblages of Gammarus fossarum and Gammarus roeseli thrive in its middle and upper reaches.

In addition to the distinct differences between the two watercourses concerning the composition of alien species, notable differences were detected in respect of alien pathways. Dreissena polymorpha and Corbicula fluminea showed the highest densities in the upper reaches of the Mitterwasser brook, suggesting a downstream spreading, whereas the bladder snails Physella acuta and P. heterostropha apparently colonise the brook in the upstream direction, their densities decreasing towards the source.

Explanatory models for the evident differences are established by both considering the autecological aspects of the alien species and including comparative data from nearby tributaries to the Danube.

Session **GS04/06**

Invasion dynamics of non-native gobies along the Elbe River in Germany

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Non-native gobiid species such as round goby Neogobius melanostomus (Pallas, 1814) and bighead goby Ponticola kessleri (Günther, 1861) have now invaded most major river systems in Central Europe, with the Elbe being a rare exception. First records of invasive gobies were documented between 2008 and 2017 in the tidal Elbe River, near the city of Hamburg (Germany) as well as at the upper Elbe River (Czech Republic). This suggests a beginning invasion process from two opposing directions and provide the unique opportunity to study the invasion dynamics of invasive gobiid species into a hitherto uninvaded river system. To quantify and locate the goby invasion dynamics along the Elbe River, we sampled 13 sites from Dresden (rkm 66,0) to Geesthacht (rkm 582,7) in October 2018. We used electrofishing to quantify abundance, age structure and gut contents and supported this with the analysis of Environmental DNA (eDNA). The results showed very low abundances of P. kessleri near the tidal Elbe River. For N. melanostomus two decreasing abundance patterns from upstream and similar from downstream were identified with sites of no positive goby detection at the middle Elbe. The two population peaks of N. melanostomus indicate different age structures, suggesting two discontinuous population centers with a reproduction hot spot in the upper Elbe and demonstrating few adult goby specimens in the lower parts of the river. Further genetic analysis would clarify whether there are two genetically distinct populations of N. melanostomus.

Session **GS07**

A Framework for Defining the Role of the Hydrogeomorphic Template in Determining Community Composition

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Biocomplexity is an emergent property of ecosystems that captures the interplay of structures and processes across multiple scales. These interactions can establish a dynamic habitat template that acts as a filter to define ecological organization across landscapes. Among the three disciplines of river science, hydrology, specifically hydrological variability, is seen as the critical determinant of the geomorphological and ecological organization of riverine landscape. For example, the work of Baranyi and others in their 2002 paper examined how the duration of hydrological retention shapes zooplankton community composition through abiotic and biotic processes. While this work marked a significant contribution to the regulation of zooplankton communities, it did not address the role of geomorphologic organization on biocomplexity. The objective of this presentation is to demonstrate the differential interaction of hydrology and geomorphology on the ecological organization across riverine landscapes. A three-year study of zooplankton community composition of four habitat types (channel, embayments, lateral-connected lakes, and island backwaters) was conducted on the Upper Mississippi River. Zooplankton samples were collected periodically during the summers of 2009 - 2011. Mean daily discharge served as a measure of hydrological variability over the sample period. Measures of the geomorphic attributes of habitats where determined by field measurements and remote imagery. The general pattern was low hydrological variability in 2009 to very high variability in 2011. The highest densities of Cladocera, including large species, and Copepoda was in 2009 whereas densities for both groups were very low in 2010 and 2011. In contrast, abundance of Rotifera was low in 2009 and 2010 and high in 2011. Multivariate analysis of variability in community composition decreased progressively from 2009 to 2011, indicating that greater hydrological variability leads to a homogenization of zooplankton communities. Geomorphic influences are evident across all the habitats, particularly in 2009, where site-specific geomorphology produced more distinct communities within and across habitat types. A workgroup initiated the development of a conceptual model to provide a framework for examining the abiotic and biotic influences on zooplankton community compositionin floodplain-river ecosystems. In the model, hydrological and geomorphic processes operate interactively to establish a physical habitat template. This template, in turn, defines the regional species with the adaptive strategies that fall within the rangeof hydrogeomorphic conditions, thereby establishing a first-level determination of community composition. The regional species pool is further modified by hydrological variability and geomorphic heterogeneity, which influences the biotic and abiotic factorsthat determine the realized community composition. This dynamic organization of communities can be addressed across multiple spatial and temporal scales, with selection of scale(s) applied dependent on the nature of research and management questions. Theapplication of this model is applicable to all types of river networks and should be applicable to other organismal groups.

Session **GS07**

Quantifying the effect of river morphology on salmonid habitat in post glacial streams

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In the postglacial landscapes of Scandinavia river channel patterns are highly diverse, do not follow the traditional concepts of fluvial models and are distributed seemingly randomly over the rivers' run. Hauer and Pulg (2018) described a characteristic highly variable morphology determined by non-fluvial patterns such as glacial and colluvial deposits and bed rock defining the river's longitudinal profile shape, bed slope and channel patterns. It is presumed that the characteristic morphology evolved during the Holocene due to riverbed incision and low fluvial sediment yields, which are typical for post-glacial landscapes with low sediment supply such as large parts of Scandinavia, Greenland and the eastern Canadian shield.

It was concluded that the non-fluvial nature of the rivers studied has significant implications sediment characteristics and channel stability.

Therefore it was hypothesized that the characteristic morphology of the rivers is decisive for the distribution and quality of fish habitats as well as connectivity for fish. To test this hypothesis 20 rivers with regulated and natural parts were classified on the basis of aerial photos, LiDAR scans, sediment sampling, and geological data according to Hauer and Pulg (2018). The distribution and quality of spawning and rearing habitat of Atlantic salmon (Salmo salar) and anadromous brown trout as well as migration barriers were mapped in the field in the whole anadromous stretch of these rivers following the methods of (Harby and Forseth 2013). Backpack-electrofishing was conducted in all morphology types of the rivers on a total of 100 stations (Hedger et al. 2018). The data was thereafter correlated to river typology of Hauer and Pulg (2018). The results show that the morphology types can be associated quantitatively with typical fish habitats, their quantity, quality and distribution. Also the occurrence of migration barriers can be linked to the applied morphological concept. Juvenile densities vary in general, but most channel patterns could be associated with a typical range of juvenile densities. This knowledge contributes significantly to define hydromorphological reference states of rivers. These are important preconditions for river restoration and international water management guidelines such as the water frame work directive. The findings are also helpful to calculate the likelihood of fish habitat occurrence based on remote sensing data and for the application in hydraulic and habitat modelling.

Ref:

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Session **GS07**

Phytoplankton development during hydrological extremes in the Lower Vistula oxbows

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Presenting author: Ewa A. Dembowska

Extreme weather effects have led to unprecedented hydrological changes. River levels fluctuations have become more dramatic and occur with higher frequency, so hydrological conditions have an enormous impact on the biocoenosis of oxbow lakes and may impede their development. The aim of these study was to analyze development of phytoplankton communities in various oxbows during different hydrological conditions. All investigated oxbow lakes were created as a result of regulation of the Lower Vistula at the end of the 19th century. The study was conducted in six lakes, which differ in terms of isolation - connection with the river and communities of vascular plants. During the five-year research project, there were significant differences in water level, i.e. levels typical of the lower course of the Vistula (mean water levels - MWL) as well as water levels deviating from the norm: extremely high (HWL) or low (LWL). The functioning of oxbow lakes depends on the succession of two phases: the first one is potamophase, when water from the river flows into the valley and floods the lakes. Inflow of river water to the oxbow lake may increase or decrease the phytoplankton diversity, depending on the size and duration of the flooding. Studies on the effects of extreme flooding of the Vistula in 2010 on phytoplankton in the oxbow lakes indicate rapid changes in their ecological states. In three lakes a clear water state with the dominance of submerged macrophytes changed into a turbid state with the dominance of planktonic algae. In one lake a turbid water state shifted into a clear water state. Changes in the phytoplankton abundance in lakes exposed to frequent shifts between limno- and potamophase are rather insignificant, while high biodiversity is stimulated by short-term, frequent disturbances. The second phase, isolation (limnophase) is quite stable and lasts for the entire growing season or even for several years. Prolonged periods of hydrological drought increase the importance and duration of many factors such as wind dynamics, chemical potential, allelopathic influence of macrophytes, shading by vegetation, and zooplankton pressure. In the isolated lakes during limnophase, the number of phytoplankton species was lower compared to the connected lake. The lowest values of biomass were noted in lakes, where submerged vegetation regularly covers more than 75% of the bottom. In these lakes, the total biomass of phytoplankton was dominated by small flagellates: Chrysophyta, Cryptophyta, and Euglenophyta. The phytoplankton abundance and biomass in isolated oxbow lakes was determined by the seasonality of macrophytes because of strong inhibitory impact of submerged or free-floating plants.

Session **GS07**

Multi-year, high resolution data on coarse bedload transport: implications for river science

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Presenting author: Peter W. Downs

Passive, indirect monitoring of river bedload offers the prospect of obtaining high-resolution measurements of coarse sediment transport over multi-year time periods at relatively low cost and without the dangers inherent to active approaches. Based on experiences derived from a five-year programme of monitoring using seismic impact plates, we offer several observations on the extent to which such measurements do indeed offer a 'revolutionary' concept in fluvial sedimentology, as suggested by Gray et al. (2010). First, near-continuous data permits detailed examination of time-dependent behaviors in coarse sediment transport related to instantaneous fluctuations, event-based hysteresis, inter-event variability and the extent to which such factors are dominated by energetic controls (Downs et al. 2016). Second, high resolution particle counts facilitate a new and complementary class of data-driven bedload assessment. Based on bedload entrainment theory, monitored bedload counts and a probabilistic optimization of individual particle sizes in transport, the result is an uncertainty-bound range of bedload estimates without the inherent overestimation associated with traditional bedload formulae (Soar & Downs 2017). Extending high resolution data collection to multiple years with very variable hydrology, we observe that effective discharge at our site occurred consistently at 'bar-building' flows significantly below bankfull, emphasizing the importance of reach-scale bedload availability and transport on the falling limb of the hydrograph. Partly in consequence, bedload rating curves are not stationary and demonstrate a two-phase rating relationship. Capacity-related controls were dominant only in flows above bankfull while the dominant below-bankfull element consists of a discernable 'bulge' that is maximized in wet years and appears to reflect sediment supply variations (Downs & Soar 2018). Exploring these controls further, we develop a sensitivity-style index for sediment supply that highlights the role of annual wetness, reach-scale bed conditioning and antecedent hydrology on time dependent behavior in coarse sediment transport (Downs & Soar, submitted). Overall, high resolution passive monitoring suggests that bedload dynamics may be highly dependent on a site's 'hydrogeoclimatic' context and position in the watershed, and that 'partial data' perspectives obtained from active bedload monitoring may have focused on the influence of capacity-related controls to the detriment of factors related to coarse sediment supply.

Session **GS07**

Sediment transport, grainsize distribution and morphodynamics of glacier-fed rivers

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Presenting author: Walter Bertoldi

Water discharge and sediment supply in glacier-fed rivers exhibit daily and seasonal fluctuations, which drive their morphological evolution at various time and spatial scales. In this work, we set up a laboratory model to highlight how discharge unsteadiness affects sediment transport processes and bed surface texture in gravel-bed, glacier-fed rivers. Innovative photographic techniques were used to continuously monitor the experiments.

The physical model consisted of a 24 m long straight channel with fixed banks. Three values of channel width (0.2, 0.4, 0.6 m) were reproduced in order to obtain a range of channel configurations (plane bed, alternate bars, wandering). The flume was filled with a poorly-sorted sediment mixture with median grain size of 1.3 mm. Discharge and sediment supply were software-controlled and bedload was monitored using a continuous weighing system. Topographic information was acquired using Structure-from-Motion photogrammetry technique and continuous photographic survey provided innovative data on bed load activity and surface grainsize distribution.

For each channel configuration, the flume was first run under steady flow conditions to estimate transport capacity and define equilibrium bed morphology for a range of discharges. Afterwards, sequences of 30 identical, triangular hydrographs were run in order to simulate daily snowmelt cycles. Sediment supply was set to transport capacity and in a subsequent set of runs with an anticipated peak by assigning a phase lag to the transport capacity.

Results show that mean bedload output is higher during the rising phase, resulting in a clockwise hysteresis cycle with respect to water discharge. Active width shows an opposite behaviour, with a counterclockwise hysteresis. This means during the rising limb more sediments are transported on a narrower area. In the case of alternate bars and wandering morphologies, clear sorting patterns are also visible. The relationship between texture and topography is stronger for morphologies with higher relief; a well-defined morphology, such as one with alternate bars, promotes clear segregation of grain sizes. Local coarsening/fining over time is strongly associated with local scour/deposition; areas where fining occurs are more likely to be subject to deposition; areas where coarsening occurs are more likely to be subject to scour, regardless of discharge and sediment supply regime.

The experiments highlighted complex flow / sediment transport / grain size relationships with significant differences when a sediment supply lag was introduced, possibly caused by selective transport processes and riverbed morphological adjustment. Moreover, results show that the history of flow variations plays a role in defining the bed morphology and its evolution. These observation may be relevant to better design and evaluate the effect of river restoration projects and the associated habitat suitability.

Session **GS07**

Soil Loss Estimation of Mandakini River Watershed of Central India using Universal Soil Loss Equation

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Presenting author: Nikhilesh Singh

Soil erosion by water is one of the major problems in India. Soil erosion reduces the soil capacity to support life and has an impact on the agricultural production of any area. The study area belongs to Central Indian marginal plains located between Northern Vindhyan foothills and marginal Ganga plain. The Master stream is Mandakini here, which is an ephemeral river. Vindhyan is one of the oldest sedimentary basins of India. This terrain receives an annual rainfall of 800 to 1100 mm.

Morphometric analysis is an effective tool to understand a river basin, its process and controlling factor. Morphometric analysis with Pearson's pair wise correlation coefficient produces system models, in the form of positive and negative feedback loop models. System models are a pictorial representation, gives very vital information regarding watershed and drainage basins. The various derived parameters such as infiltration number (If), Overland flow (Lg), Drainage density (Dd) and Constant of channel maintenance(C) of the Mandakini watershed has been derived using morphometric analysis. The system model developed for a part of Mandakini watershed is a positive feedback loop model. This model explains that with the increase of Infiltration number (If) overland flow (Lg) decreases that subsequently increases Drainage density(Dd) and decreases Constant of channel maintenance(C), which explain erosion is prominent in the watershed. Lower value of Constant of channel maintenance(C) less than 0.2- 0.3 and overland flow (Lg) less than 0.4 indicates channel erosion is more prominent in the Mandakini watershed rather sheet erosion and the intensity of erosion can scale into high to moderate class.

In the present study, estimation of annual soil loss of the Mandakini watershed of Central India located in the Vindhyan rocks is done using the Universal Soil Loss Equation (USLE), remote sensing (RS) and geographic information system (GIS). GIS data layers including, rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), cover management (C) and conservation practice (P) factors are computed to determine their effects on average annual soil loss in the area. The resultant map of annual soil erosion shows that 93.39% area of the watershed has come under erosion threat. The highest annual erosion rate that has been recorded in the watershed is 299.09 to 640.91 ton/ha/yr over 0.72-hectare area. The mean annual erosion in the watershed is 4.72ton/ha/yr. The rate of erosion is exceedingly high along the river bank. This kind of channel erosion subsequently hampers river health and can decrease the accommodation space of the river and may enhance flooding rate as well.

Thus the system models developed on basis of morphometric analysis of the river basin and the spatial erosion maps generated with USLE method, remote sensing and GIS can serve as effective inputs in deriving strategies for land planning and management in the environmentally sensitive areas.

Session **GS07**

Evaluation of Morphometric analysis utilizing Geo-informatics techniques for an Indian catchment

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Geo-informatics techniques are viable being utilized in recent decades as a critical apparatus in deciding the quantitative portrayal of Morphometry of a watershed. These procedures portray the high exactness of mapping and estimation of the morphometric analysis. The point of this study is hence to break down the GIS-based morphometric exercises of the River Ganga basin including parts of Varanasi, Mirzapur, Chandauli and Allahabad districts in Uttar Pradesh, India. This analysis requires depiction of every single existing stream. The estimation and investigation of the basin and its seventeen noteworthy sub-watersheds are carried on GIS stage to portray the geology and drainage attributes. The parameters required as inputs are pour point, stream order map, DEM. Streams were automatically delineated from SRTM DEM data. The maximum Stream order of the watershed was 7th order. The morphometric analysis was done using GIS software. The results uncovered that the mean estimation of Form Factor (Ff) is 0.29 and Compactness coefficient (Cc) is 3.16, which demonstrates the shape of the watershed isn't circular it is elongated. The mean estimation of Stream Frequency (Sf) is 1.22 which indicates that the basin has reduced infiltration capacity. The value 2.87 of bifurcation Ratio (Rb) Proposes that the watershed is steady. The distinctive estimations of Texture Ratio (T) recommend that the watershed has a fluctuating slope yet plain at the more significant part of the area. By the estimations of linear and shape morphometric parameters, it can likewise be reasoned that the sub-watersheds SW15 and SW16 are more soil erosion-prone sub-watersheds among all the seventeen sub-watersheds. These results can be further utilized for prioritizing watershed for soil erosion-prone areas and also for watershed management planning zones.

Session **GS08**

Modelling channel planform dynamics of Ramganga River, India

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Presenting author: Ashwani Kumar Agnihotri

Channel planform dynamics is one of the main problems of alluvial rivers in the world, which causes natural hazards like lateral channel shifting, flooding, bank erosion, and damage to hydraulic structures, transport network, agricultural land and settlement. This occurred due to the erosion of the banks, widening of the river, degradation and aggradation of the bed, evolution of bedforms etc. Therefore, the modelling of such rives are required to predict the nature of the rives. Ramganga is one of the highly meandering river in its lower reaches which is threatening engineering structure which results in various socio-economic as well as environmental problems. This study focused on the prediction of a meandering channel migration using river-migration model namely RVR Meander. RVR Meander is a toolbox that can be used to model river channel meander migration with physically based bank erosion methods. This study assesses meandering processes through predictive modelling of the naturally meandering rivers over engineering scale. The results revealed its overall shifting towards the south-west direction under the influence of regional slope.

Session **GS08**

Periodic monitoring of thermal variation in rivers using satellite images

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The temperature of the river is a fundamental aspect of ecosystem health of the river affecting its physical, chemical and biological processes. Remote sensing technology can be used as an effective substitution to the conventional methods of measuring the temperature of the water bodies because satellite images can be used effectively for long term periodic monitoring of large stretches of river length. In this study, thermal infrared (TIR) bands of Landsat-7 (L-7) and Landsat-8 (L-8) satellite have been used to estimate the surface water temperature (SWT). Satellite-based thermal monitoring is usually applicable to wide rivers as the thermal bands of L-7 and L-8 have poor resolution in comparison to other bands. The L-7 and L-8 satellite data for the period of 1999-2018 have been acquired from United State Geological Survey (USGS) Earth Explorer website. In this work, a study stretch of river Ganga, India has been selected between the cities of Mirzapur and Ghazipur.

The objectives of this study is (1) to delineate longitudinal and temporal variation of SWT, (2) to understand relationship between air temperature and SWT, (3) to observe the variation in temperature between the midstream and along its banks, and (4) to compare L-7 and L-8 estimated thermal temperature results. Long term monitoring of thermal patterns in the river can be a good indicator of climate change. It can also indicate the effect of anthropogenic activity in raising SWT of the river.

Session **GS08**

Verification of a macroinvertebrate field screening method at three hydropeaking affected Austrian rivers

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Presenting author: Leonardo Zoltan

Previous studies showed that status classifications based on Multi Habitat Sampling (MHS) does not properly reflect the impact of hydropeaking on macro-invertebrates. A newly developed stressor-specific assessment for hydropeaking based on macro-invertebrates could benefit from the efficiency offered by a field screening method. This study aimed to verify if estimated macroinvertebrate abundances obtained by a newly developed field screening method realistically represents the sampled taxa composition. Macro-invertebrate samples were screened on site by picking live specimens by unaided eye. If the samples included high macro-invertebrate (MIV) densities, the samples were subsampled. Then the complete samples were preserved, sorted and identified in the laboratory. Linear regression was used to explore the relationships between the two methods. Taxon-specific analysis revealed that the abundance of the indicator taxon Rhithrogena was reasonably estimated in the field. Subject to overestimation was the abundance of the indicator taxon Allogamus, due to empty cases being counted as individuals. Results showed that small individuals with body weight below 0.001g were underestimated in the field and that the accuracy of the estimation benefited from subsampling in the field. The analysis of minerogenous and organic components present in the samples indicated that a very high minerogenous content led to an underestimation of abundance in the field. Considering the study's recommendations for further improvement, rapid field screening can serve as a sampling method for a newly developed stressor-specific assessment of hydropeaked sites based on macroinvertebrates.

Session **GS08**

Testing unsupervised 2D hydraulic modeling-based techniques to model fish habitats at the meso-scale in the Mareit-Mareta River, NE Italy

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Presenting author: David Farò

Alpine gravel-bed rivers are subject to many hydro-morphological pressures. In recent years, habitat models at the meso-scale have become widely accepted to quantify such pressures. Moreover, they can help guide water resources planning through the design of environmental flows, or renaturalization of rivers through restoration.

Despite their potential, broader applicability of meso-scale habitat models is limited by the difficulty to conduct field-based mesohabitat mapping in large streams or at high flows, at which wadability decreases. Furthermore, construction of reliable habitat-streamflow rating curve can be a highly time consuming process, as it requires mapping over a wide range of streamflow values.

In this work, the potential of two-dimensional hydraulic modeling to reproduce fish habitat at the meso-scale is tested. Micro- (water depth and column averaged velocity) and meso-scale hydraulic and bathymetric (e.g. channel water surface slope and bedform) information is combined using a semi-automatic approach based on unsupervised clustering techniques. Sensitivity of prediction of a variety of widely used hard and fuzzy clustering algorithms is tested.

Applications of the model are tested on a reach of the Mareit/Mareta river in South Tyrol (NE Italy), that was recently restored to a braided morphology. A high resolution bathymetry was collected by airborne bathymetric LIDAR, and hydraulic simulations run on a mesh with sub-meter resolution. The model is calibrated on velocity and depth profiles collected at various discharges. The outcomes are then compared with ground mesohabitat surveys collected at low flow (discharges of Q = 1.7 and 3.4 m3/s) and high flow (Q = 10.2 m3/s), at which many portions of the reach start to become non-wadable.

The proposed approach shows potential for application of the mesohabitat concept at non-wadable flow conditions. By allowing habitat estimates at flow ranges that could not be surveyed in-stream, and for large alpine rivers, the approach would allow to extend the range of applicability of meso-scale habitat models.

Session **GS08**

Ecological health assessment of alpine lotic ecosystems in Khunjerab National Park, Upper Indus Basin, Gilgit-Baltistan, Pakistan

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Presenting author: Salar Ali

The research work based on ecological health assessment of alpine lotic ecosystems in the Khunjerab National Park above 4000m at Karakoram ranges located in Pakistan-China border. This study evaluated the integrative approach of alpine streams ecosystem based on the assessment of benthic macroinvertebrates indices along with the changes in physicochemical habitat variables. Kick net (500um mesh size) and hand picking methods were used for the collection of benthic macroinvertebrates samples in dry and wet seasons (early spring and summer) to check the seasonal fluctuation of benthic macroinvertebrate communities based on functional feeding groups, community composition and structure in addition to hydromorphological characteristics. The results shows the total counts higher in early spring (1250 individuals) as compared to the summer (710 individuals), comprising 30 families and 6 orders in early spring and 41 families and 7 orders in summer, respectively. Seasonal variation influences the benthic macroinvertebrates abundance and richness; as high abundance were found in dry season and the wet season had high taxa richness. The statistical tools, including principal component analysis (PCA), cluster analysis (CA), and analysis of variance (ANOVA) shows a strong correlation between water quality and biological parameters. While in the early spring noted highest score of biotic indices as well as high diversity indices scores were found in the summer. Furthermore, the summer had high Shannon-Wiener diversity index followed by Fisher_alpha and Margalef index. Ephemeroptera had high individual's (906) with relative abundance 73% in early spring followed by Placoptera (237) 33% in summer and Tricoptera (118) 9% in early spring while Diptera (98) 14% and Coleoptera (10) 1% in the summer. Whereas Neuroptera, Odonata and Heteroptera had lowest densities and relative abundance among the seasons. The biotic indices assessment results with respect to eight diagnostic categories indicated that the catchment has minimal anthropogenic disturbances. This research is also important in the context of the conservation of natural resources and to assess the ecological health status based on benthic macroinvertebrates community structure and to understand the current features for the management of the alpine lotic ecosystems.

Session **GS08**

Investigative monitoring of surface water quality using autonomous surface vehicles equipped with innovative detection technologies

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Surface water quality is often menaced by increasing anthropogenic activities, through rapid industrialization and urbanization. Therefore, an extensive monitoring is needed to prevent contamination of water bodies and to take actions for their protection. In the frame of the Horizon2020 project INTCATCH, innovative approaches are developed towards monitoring and managing water bodies. The digital technologies and innovative tools used to deliver smart water monitoring solutions, enable an active engagement of citizens in monitoring activities for the benefit of society.

Autonomous surface vehicles are developed to assess the quality of water bodies, to detect significant quality changes from point source or diffuse pollution, e.g. wastewater misconnections or discharges from industrial effluents, road or agricultural runoffs. Two autonomous systems are developed, implementing robotic boat, data acquisition and transfer into the cloud, as well as the standard water quality probes for Temperature, pH, dissolved oxygen, electrical conductivity. Additionally, the autonomous systems are equipped with specific devices for detection of heavy metals (HM) and/or other water quality parameters, such as biological oxygen demand (BOD5), chemical oxygen demand (COD), total organic carbon (TOC), nitrate, ammonium, phosphate, and turbidity. Those integrated autonomous systems were both validated under controlled conditions, simulating "real scenarios" (in-door) and under real conditions (out-door), using water from the Danube river. An extensive validation is performed regarding accuracy, sensitivity and measurement precision for the integrated system. The combination of a screen-printed sensor, implemented in a fluidic measuring device, and the use of square wave anodic stripping voltammetry technique allow the detection and monitoring of lead and copper in water bodies at trace concentration levels (below 10µg/L). For detection and quantification of quality parameters BOD5_eq, CODeq, TOCeq, NO3_eq, NH4_eq, PO4_eq, and Turbidityeq, the in-situ UV/VIS spectrometry method is used, followed by multilinear regression statistic calculation. The detection of NH4_eq and PO4_eq in surface water using this technique represents an innovative approach, which is developed and validated within this study. The presence of a graphical user interface (GUI) to control the vehicle allows the pre-programming of navigation routes. During the navigation, the system is able to perform measurements continuously and to transfer the data to the cloud. The validation process confirmed the ability of the system to detect point or diffuse pollution, through combining information from the simultaneously measurement of all mentioned water quality parameters.

The autonomous surface vehicles developed in the frame of the INTCATCH project present a promising tool for the investigative monitoring of surface water quality and detection of point source or diffuse pollution.

Session **GS09/10/15**

What do we learn from transition matrix modeling applied to river science?

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Presenting author: Cybill Staentzel

Transition matrix modeling has been developed since the 1990s. However, their potential for transposition to river science has remained poorly studied and feedbacks are therefore limited. The exploitation of transition matrix modeling makes it possible to quantify the changes in pixel nature on maps between two dates, generating percentages of pixel transition. Here, we present two examples of the use of transition matrix modeling applied as an efficient tool to investigate succession processes or evolutionary trajectories. The first study takes place along the program INTERCONNECT, in two cross-border European rivers, the Upper Rhine and the Danube River. The transition matrix allowed to identify and quantify the changes in land use, in particular, the alluvial forest, between 1945 and 2017. The alluvial forest increased over time on the study sites at the expense of agricultural areas. However, the fragmentation of forest patches increased and forest-friendly interfaces decreased. The second study is a program aiming the redynamization of the Upper Rhine River. We studied vegetation dynamics and phytosociological habitats following an ambitious and unique in the world restoration involving controlled erosion. Transition matrix modeling has been applied on patches of vegetation assemblages to determine how they have been modified over time. The use of transition matrix modeling permitted to clearly quantify the part of the in-channel water area that has been colonized three years after the restoration by aquatic vegetation. These examples of the application of this tool to river science make the interpretation of maps more quantitative than descriptive, giving us new paths in decision-aiding strategies.

Session **GS09/10/15**

Fluvial Hazard Zone Mapping: Hazard Planning with Secondary Benefits

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River change from floods has largely been ignored in floodplain management, which is focused on inundation risk. Rapid change in stream location and the scour and filling of floodplains with debris are natural processes and are linked to stream system function and overall ecological health. These processes create hazards to communities that often go unrealized until a disaster occurs. A method for mapping river-related erosion and deposition hazards has recently been developed in the State of Colorado. The goal of this mapping is to reduce the long-term risk to life and property by educating communities and landowners about the existing risk associated with fluvial processes. Fluvial Hazard mapping used in conjunction with floodplain inundation maps can further help us understand and define the concept of an active river corridor with secondary benefits of (hopefully): reducing human investment in these high risk areas; allowing for mechanisms that create complexity in stream systems including space for biotic-drivers such as wood and beaver; allowing for natural creation of wetlands; and helping us understand the concepts of river channel change as a driver for long-term physical and ecological meta-stability. The new mapping protocol will be presented along with data and several case studies. Feedback from conference attendees on the use and application of this mapping technique will be sought.

Session **GS09/10/15**

Response of phytoplankton and zooplankton to restoration and climate warming in urban Alte Donau over more than 20 years

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Presenting author: Katrin Teubner

Heavy blooms of blue-greens (Cylindrospermopsis raciborskii) associated with a poor water transparency in 1993/1994 (p_1) prevented the use of Alte Donau for bathing, fishing and other recreational activities and thus provided arguments to start restoration. A five-year restoration period (p_2) followed, which included chemical phosphate precipitation (Riplox). Another seven-year period (p_3) was designated to a successful re-establishment of macrophytes. The last period (p_4) of once again mesotrophic "stable conditions" lasting over recent years relied mainly on the sustained underwater vegetation and modified fish stocking of less cyprinids and more predatory fishes. According to surveys, the success of the restoration has increased public awareness of this recreational area in Vienna.

Phytoplankton and zooplankton responded significantly to drastic phosphate reduction during restoration and re-establishment of macrophytes. In the long term, the main compositional change in plankton related to a shift from cyanobacteria to a mixture of phytoplankton taxa on the one hand and a shift from a cladoceran-rotifer-rich to a copepod-rotifer-rich zooplankton assemblage on the other. In case of phytoplankton the chlorophyll-a content (chl-a) per biomass varied in accordance with species alterations of higher taxonomic ranks. The chl-a content was lowest before restoration during cyanobacterial blooms and highest during an intermitted stage after Riplox-treatment when chlorophytes became most dominant. The relationship between phytoplankton chl-a and total phosphorus (TP) seemed more robust than between phytoplankton biovolume and TP for indicating the lake's trophic state, although both responses were statistically significant and provide roughly the same main picture of the ecosystem shift from hypertrophic in 1993 to mesotrophic in 2000 and the persistence of mesotrophic conditions for recent 15 years. The carbon ratio between zoo- and phytoplankton increased significantly during the first three periods of restoration and remained high under 'stable conditions'. Besides the main response of zooplankton to the 'bottom up' control that was triggered by the reduction of phytoplankton food supply by one order of magnitude, the zooplankton responded also to climate change. The impact of global warming became evident from intra-annual coincidence of the climate signal (NAO) and water temperature in winter and early spring, the increase of surface water temperature by 1.52 °C per decade in April and the prolongation of the warm period (> 22 °C) by 10.5 days per decade in summer. This prolongation of the warm season supported the summer development of the medusa stage of freshwater jellyfish (Craspedacusta sowerbii).

This lake study over more than 20 years is summarized in the book "The Alte Donau: Successful Restoration and Sustainable Management - An Ecosystem Case Study of a Shallow Urban Lake" (Dokulil MT, Donabaum K, Teubner K, eds), released by Springer

Session **GS09/10/15**

Towards a plastic free Mekong delta

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Presenting author: Jeroen Rijke

Plastic has become a hot political issue and is widely publicised. Research has shown that plastic is omnipresent in the environment and that the accumulation of plastic in oceans, rivers and other waterbodies is hazardous to aquatic ecosystem and public health. In this paper, we explore how floating macro-plastics can be eradicated sustainably from the delta of the Mekong, which is the world's 11th river in terms of contribution to plastic soup in the oceans.

The research has comprised of three steps. Firstly, a series of interviews was conducted to explore the informal and formal waste management practices in two major cities in the Vietnamese Mekong delta: Can Tho and Long Xuyen. These interviews were set up to provide insight in contemporary value chain and available infrastructure for plastic waste management and recycling, and the potential for incorporating plastic waste from the river into existing waste management and recycling processes.

Secondly, measurements were done in the city of Can Tho to get an initial understanding of the volumes and characteristics of floating macro-plastics. For this, a temporary catcher was built from local materials and installed in the river near the city centre. The measurements were validated through visual inspections of plastic in various locations in the cities' river system.

Thirdly, opportunities were explored for applying recycled plastic in housing and infrastructural projects in the city centre and in nearby agricultural areas that are prone to seasonal flooding. This was done through a combination of field visits, workshops and interviews. For this, initial results showed that applications are most promising if they can be produced in relatively large volumes from relatively low quality recycled plastic, and have a relatively long lifespan (>5yrs).

The findings show, amongst others, that the current waste management system is insufficiently able to effectively cope with the volumes of waste that are generated. Moreover, there is an institutional void for waste that has entered the river system. Plastic waste removal from water bodies is therefore relying on bottom-up initiatives from private and informal sectors. Although this may provide opportunities for new business models, it is at present difficult to incorporate floating plastic debris into existing value chains due to the cost of additional washing requirements. Moreover, floating macro-plastic needs to be separated from water hyacinth if passive catchers are used.

We conclude that creating a plastic free Mekong delta is facing a range of behavioural, regulatory, technological and business challenges. Our findings support the following actions: 1) improve waste management systems; 2) create value chains for floating macro-plastics; 3) stimulate behavioural change in the FMCG sector and consumers; 4) regulate the use of styrofoam and single-use plastics; 5) adopt a transboundary approach with nations upstream.

Session **GS09/10/15**

Occurrence and extent of infection of intermediate hosts snals of Schistosomiasis by Schistosoma cercariae in the communal water reservoirs in Malawi

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Presenting author: Austin Mtethiwa

Cases of Schistosomiasis are rampant in Malawi with a mean prevalence of about 50% in many rural areas. Freshwater Planobirdae snails of the genera Biomphalaria and Bulinus is an intermediate host in the life cycle of Schistosoma species that cause the disease. However, information on its ecology in the communal water reservoirs is scanty. The present study assessed the occurrence and level of infection of the snails by Schistosoma cercariae in communal water reservoirs in Malawi and the ecological niche of various aquatic strata. Snails were collected once every month for twelve months (one year) from three water reservoirs (Njala, Ukonde and Mlala) located in three difference ecological zones. The snails were then identified, enumerated, and singly placed in vials containing dechlorinated water. They were later exposed to light to induce cercariae shedding. The cercariae shed were identified and quantified using a dissecting microscope. A total of 10,923 Bulinus globosus and 104 Biomphalaria pfeifferi snails were collected. There were significantly more B. globosus snails at Mlala reservoir (4, 465) than at Njala (3, 495) and Ukonde reservoirs (2, 963) (P=0.04). Significantly higher number of B. pfeifferi snails was found in Ukonde reservoir (65) than Njala (25) and Mlala reservoirs (14) (P=0.001). Furthermore, significantly more snails were found during the dry season than the rainy season (P=0.012). The proportion of snail infection by Schistosoma cercariae was 14.6 % in B. globosus and 47.5 % in B. pfeifferi snails. Close to 80 % of the B. pfeifferi snails were collected from the open water sediments whilst more than 60 % of the B. globosus snails were collected from aquatic plants confirming the ecological significance and niche of every aquatic strata. B. globosus and B. pfeifferi are the two intermediate hosts snails responsible for schistosomiasis in communities around water reservoirs in Malawi. The fact that the snails are infected by Schistosoma cercariae confirms their responsibility in existence of schistosomiasis in communities around water reservoirs making them risky areas for schistosomiasis.

Session **GS09/10/15**

Sustainability of Protein Sources Security and Fish Diversity in the Northern Thailand.

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Presenting author: Apinun Suvarnarsaksha

The hill tribe people are commonly living on the high mountain of the north of Thailand, in the areas do not have electricity, water supply and temporary roads. There are living on the basis of natural resources e.g. organic rice fields (main food for the family), seasonal vegetable, and protein sources (insects, fishes, rodents, squirrels, etc). They waste of time for their protein sources, 5-6 hours per day and depend on their luck. They are consuming insufficient protein food can affect the body' growth and brain development for child. Then, the sufficiency fish farming is the chance to produce the protein sources for local hill tribe people. There are highly slope on the mountain area, only a small pond (3*5*1.5 m) can be made and then release different feeding habits species of fishes e.g. Barbonymus gonionotus, Cyprinus carpio, Cirrhinus cirrhosus, Oreochromis niloticus and Hypophthalmichthys molitrix or different of size of single species about 300-500 fingerlings into the small pond. Secondly, feed the by the artificial ecology system by fermented rice straw and dry cow manure in the fence. This method produce the phytoplankton, zooplankton and aquatic insects as natural technique for fish food, some species of fish eating the fermented rice straw. This technique can be helping them from the time waste for their mills, they can starting to train them self to work for their highly family income. They can be security and enough protein for their family and community from fish pond, they do not fishing from the natural stream and they were train from the fish breeders to breed the fish pond for culture and selling fingerlings and local species e.g. Garra cambodgiensis, Neolissochilus stracheyi and Devario spp. breeding for culture and release for protect the populations. The sustainability of natural resources consist of food, occupation and knowledge. This technique is show the great economic to protect an ecological and safe the social, equal ECONECO (ECONomic+ECOlogy) for no hand conservations.

Session **GS09/10/15**

Riparian zone recovery following the large-scale removal of bank protection in a large impounded and navigable river

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Presenting author: Tom Buijse

Naturalizing riparian zones is considered an effective rehabilitation measure to reach the objectives of the European Water Framework Directive. The River Meuse is a large river with both commercial and recreational navigation. Due to its large discharge variation ([lt]10 - >2,800 m3/s) it is impounded over the greater part of its course to be year-round navigable. In the 20th century the banks have been protected by riprap. To improve its ecological status and reallow shoreline erosion, bank protection has been removed in the Netherland over more than 100 km in the last two decades, which is an unprecedented dimension of large river rehabilitation. Riparian strips up to 75 m wide have been purchased reallowing shorelines to erode without undesired side-effects for land-owners. The morphological, aquatic and terrestrial ecological developments have been monitored for 10 years. Not only how this rehabilitation measure is actually implemented, but also the local context steers the morphological and ecological succession. This has been conceptualized in a hierarchical DPSIR scheme. Navigation accelerates bank erosion, but most likely restricts the aquatic flora and fauna. Fish respond quickly to altered shoreline habitats and aquatic flora with a time-lag while benthic invertebrates are mainly affected by substrate composition. Eroded banks host hundreds of sand-martins and characteristic species of the endangered vegetation type 'Xeric sand calcareous grasslands (Habitats Directive Annex 1 code 6120)' appear when the riparian zone is managed with low cattle densities. After 10 years the banks are still in an early succession stage. The development is expected to proceed for several decades. It has resulted in a significant morphological improvement of the shoreline complexity. On the other hand, the reduced flow velocity in the impounded river sections directs the aquatic species composition and requires another 'leitbild' than in free-flowing sections.

Session **GS09/10/15**

"It's dry, it has less charms!": how do perceptions of intermittent rivers influence the management of these complex socio-ecological systems

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Presenting author: Marylise Cottet

Intermittent rivers, those rivers which do not flow all year round, are complex socio-ecological systems which have functioning specificities. Those specificities deserve to be taken into account in management plans to maximize the biodiversity and ecosystem services they provide. This is not the case in France and more widely in Europe where intermittent rivers benefit from the same regulations as permanent rivers. The lack of specific consideration was explained by poor scientific understanding in the past, but nowadays, by a low social value compared to permanent rivers. This second issue has not yet been explored. We have therefore conducted an exploratory study to understand how different types of local stakeholders perceive an intermittent river located on their area. We considered the case of the Albarine River, a tributary of the Ain River, in France. This river is intermittent only on its downstream section, which permits to consider the impact of intermittence on perceptions (by comparing perceptions of downstream and upstream sections). We carried out a survey by semi-directive interviews with river managers (n = 3), elected local authorities (n = 8), fishermen (n = 8) and riverine residents (n = 9). Our results demonstrated that (1) cultural services (aesthetic and recreational) of the river are above all mentioned; (2) uses and values associated to the river are strongly influenced by the intermittent process, which is generally depreciated; and (3) surveyed people have a high familiarity with the intermittent process but a weak understanding of it. These results enabled us to identify levers to improve the management of these complex socio-ecological systems.

Session **GS09/10/15**

Post-restoration dynamics of habitats, aquatic vegetation and benthic macroinvertebrates following a unique controlled erosion action in the Upper Rhine

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Presenting author: Jean-Nicolas Beisel

An unprecedented restoration action has been initiated in April 2013 by a controlled bank erosion action in the Upper Rhine. It has been followed during 5 years with a biomonitoring program. New fluvial forms appeared rapidly and following the settlement of fine-substrates new mesohabitats added up to those already in place. Sedimentation habitats harbor specific fauna that are not observed elsewhere and thus contribute to an increase in the taxonomic and functional richness of the whole site. Three years after the restoration 7.3 % of the open water area with filamentous algae was colonized by aquatic vegetation, previously absent within the main channel. New taxa of macroinvertebrates appeared rapidly on the study site as sedimentation habitats have developped. Functional measurements have confirmed that newly created habitats in the restored section facilitate the establishment of particular profiles of burrowing species, such as Odonata whose ecological requirements are targeted to fine-grained habitats and slow-current velocities. Since the restoration action, their life-cycle completion has been especially improved by a softer water-riverside interface. Our feedback is that the implementation of in-channel, transverse, artificial groynes to facilitate the lateral erosion process was a decisive technical option for obtaining the results observed. We also emphasized invasive species impacts that can hinder or delayed restoration action effects.

Session **GS13/14**

Testing the River Continuum Concept with geostatistical stream-network models

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Presenting author: Stefano Larsen

The River Continuum Concept (RCC) provided one of the first unifying frameworks in fluvial ecosystem theory. While the RCC predictions held in many empirical tests, other research highlighted how the model overlooked sources of heterogeneity at different scales e.g. the effects of tributaries. Disentangling these effects requires an assessment of variation in key ecosystem variables over the longitudinal and lateral dimension of river networks. However, so far, no empirical tests have employed a spatially explicit statistical approach to this assessment.

Here, we show how recently-developed spatially-explicit models for river networks can be used to test predictions of the RCC whilst taking into account cross-scale sources of heterogeneity. We used macroinvertebrate data from 195 monitoring sites from 1st to 4th order streams spread across the Adige River network (NE Italy). We compared theoretical expectations with empirical semivariograms that incorporated network topology to assess the continuity and patchiness in the proportion of invertebrates functional feeding groups (FFG) over Euclidean and in-stream distances. Geostatistical stream-network models were then used to quantify the influence of the longitudinal gradient relative to local-scale water quality and land-use drivers, while accounting for network spatial autocorrelation.

Patterns in the semivariograms based on flow-connected relationships were characterised by a nested structure associated with heterogeneity at multiple scales. Therefore, the longitudinal variation in FFG was better described by a patchy discontinuum rather than a gradient, implying that both in-stream processes and landscape factors influenced stream ecosystem function. The overall shift in FFG along the longitudinal profile was generally consistent with the RCC predictions, although the best models often included water quality and local land-use predictors. Stream-network models further indicated that up to 90% of residual variation (mean=50%) was accounted for by spatial autocorrelation, especially among flow-connected communities. Accounting for such autocorrelation not only improved model performance relative to non-spatial approaches, but indicated that most flow-connected communities were spatially correlated to some extent. This has clear implications for the assessment of the RCC tenets. This is the first test of the river continuum model that explicitly accounted for stream network topology and autocorrelation. Results indicated that in the Adige River, macroinvertebrates feeding groups exhibited heterogeneity along the longitudinal gradient, which appeared punctuated by local habitat transitions. Such transitions could be associated with artificial impoundments that alter the natural continuity of river processes, and we advocate the use of spatially explicit network models to test the RCC in more natural contexts.

Session **GS13/14**

River-fen interaction as a driver of stress in wetland ecosystems. Case study of Upper Biebrza, Poland

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Natural river-fen systems have nearly disappeared from the managed landscape of Europe. Majority of fens (groundwater fed peatlands) was drained in result of conversion of peatlands into pastures and meadows with controlled water levels and outflow. Rivers were regulated and remain exposed to regular disturbances resulting from maintenance works and discharge control. Together, these systems have been impaired in Europe to the extent that finding near-natural river-fen systems persisting under relatively natural processes of water flow and biodiversity development remains challenging not only for the documentary purposes but - mainly - as a reference for ecosystem restoration.

In our study we analysed selected habitat characteristics in a near-natural fen-river system located in the Upper Basin of the Biebrza Valley (NE Poland) in order to determine natural flow paths and stressors allowing fen habitats and rivers to develop in nearly undisturbed state. The study area was a 6 km long reach of the Biebrza river valley, located within the Biebrza National Park, in which we collected soils samples from around 60 randomly distributed measurement points (riparian forests, wet meadows fen meadows and reedbelts). Soil samples were taken from the vegetation root zone, 45-55 cm below the ground level, within and beyond the growing season (June, November and March). We determined moisture content and nearly 20 water quality parameters.

Our research indicated that the most variable hydrogeochemical conditions are present within the sites persisting under the influence of agriculture and in the vicinity of the elements of infrastructure. Soil moisture content and EC distribution indicated varying intensity of groundwater feeding in the left- and right-hand side of the valley. Results of our research indicated that interaction of groundwater and surface waters along the relatively short stretch of a natural river induce variable levels of stress to fen and riparian habitats that allow for the development of specific vegetation (incl. Caricetum davallianae and Caricetum gracilis). We confirmed that human intervention reduced the levels of stress by increasing availability of elements and causing hydrological instability, which the lack of in untouched habitats is likely to be responsible for the development of specific fen and riparian habitats.

Session **GS13/14**

Stream bryophyte communities across a gradient of thermal regimes in Arctic streams, Disko island, Greenland.

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Presenting author: Paraskevi Manolaki

Aquatic mosses constitute one of the dominant autotrophic components in high-latitude freshwater ecosystems, due to their adaptation to low temperature, light and nutrients, and their slow growth. Thus, they are essential contributors to the primary production in these habitats. Despite the ecological importance of Arctic stream mosses, little is known about their community composition along with different stream types, although this is essential for ecological preference and sensitivity studies. Community studies of stream mosses along a thermal regime are needed to understand changes due to global climate shifts. Climate change is expected to cause streams to shift from glacial- to groundwater-dominated sources due to receding glaciers. Moreover, as the climate warms, tundra environments are generally "greening" and along with the projected increase of nutrient runoff, streams are expected to become more productive. Changes in bryophyte communities could affect key stream processes such as metabolism and organic matter decomposition in streams, affecting downstream ecosystems.

Our aim was to evaluate the effect of the thermal regime on the moss communities in the Arctic streams. We selected six streams with the different thermic regime (i.e. homothermic vs heterothermic) in Disko Island in the area around Qeqertarsuaq. Disko Island is well known to have some areas with geothermal activity, with source water of a temperature > 2°C (homothermic springs). Thus, homothermic streams maintain the same temperature year-round which makes them very unique freshwater habitats in the permafrost zone. In contrast, heterothermic, such as glacier-sources streams, are characterized with low-vegetation, stream water freeze during winter, thus representing harsher environments for the organisms living in them. We conducted transect samplings in 100m steam reach, in September 2018. Moreover, we characterized thermal regimes deploying temperature loggers to record temperature in continuum and measure the main physical-variables potentially affecting the bryophytes communities (light, water velocity, nutrients). We found 15 taxa, of which 3 were first described for the Arctic steams (Schistidium subjulaceum, Hygrohypnum molle, Hygrohypnum styriacum). Moreover, our results showed that homothermic streams presented more stable habitats for bryophyte growth as we found higher mosses abundance and higher diversity values. Our results show that although stream mosses are adapted to Arctic environment, i.e. low temperatures, communities are established according to local temperature regime and environmental variables. The study of stream moss community composition across different thermal regime can help to understand stress responses caused by global change as mosses are resistant to rapid and significant changes in the environmental conditions. Our results will provide insights into how global change will affect stream functioning in Arctic lotic ecosystems.

Session **GS13/14**

Water temperature and water depth shape macrophyte-bacterioplankton interactions in a groundwater-fed river

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Presenting author: Yanran Dai

The effect of abiotic variables on the growth of macrophytes and separately the activity of aquatic microorganisms by modifying their respective metabolisms has been wellunderstood. It is, however, unclear how abiotic factors regulate non-trophic macrophyte-microorganism interactions, especially in a river with low environmental and hydrological variations. Here, we conducted structural equation modeling on datasets collectedfrom a groundwater-dominated river and grouped by hydrological conditions, to investigate how the abiotic factors water temperature (related to the season), water depth (related to spatial patterns of river morphology) and nutrients affect the growth of macrophytes,the abundance and viability of bacterioplankton, and more importantly, the macrophyte-bacterioplankton interactions. Overall, plant height and heterotrophic bacterial abundance display a similar dynamic pattern with water temperature and water depth. However, the temporal and spatial variation of neither macrophyte biomass nor bacterioplankton viability was well synchronized with any single abiotic variable. Deeper water depth intensified the positive interaction between macrophytes and bacterioplankton, while higher temperature switched the interaction from being positiveto negative. Different nutrients (inorganic and organic) showed distinct effects on macrophyte growth, bacterioplankton abundance and activity, as well as the interaction between the two groups. Nonetheless, these effects varied with water temperature andwater depth. Our study provides empirical evidences that abiotic variables, even with relatively low fluctuations, play a critical role in regulating the patterns and strengths of interaction between macrophytes and bacterioplankton. These findings can supportan improved understanding of the effects of climate- and or management-induced (e.g. dredging and channel modification) changes on ecosystem functioning in riverine systems.

Session **GS13/14**

Comparing the relative importance of biotic versus abiotic factors in large floodplain rivers - Insights from response of fluvial zooplankton to the arrival of the Silver carp, H. molitrix, in the Illinois River

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Presenting author: Andrew F. Casper

Developing a fuller understanding the factors shaping aquatic community structure has implications for aquatic ecosystem restoration and management. For example, testing if abiotic variables like temperature, turbidity, or velocity are the main predictors of large rivers zooplankton assemblage abundance, biomass, and diversity. However, if biotic factors like planktivory by an invasive fish are more important, this suggests the structure and dynamics of this type of ecosystem and assemblage is more complex. To make this comparison, the influence of a suite of abiotic and biotic variables on zooplankton density, biomass, and richness over 5 years from 300 km of the Illinois River. Richness responded differently than density or biomass. For example, richness is strongly affected by Asian carp planktivory across the basin, whereas the fish only influenced biomass and density where the invaders abundance was highest. Hydrology and temperature were more important in the upper river, but only for density and biomass. This type of complex response pattern illustrates that, rather than being transient, unstructured ecosystem components, zooplankton are actually integral components of river ecosystems that respond to the mixed drivers of the riverine environment.

Session **GS13/14**

Basal resource quality and energy flow in a lowland river food web

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Presenting author: Paul Mcinerney

Understanding energy flow through ecosystems and among sub-habitats is critical to understanding patterns of biodiversity and ecosystem function. It can also be of considerable applied interest in situations where managing for connectivity among habitats is important to restoring degraded patterns of productivity. Here, we describe patterns of basal energy flow in different habitats in a lowland river in the Murray River catchment, Australia. The three habitats - river channels, anabranches and wetlands - are of particular interest as substantive management effort is currently being expended to connect these habitats using environmental flows, which seek to restore critical functional components of natural hydrological regimes, including such inter-habitat connections. A combination of stable isotopes and fatty acids were used to determine the source of energy and energy pathways through food webs across the three habitats. We found clear differences in the quality of basal resources between the river channel and floodplain habitats. Floodplains were characterized by food resources with higher concentrations of essential fatty acids. We show that inundation of floodplains and subsequent reconnection to the river is critical to: 1/ mobilise high quality food resources to the main channel; and 2/ to afford riverine consumers the opportunity to access to high quality resources by moving onto the floodplain. This research shows the importance of determining both the quantity and quality of organic matter fluxes into food webs, and the potential role of targeted environmental flows to re-establish critical energy pathways in riverine ecosystems.

Session **GS16**

Remotely sensed, high resolution, catchment scale habitat mapping for rivers

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The advent of high resolution data has led to the development, and application, of varying methods to map bathymetry in freshwater systems. These methods can be active, such as acoustic bathymetry (sonar), or passive, such as optically-derived (image) depth maps. Concurrent with these advances, local natural resource management agencies are beginning to acquire high resolution imagery at regional scales. In this study, we use high resolution airborne imagery (50 cm - 4 band: R, G, B, NIR) and a method developed by Legleiter (2015) - Flow REsistance Equation-Based Imaging of River Depths (FREEBIRD), along with high resolution (6 points/ m2) light detection and ranging (LiDAR) data to remotely map river surfaces and depths for a 4,000 km2 catchment in a prominent Atlantic salmon (Salmo salar) and brook charr (Salvelinus fontinalis) river, the Northwest Miramichi, New Brunswick, Canada. Following the derivation of depth maps, we apply hydraulic equations to predict velocity, Reynolds numbers, Froude numbers, fluid shear stress, and bed curvature. We then apply a PCA to investigate multi-collinearity between the derived hydraulic parameters. Finally, we reduce our suite of hydraulic parameters, and conduct an Iso cluster unsupervised classification to delineate fluvial geomorphic units of relevance for Atlantic salmon management.

Session **GS16**

Booming three-dimensional planning for river restoration

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Presenting author: Keigo Nakamura

River restoration demands the three-dimensional data for its complex nature. A survey using UAV and Lidar made it possible to acquire detailed river morphological data. In particular, Airborne Lidar Bathymetry (ALB) opened new possibility because of the ability measuring under the water by green laser. In Japan, more than 30 rivers have already applied ALB for river surveys. Practitioners started to use ALB data for planning and river management. For river works, intelligent construction machines have become widespread in Japan since the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) started CIM initiatives (BIM for infrastructure), which means construction information modeling/management (CIM). The CIM initiatives started from the fiscal year 2012 to solve labor shortage and to improve construction productivity. These intelligent construction machines enable to curve complicated river morphology efficiently using three-dimensional (3D) data. As the result, 3D design is becoming issues to bridge the gap between Lidar surveys and river works. For 3D design, we developed RiTER (River Terrain EditoR) series consisting of RiTER Xsec (cross-section) and RiTER 3D based on iRIC software. The iRIC software is free numerical simulation of flow and morphodynamics in rivers. RiTER Xsec is 2D-based river design software, which creates 3D data from 2D-based design automatically. RiTER 3D is 3D-based software which is still in developing stage. Additionally, EvaTRiP has produced to evaluate mainly fish habitat of the river based on 3D data. Using these software and 3D data, we try to conserve and restore the nature of rivers from urgent river works even after severe flood disasters. In my presentation, I would like to introduce the new trend of river restoration in Japan as mentioned above.

Session **GS16**

Conceptual model of ecological impacts of barriers in EU considering fish habitat selection criteria for running waters

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Presenting author: Piotr Parasiewicz

The core element of this study is to develop a conceptual model of barrier impacts on rivers developed within the project Adaptive Management of Barriers on European Rivers" (AMBER). The model uses the Fish Community Macro Habitat river typology (FCMacHT) based on a number of physio-geographic factors associated with Expected Fish Communities (EFC) to assess, on a continental scale, the response of fish communities to riverine habitat changes caused by barriers. Macro habitat use and tolerance guilds were adopted as an impact indicators. We assessed 21 physical river attributes modifiable by barriers, and developed macro-habitat suitability criteria to estimate their influence on fish guilds occurrence. For each attribute a proportional alteration of a suitable habitat area was estimated. Subsequently, for 6 identified barrier types located in every FCMacHT the expected amount of remaining suitable habitat area was calculated, weighted by the proportions of each guild in the EFC(weighted Remaining Habitat proportion (wRHp)) . We first assumed that good ecological potential (GEP) is maintained and river ecological connectivity was preserved. The calculated wRHpwas arranged in five impact categories. As a second step, we assumed, that river GEP is affected by shortcomings in barrier construction and operation. In this case a penalty of 25% of wRHp was included, changing the impact class for each barrier type in each FCMacHT. The results demonstrated, that dams in mountainous areas have the highest impact on fish habitat. The model presented here provides a framework for regional assessment of barrier impacts on riverine habitats. It is also a foundation for examining barrier impacts under various scenarios of landscape management and climate change."

Session **GS16**

Strategic tools for eco-sustainable hydropower development

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Presenting author: Carina Seliger

Hydropower is an important energy source in Austria. With the exploitation of approximately 70 % of the hydropower potential Austria can cover about two thirds of its electricity demand. At the same time, about 60 % of Austria's waterbodies are at risk of failing the aims of the EU Water Framework Directive, half of them due to hydropower-related pressures such as hydropeaking, water abstraction and impoundments.

In order to reach the targets of the EU Renewable Energy Directive, Austria strives for a further increase in hydropower production, thereby jeopardizing the aim of the EU Water Framework Directive. Although the implementation of mitigation measures, such as fish passes and environmental flows, has nowadays gained broad acceptance, state-of-the-art solutions for several other hydropower-induced problems (e.g. related to hydropeaking, downstream migration, impoundments and sedimentation) are either under development or entirely missing. As a result, the realization of new hydropower plants will inevitably increase pressures on aquatic ecosystems.

Under these circumstances, and especially since river sections with unexploited hydropower potential often coincide with predominantly natural river sections of high ecological value, the fulfilment of both directives (EU Renewable Energy Directive and EU Water Framework Directive) seems highly unrealistic. Thus, the hydropower sector needs to make use of the full mitigation hierarchy starting with avoidance, minimisation and eventually compensation. Furthermore, in order to find the right balance between both directives, strategic tools for sustainable river management have to be applied.

Based on a literature review, strategic tools for sustainable hydropower development are compared and assessed with regard to their applicability in Austria. Furthermore, the comprehensive database established in the course of the WFD monitoring routine, will be analysed to tackle the questions where, whether and to which degree hydropower exploitation in Austria is ecologically tolerable. This should guide the way towards eco-sustainable hydropower development.

Session **SP01**

An index to assess the success of river and floodplain restoration

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Presenting author: Ian Fuller

How should the success of river and floodplain restoration be assessed? We contend that the benchmark for restoration should be the river in its natural condition prior to modification. The pre-modification condition of the river represents the natural pseudo-equilibrium state in which the river accommodates and adjusts to catchment water and sediment fluxes. The resulting assemblage of river landforms (e.g. bars, channels, cut-banks, backwaters, floodplains) is in balance with the prevailing flood regime and sediment supply. Furthermore, these equilibrium forms are able to adjust to changes in e.g. flood magnitude and frequency via e.g. channel expansion and / or contraction. A restored river is one that has the capacity to adjust its form. It behoves river restoration to understand the history and trajectory of pre-modification channels, so that the 'right' river type can be restored. To assess the success of restoration, we propose the use of a natural character index (NCI). The NCI is simply the ratio between a parameter which describes the form and function of a river now and the same parameter measured at a point or points in time past. Example parameters include sinuosity, floodplain width, active channel width, bar area (at a given flow), riparian vegetation. Measurement of these parameters utilises a combination of aerial photos, archive maps and LiDAR-derived terrain models, the availability of which necessarily limits and determines what parameters can be used in assessment of a site NCI. LiDAR in particular provides an opportunity to comprehend pre-modification river and floodplain character. We illustrate the NCI concept and its potential for use in assessing restoration using examples from New Zealand, Spain and Croatia.

Session **SP01**

A tool to optimize understanding of hydromorphological characteristics for river management and restauration, Carhyce

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Presenting author: Frederic Gob

Restoring the hydromorphological characteristics of rivers has become a major issue in France since the establishment of the European Water Framework Directive in 2000. Hundreds of rehabilitation projects of all sizes have since been developed to improve the ecological quality of French rivers. Despite the fact that the restoration program is already well engaged, practitioners are still asking for tools to support decision-making, in order to better take account of the hydromorphological component in restoring river channels. Such tools are particularly needed to identify river reaches that have to be restored and quantify the physical alteration that effects the ecological functioning of the river. This paper presents the Carhyce tool that is based on a rich database gathering quantitative descriptions of the characteristics of river reaches (channel geometry, bed grain size, riparian vegetation, stream power, etc.) collected by the French Agency for Water and the Aquatic Environment. It relies on a standardized field protocol applied to more than 2500 river reaches collected throughout the French territory. Analysis and treatment of the data from the Carhyce database provides three sorts of applications available through a web interface:

- It allows visualization through tables and graphs of the hydromorphological characteristics of any river reach surveyed on the field according to the Carhyce protocol.
- It provides a rich catalogue of physical parameters of every type of river reach present in France and the corresponding regional hydraulic-geometry relationships.
- It proposes an integrated calculation of the deviation from regional reference models of different parameters of the channel geometry of any reach present in the database. These models have been built from a selection of about 600 reaches considered as poorly impacted by direct human influences. They allow the parameters of the geometry of the channels that do not correspond to the regional norms to be identified.

The reference models and the hydromorphological database provided by the Carhyce application is an adjustable guide to manage and better understand key parameters controlling hydromorphological pressure on biocenoces. Several examples of studies before and post restauration using the Carhyce data will be presented.

Session **SP01**

Using Geomorphic Covariance Structures In River Builder Software To Rehabilitate Whole River Corridors

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Presenting author: Gregory Pasternack

River corridors (i.e., channels, floodplains, and terraces combined) of all size and landscape position are threatened by anthropogenic impacts. Despite well-meaning flow and landform manipulations to enhance rivers, many projects instill further harmful anthropogenic disturbance. A central problem arises from the mismatch between the reach-scale understanding of rivers versus the occurrence of ecosystem services and morphodynamic processes at meter-to-sub-reach scales. To drive these services and processes, research increasingly corroborates that river corridors require multiple scales of spatially coherent topographic variability. However, the types and metrics of topographic variability remain largely unknown. The emergence of topo-bathymetric point clouds of river corridors now enables analysis of topographic variability, but within what scientific paradigm? How can such knowledge guide design of better river corridor projects? These questions may now be answered by using a growing theory about rivers called geomorphic covariance structures" (GCSs) and applying it to river rehabilitation design using the free, open-source River Builder R package. A GCS is the bivariate longitudinal pattern of any two variables down a river, and it is computed for a range of discharges to cover in-channel and floodplain states. A set of GCSs spanning the key variables for a given river setting can describe the requisite layers of topographic structure a river corridor needs to deliver intertwined physical-ecological functioning. Once that is in hand, then River Builder- the world's first open-source procedural software for creating river terrains exactly to specification- may be used to design a functional river corridor. River Builder uniquely integrates channel, floodplain, and terrace design into a coherent lateral and longitudinal continuum of layered variability. This presentation will explain GCSs and the use of River Builder for river-corridor-scale integration."

Session **SP01**

Biophysical Monitoring of Floods and Floodplains: Spatiotemporal Analysis of the McCormack Williamson Tract Restoration in California's Delta

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Presenting author: Anna Rallings

The Sacramento-San Joaquin Delta of California exists at the intersection of complex environmental, economic, and water resources management issues. The land use of this region has transformed from extensive tidal wetlands and converging river systems to an array of leveed deltaic islands, channelized rivers, and regulated waterways. In addition to the 25 million people who depend on drinking water managed from the Delta, it is home to threatened riparian and wetland habitats and endangered species. In recent decades, an increasing interest in process-based restoration has led to the strategic removal of levees to reconnect the river system to the floodplains for the renewal of wetlands and riparian ecosystems as well as the reinvigoration of the floodplain-dependent food web. The McCormack Williamson Tract is a 650 hectare leveed island at the tidal-fluvial boundary of the Delta encircled by two major rivers and a network of adjoining sloughs. The tract is adjacent to the only unregulated river entering the Delta, the Cosumnes, making it a model location for understanding a natural flow regime and process-based restoration. The seasonal flooding of the Cosumnes River results in dynamic geomorphic and biological processes, sediment transport, nutrient transfer, and creation of episodic floodplain ecosystems.

The 3-year biophysical monitoring of the aquatic habitats around and within the tract has served as a pre-restoration baseline assessment of water quality and food web dynamics as impacted by these seasonal flow variations. In situ water quality monitoring was paired with carbon (?13C) and nitrogen (?15N) isotopes in suspended particulate organic matter and ?2H and ?18O of waters to assess conditions in the surrounding riverine and slough sites at a fine spatiotemporal resolution. Isoscape mapping and water parameter interpolation were used to evaluate the impact of flood periods on these conditions throughout the year, providing insight into the role of flood magnitude and timing as well as floodplain reconnection. Changes in isotopic composition were impacted by changes in seasonal flow at a much finer scale than previously observed in the Delta region and indicated more dynamic and complex local processes. Floodplain inundation and stochastic flood events were observed to have a significant impact on not only on downstream water quality but also waterways typically disconnected from the river environment. An unanticipated levee breach in 2017 at the tract also provided a preview on the impact of inundation on water quality and isotopic markers. This study provides the spatiotemporal context for evaluating floodplain restoration trajectories in highly dynamic and complex hydrological systems.

Session **SP01**

Toward more effective stream restoration : a demonstration site network to assess efficiency

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Presenting author: Evelyne Tales

Hydromorphological river restoration has been encouraged since the publication of the Water Framework Directive all over Europe in order to improve ecological status of running waters. Thus, numerous restoration operations occurred with various objectives: restoring ecological continuity, increasing river habitat heterogeneity, etc. However, it is often impossible to conclude on their efficiency because many of these operations lacked suitable monitoring or were wrongly designed.

European projects (e.g. Reform ERC, Walphy Life Environment) attempted to resolve this matter by analysing restoration outcomes of selected case studies. They provided a set of good practices to insure more effective restoration. But, it is also necessary to better plan restoration projects from conception to implementation, to improve monitoring and thus understanding of processes sustaining restoration. These objectives rely on feedbacks from multiple projects implemented in various contexts.

Since 2010 in France, such an approach is realised as part of the demonstration sites network. Coordinated by the French Agency for Biodiversity, it results from a collaboration involving practitioners, stakeholders and researchers. It currently includes about 40 sites which experience restoration works. This device comprises several key elements to allow good assessment of restoration efficiency. On these sites, a scientific long-term monitoring is applied following a BACI (Before After Control Impact) design and using standardised protocols for data collection. Guidance documents concerning monitoring are published to support restoration approach at site scale. A reflection is engaged to provide guiding procedure for restoration project evaluation.

Finally, this network is also a tool to promote adaptative management.

Session **SP01**

Rehabilitating channel-floodplain connectivity in highly regulated river systems: A case study from the Middle Rio Grande, New Mexico USA

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Presenting author: Todd Caplan

The dynamic interaction between a river and its floodplain is important for a variety of hydrologic, geomorphic, and ecological processes. During high discharge events, inundated floodplains provide productive rearing and refuge habitat for native fish until flow conditions in the river channel are more physically and biologically accommodating. Along many large, low-gradient rivers throughout the world dam construction and other actions by river management agencies have severed this channel-floodplain connection, resulting in widespread aquatic and riparian habitat degradation and heightened risk of species extinctions. Because rehabilitating these altered river systems is technically complex and costly, comprehensive strategies are needed to ensure rehabilitation efforts are functionally sustainable.

Driven by legal and societal pressure to comply with laws such as the Endangered Species Act, water management agencies throughout the American West must devise strategies to recover declining native fish populations. For example, on the Rio Grande in central New Mexico water managers are modifying reservoir operations to store and release mountain snowmelt runoff to support floodplain dependent reproductive cycles of the endangered Rio Grande Silvery Minnow. Release schedules are optimized whenever possible to mimic the timing and overall shape of the snowmelt hydrograph. However, achieving flood pulse magnitudes large enough to inundate floodplains and generate new off-channel aquatic habitats is infeasible without incurring unacceptable risk to surrounding urban infrastructure. Without such large magnitude flood pulses, bulldozers and other mechanical equipment are used to replicate the flood disturbance regime by physically lowering elevated floodplain terraces, excavating backwater channels and creating new riparian-wetlands.

Recent monitoring data demonstrate that Rio Grande Silvery Minnow populations are using and successfully reproducing in these seasonally inundated floodplain habitats, although other data indicates that these projects have limited life and will be unsustainable without ongoing monitoring and adaptive management. However, most project funders employ a build it and walk away" approach that fails to address this need and invariably limits the functional life of the project. This scenario is not unique to the Rio Grande - it is a pervasive conservation issue for regulated rivers around the globe. Despite this pervasiveness, transferable solutions are surprisingly scarce. In this session we present a case study from the Rio Grande that highlights how the authors are working to resolve this complex issue. We provide an overview of technical approaches and costs to design, build, monitor and adaptively manage river-floodplain rehabilitation along with permanent public funding schemes and community-based operational concepts we are exploring to ensure long-term ecological functionality and overall project success.

Session **SP01**

Restoration of Floodplain Ecosystem Functions: Case Study of the Danube Floodplain between Neuburg and Ingolstadt, Germany

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Presenting author: Bernd Cyffka

The Danube floodplain is disconnected from its river and natural water dynamic is inhibited by regulation and hydropower generation. Notwithstanding the hydropower dams, this restoration project aims to bring back natural water dynamics to the floodplain by a new floodplain stream, by ecological flooding and by temporary groundwater drawdown during summer months. Due to the new floodplain stream, former fluctuating water zones that are habitat for target species changed to aquatic habitats, which are also required. The measure groundwater drawdown aims to enhance the abiotic conditions for pioneer species e.g. of muddy streambanks.

With a scientific efficiency control the situation before restoration implementation with the effects of three different types of groundwater drawdown is compared. For these three types, the hydrological situation was investigated, and the effects on the potential area and on the occurrence of resp. species were mapped. The outcome is that one type of groundwater drawdown can enhance germination of species in the fluctuating water zones, but is detrimental for aquatic organisms. The other type is able to provide the same suitable conditions, without severely harming the aquatic habitats. The third type cannot reach the needed low water levels and is therefore not a comparable option. The results show that an interdisciplinary monitoring is able to develop a measure suitable for both competing habitat types. Thus, it is possible to restore certain ecosystem functions.

Session **SP01**

Three Projects - One Goal: Restoring The Lower Rhine's flood plain

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Presenting author: Thomas Chrobock

Due to its relevance as Europe's most important water way, the Rhine is heavily modified and managed. Along with its ongoing sole incision and lower and rarer flood events, the Rhine and its flood plain became progressively disconnected. This results, on the one hand, directly in a decrease of natural flood plain habitats and, on the other hand, in an associated local loss of individuals and, ultimately, species adapted to the special conditions of a flood plain.

In three ongoing EU-Life-Nature projects with a total budget of about 9.2 Mill ¤, we aim to counteract the decoupling of the Rhine and it's flood plain and to re-establish and improve the hydrological and ecological connections between them. In one of these projects, we constructed a new branch in the Rhine's flood plain near Wesel-Bislich (North Rhine-Westphalia, Germany) with a length of ca. 1300 metres. Here, we significantly improved the dynamic hydrological situation and increased the water-affected area. Several species, such as northern lapwing, bitterling and resting arctic geese, already benefit from the measures. In the second project, we developed and built a new 2.2 kilometre side-channel at the Dutch-German border close to Emmerich and initiated the development of 22 ha of a hard wood flood plain forest. While the new side-channel offers e.g. fish spawning grounds and small-scale structured wave-protected refuges for plants and other organisms that disappeared from the main stream, the flood plain forest will become one of the largest along the Rhine in North Rhine-Westphalia, at least. These two projects represent the first two ecological motivated side-channels in North-Rhine Westphalia. In the third project, we will restore wetlands of the nature reserve Emmericher Ward. Here, we will optimize the water management of the poldered area, restore oxbow lakes and flood channels and install active irrigation.

Besides the technical, financial and logistical challenges of such projects (e.g. floods, mining legacies, warfare material), we were surprisingly faced with other problems and constraints. Most importantly, although legal national guidelines for the implementation of European guidelines (e.g. Fauna-Flora-Habitats-Directive, Water Policy Directive) do exist, their implementation is hampered by responsibilities of different federal and state authorities. Additionally, superposing legal public and private rights on properties and usage, maintenance and management had to be solved. However, our side-channel projects clearly demonstrate that the safety of the waterway is not affected by re-establishing connections between the river and its flood plain, and we hope that these projects may act as role models in the future.

Session **SP01**

Principles for sustainable floodplain management in the Netherlands

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Presenting author: Jeroen Rijke

This paper sets out principles for sustainable floodplain management in the Netherlands. Floodplain management in the Netherlands relates to a multitude of issues, including flood protection, ecological restoration, mining, agriculture, residential development, inland navigation and other economic activities, and cultural heritage. Being located at the downstream end of a major river system means that river discharges are subject to natural variability, changing land use and water management practices upstream of the Netherlands, as well as climate change. Sustainable floodplain management is therefore a complex affair.

Here, sustainable floodplain management refers to achieving and maintaining a state of environmental, and socio-economic sustainability in Dutch floodplains. We have identified seven principles for sustainable floodplain management, by reflecting upon seven research projects that took place between 2010 and 2019. These projects explicitly focused on sustainable management of floodplains in branches of the lower Rhine: scientific evaluation of Room for the River, Waalweelde, NWO UDW Delta Oost, STW RiverCare, KCNL SteenGoed, KCNL Circulair Uiterwaardenbeheer and KCNL Noordwaard. The principles are:

1. Optimise value for society of floodplain development, by using a regional perspective to prioritise interventions and a local perspective to connect to stakes and opportunities.

2. Anticipate change and uncertainty, by avoiding irreversible and regretful interventions in terms of ecosystems, flood risk and cultural heritage.

3. Nurture ecosystem services, by using and reinforcing natural and landscape characteristics of the river as much as possible.

4. Promote natural capital, by allowing for natural dynamics in floodplain management plans as much as possible.

5. Reinstate self-shaping natural river dynamics after gravel, clay and sand extraction in floodplains, through regulatory and/or financial requirements for mining activities.

6. Adaptively use and increase understanding in system behaviour, by embedding state-of-the-art monitoring, analysis and feedback to everyday floodplain management practice.

7. Encourage floodplain stewardship of landowners, by establishing collaborative governance arrangements that reflect the scale of ecological (sub)systems.

These principles reflect trends in floodplain management that have taken place over the last two decades in the Netherlands and are set up to support the adoption of 'good' practice. They relate to social-ecological resilience, integrated planning and governance, adaptive management and the circular economy. Whilst the principles are developed in the context of the Netherlands, they could be used as inspiration for sustainable floodplain management in other lowland river systems.

Session **SP01**

Re-operating dams to provide environmental flows: From recommendation to practice

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Presenting author: Afua Owusu

Construction of dams for economic development alters the hydrology of rivers and degrades riverine ecosystems. In recent decades, the call to reverse these negative impacts by re-operating dams has become stronger. Dams can support these riverine ecosystems through releasing environmental flows (e-flows). Unfortunately, despite the development of numerous methodologies to determine e-flows and optimise dam releases, actual implementation has not followed suit. Only few cases exists where e-flows have successfully been implemented. Integrating e-flow requirements in the design of new dams is relatively easier than changing operations of existing dams, however re-operating existing dams is essential to restore ecosystems and ecosystem services that have already been affected by the construction and operation of dams.

This study will provide insights into how e-flows evolve from recommendation to practice through a systematic literature review on practical experiences to integrate e-flows in dam operations. Approximately thirty cases of successful dam re-operation have been identified ranging from the well-documented case of the Glen Canyon Dam in USA to lessor known cases such as the Katse and Mahale Dams in Lesotho. These cases show that incorporating e-flows in dam re-operation goes through several stages, e.g.: stakeholder consultations, flow experimentation, drafting of new dam operation policies and adaptive management or blanket implementation. At each of these stages implementation of e-flows may be impeded for various reasons such as the occurrence of a drought which restricts water allocations to all users; aging infrastructure which limits how often gates can be adjusted to release e-flows; or the presence of an endangered species which must be protected at all costs. Illustrations of the important role of collaboration between various stakeholders, set timelines for experimentation to begin and the ability of stakeholders to identify and take advantage of opportune events occurring in the basin will also be given. These insights will inform how dams can be designed, operated and governed in a more equitable and sustainable manner for both humans and the environment.

Session **SP01**

Temporal changes in sensitive rheophilic fish communities: the effects of 20 years of floodplain management in the lower river Rhine, the Netherlands

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Presenting author: Twan Stoffers

The extensive modifications in the river Rhine resulted in the severe decline, or even loss, of diadromous fish species typical for European lowland river systems, such as Atlantic salmon (Salmo salar) and European sturgeon (Acipenser sturio). In addition, the numbers of potamodromous, rheophilic species, such as European barbel (Barbus barbus), nase (Chondrostoma nasus) and dace (Leuciscus leuciscus) have significantly reduced. Since the 1990s, authorities in the Netherlands have reconstructed numerous floodplains to improve the ecological quality of the river systems. This resulted in positive changes to water quality and an increase in natural habitats, but not to the expected recovery of rheophilic fish species. We expect that the slow recovery of rheophilic fish populations is mainly caused by insufficient presence, accessibility, and/or quality of floodplain habitats that function as nursery areas for young fish. To study the effects of the reconstructed floodplain habitats on the population developments of rheophilic fish, and to assess why these developments are not as positive as expected, we compared species composition and abundance of juvenile fish from 1997, 2009, and 2017, for 4 floodplain systems in the Dutch part of the river Rhine. Temporal changes in the juvenile fish community were related to temporal changes in floodplain morphology (connectivity, size-length ratio, total bank length), habitat variability (vegetation cover, substrate, structural complexity), and river discharge and water flow dynamics. In general the same fish species were found during all periods, with the exception of alien gobies that were first recorded in the 2009 surveys. Rheophilic fish densities, however, all show a distinct decrease in all studied floodplain systems. We hypothesize that this decrease is related to deterioration of the nursery function of the habitats with time, probably related to silting of the systems after their construction. Silting leads to reduced water dynamics, less flow, and even detachment of the floodplain from the main channel, which makes these habitats less suitable for rheophilic fishes and may lead to an increase in eurytopic species, especially when there is also increased vegetation growth. As silting is a natural process and will almost always occur, this means that in order to maintain suitable nursery areas for rheophilic fishes, regular maintenance of these floodplain systems needs to be performed.

Session **SP01**

Continuous biodiversity changes in a ten-years-post-restoration-study - causes and pitfalls

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Presenting author: Armin Lorenz

Morphological stream restoration is first of all a big impact destroying habitat and leading to massive drifts of benthic invertebrates. Virgin bare habitats are created and normally are subsequently colonized. The invertebrate community colonizing these new habitats may return to the pre-restoration state or develop differently if colonization sources of other species exist in reasonable distance. Currently, the required time for the establishment of a more or less stable community after a restoration action is under discussion. Several projects showed that a monitoring time of a few years is not sufficient. Nonetheless, other factors, e.g. landuse change or climate change can induce additional changes in the development of the invertebrate community in a restored reach.

We investigated every year over a ten-years-period restored reaches in small mountain streams in western Germany. All streams flow mainly through a forested landscape, with minimal urban influence. We compared the communities with upstream near-natural reaches to monitor community development and change. Furthermore, we monitored the morphological changes and water chemistry. Not only the factor time turned out to be of importance but other parameters had their impacts on the invertebrate communities. This talk will shed light on the parameters influencing community development and biodiversity changes over a ten-years-period.

Session **SP02**

Fish species sensitivity classification for environmental impact assessment, conservation and restoration planning

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Presenting author: Ruben van Treeck

Species conservation, river rehabilitation, stock enhancement, environmental impact assessment and related planning tools require diagnostic indicators to identify significant impacts as well as mitigation success. River systems are triggered by disturbances from floods and droughts. Therefore, typical riverine fish species should have evolved life history traits providing resilience against disturbances. This study aimed to compile and analyze resilience traits of European lampreys and fish species to derive a sensitivity classification of species against mortality. Most sensitive species are of least resilience against adult fish mortality. Life history traits like maximum length, migration type, mortality, fecundity, age at maturity, and generation time have been compiled for 168 species and species-specifically scored from 1 (least sensitive) to 5 (highest sensitive). The single trait scores were weighted averaged to calculate a final sensitivity score for each species. Large-bodied, diadromous, rheophilic and lithophilic species like e.g. sturgeons, sea trout, Atlantic salmon appeared of highest sensitivity against adult fish mortality, whereas small-bodied, limnophilic and phytophilic species with fast generation cycles were of lower sensitivity. The final scoring and classification of 168 European lampreys and fish species according to their sensitivity can be easily regionalized by selecting the most sensitive species according to the local species pool. The sensitivity classification does not serve impact assessment only, it also allows determining target or umbrella species for conservation measures, species benchmarking in rehabilitation planning as well as success evaluation of restoration projects.

Session **SP02**

Functional response of fish assemblage to multiple stressors in a Mediterranean river

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Presenting author: Ana Sanchez-Perez

Mediterranean river systems are characterised by strong environmental constrains and poor, highly endemic fish fauna. In southern Spain these systems are exposed to multiple human-induced stressors due to extensive land use changes for agriculture, water withdrawal for irrigation, contamination and introductions of non-native species. Studies on the effects of some of these stressors on riverine fish are available but complex responses of fish assemblages to interplay of flow alteration and physical habitat changes has not been evaluated up to date. In this study, we analysed the response of functional diversity of fish assemblages to interplay of these stressors in Segura River basin in southern Spain. To do this, we estimated three functional diversity indices: Functional specialisation (FSpe), originality (FOri) and entropy (FEnt) based on nine functional traits and abundances of fish at a basin scale. Fish were sampled in 16 sites across the basin in two consecutive periods (2009 through 2010 and 2013 through 2015). A posteriori, we assessed the responses of fish assemblages (functional diversity indices, species richness and abundance) to interplay of flow regime alteration and ecological status, fragmentation as well as non-native species abundance on spatial and temporal scales. Fish assemblages were composed by three native and ten non-native species belonging to six families. Four cyprinid species added up to ~95 % of the total catch per unit effort. Even though, species richness and abundance increased in areas with deteriorated physical habitat and altered flow regime (higher base flow and variability), functional specialisation (FSpe) and originality (FOri) significantly decreased. Similarly, the increase of the ratio of non-native species caused decrease of FSpe and FOri and increase of species richness and abundance. Functional entropy (FEnt) appeared to be primarily affected by physical habitat characteristics with higher values in less disturbed habitats. It also appeared that functional diversity of fish assemblage of the Mediterranean Segura basin is primarily driven by human-induced stressors. In summary, our results indicate that in areas highly affected by multiple stressors species richness and abundance increases, but the specialisation and originality in the assemblage significantly decreases. Furthermore, complexity (FEnt) of fish assemblage was greater in areas with lower level of human-induced stressors, despite of being poorer and less abundant in species. The consistency in the definition and the availability of traits for some species generates problems in analysis at larger spatial scales. However, use of functional diversity indices based on traits at regional scale can be instrumental to diagnose responses of fish assemblages to multiple stressors for ecosystem management to enhance its ecological function.

Session **SP02**

Comparing fish Species Distribution Models on different scales as a tool to optimize river restoration projects

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Presenting author: Heiko Schmidt

A common goal of river restoration measures is re-establishing vanished fish species, or increasing the abundance and resilience of existing fish populations. Unfortunately, despite the high investments, results are often not satisfactory. Species Distribution Models (SDMs) could be a valuable tool to aid restoration managers in prioritizing river stretches of high restoration potential and distinguish restoration methods that show a particularly high effect on the increase of habitat suitability. SDMs are species-specific models that relate environmental variables and river characteristics with fish sampling data to predict and project habitat suitability e.g. for a whole catchment. SDMs are highly scale dependent (i.e. resolution and extent). There are two kinds of resolutions the model can be based on, either on the actual river segments or on subcatchments. We compared both model setups with identical data to quantify the differences. Both models yielded good and overall similar results, but larger differences could be seen in rivers of medium habitat suitability. The river network model resulted in fine scale predictions that sometimes alternated heavily on short river lengths, whereas the subcatchment setup was more consistent through its larger spatial units and overall smoothening of environmental predictors. When the model extent was restricted to longitudinal zones in which the species in principle could occur, the composition of environmental predictors building the model changed. Small-scale habitat features such as flow variation or presence of dead wood gained importance compared to models at larger spatial extents, which were dominated by general geographic predictors such as distance to source. We conclude that an SDM based on subcatchments performs better for models for restoration planning, as viable populations typically encompass larger river stretches than individual cells of a river network model. However, small scale models can be used to identify important individual habitat features and ecological deficits. Spatially restricted models that focus on species specific fish zones are better suited than models of entire catchments, as the weight of habitat features, which are supposed to be addressed by the restoration projects, is higher compared to geographic variables, which cannot be addressed by restoration.

Session **SP02**

Relative Resilience of Pacific Salmonid Lifestages to Physical Habitat Loss

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Presenting author: Gregory Pasternack

California rivers have an assemblage of native fish whose populations are steadily declining due to cumulative anthropogenic impacts. The relative resilience of individual species to such adversity partly depends on the degree of selectivity of habitat preferences; species with high selectivity to threatened river conditions are at greater risk of population collapse. The purpose of this study was to evaluate the relative selectivity of Oncorhynchus tshawytscha and O. mykiss fry and juvenile lifestages to hydraulic and cover conditions, using the 37-km gravel-cobble lower Yuba River in north central California as the testbed. Sixteen snorkel surveys of seven 122-m-long sites were conducted at a range of discharges to characterize fish habitat-utilization behavior. Meter-resolution topo-bathymetric and cover mapping was also done, along with 2D hydrodynamic modeling. Independent snorkel observations and ecohydraulic modeling were used in a novel bioverification procedure that included uncertainly analysis to evaluate relative selectivity. Results found that O. mykiss juveniles were the most selective of the conditions they utilized, while O. tshawytscha juveniles were the least selective. Fry of both species had similar intermediate selectivity. Results suggest that O. mykiss juvenile habitat conditions be carefully evaluated for enhanced management in California.

Session **SP02**

Evaluation of fish migration patterns in the lower ranges of the River Enns using passive integrated transponder tags: results after 3 years of experience

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Presenting author: Daniel Daill

Since October 2016 the efficiency of three fishways in the lower ranges of the River Enns has been evaluated using fish traps and, additionally, pit tag arrays to assess the migration patterns of tagged fish and draw conclusion on various biological traits including migration behavior, migration distance and habitat availability. More than 1.300 fish belonging to 23 species and two hybrid forms have been tagged by April 2019. Tag-codes were detected both automatically at special pass-through antenna arrays at the entrance areas of the fishways and manually during the daily controls of the fish traps. This arrangement allowed us to obtain data in a flow stretch with a length of more than 10 km.

Migration activity peaks occurred from April to July and corresponded well with the known spawning times of the detected fish species. Additionally, upstream migrations of brown trout (Salmo trutta fario) and burbot (Lota lota) were also detected outside spawning times, in June and July. It is assumed that these activity patterns corresponded to foraging and habitat search efforts.

Considerable differences in migration distances and speed were identified both between different species and within species. Larger distances of 5 km or more were mostly covered by adult individuals of rheophilic species, such as nase (Chondrostoma nasus) and barbel (Barbus barbus). Most specimens needed roughly a week to cover the 5 km distance, with some individuals being able to cover the distance within only one day. These results confirm the high potential swimming capacity of these species.

Analysis of the transponder data also showed that several specimens, though they were detected in the entrance area of the fishways, were not able to traverse the constructions. These individuals often rather dwelled in the entrance area or within the fishway for several weeks without moving further upstream. These results highlight the importance of naturally designed fishways and will be further discussed in the context of the oral presentation.

Session **SP02**

The upstream migration of juvenile and adult grayling Thymallus thymallus through five fish-bypass channels correlated to environmental factors.

Author(s): Tobias Epple

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Presenting author: Tobias Epple

At the middle river Iller (Bavaria, Germany) the river continuity has been restored at a chain of five run-off-river hydropower plants with fish-bypass channels. A fish-counting pool has been built in each of the five fish-bypass channels to monitor the upstream migration of fish. Within two years from August 2016 to August 2018 over 23.000 fish out of 29 species have been documented in the five fish-counting pools. One of the fish species that is migrating most numerous through the fish-bypass channels is the grayling (Thymallus thymallus), a potamodromous and reophilic fish species of summer cold streams. 206 adult and 2653 juvenile graylings have been counted. Additional to the fish data, the water temperature, moon phase and water flow have been recorded permanently and correlated to the migration data. A significance for the moon phase and water flow could not be proven. Only the water temperature shows a significant influence on the number of migrating grayling.

Session **SP02**

Fish-ecological monitoring of the near-natural fish bypass at the Greifenstein hydro-power plant on the Austrian Danube -results of the first monitoring year.

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Presenting author: Michael Schabuss

In 2018 the VERBUND Hydro Power GmbH finished the construction of the near-natural fish bypass at the Greifenstein power plant on the Austrian Danube upstream Vienna. It enables the Danube fish community to bypass the hydro-power plant providing an up- & downstream migration path and represents a new habitat for more than 40 fish species. The bypass overcomes a difference in height of 14 meters and covers a distance of more than 4 kilometers, with an average discharge of 4 m3/sec.

To check the functionality of the fish bypass, the Danube fish fauna below the Greifenstein power plant and in the fish bypass itself was investigated by electrofishing. Additionally, a monitoring of fish up-& downstream migration was done with 2 fish traps exposed at the lower end of the bypass for a total of 173 days during spring/summer, autumn and winter 2018. Each autochthonous fish > 100 mm total body length, is tagged with a PIT tag (Passive Integrated Transponder) and two antennas, at the upper and lower end of the bypass, record the passage of tagged fish permanently over the entire project period. To investigate long distance migrations, additional fish were tagged at the fish bypass at Nussdorf power plant, 16 km downstream the Greifenstein bypass.

First results of the monitoring period 2018 show that 37 native fish species of the 58 species within the reference fish community of the Danube and 8 allochthonous species were present. Some rare species like ziege (Pelecus cultratus and pearlfish (Rutilus meidingeri) were recorded for the first time in this section of the Danube. Roach (Rutilus rutilus), bleak (Alburnus alburnus), chub (Squalius cephalus) and perch (Perca fluviatilis) were the most abundant fish species in the up-& downstream migration at the fish traps.

Results of the fish trap catches and analyses of the up- & downstream migration by PIT Tag antenna records will be presented and further discussed with regard to the functionality check of the near natural fish bypass at the Greifenstein power plant.

Session **SP02**

Physical instream characteristics in two Norwegian rivers with European grayling observations

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Presenting author: Håkon Sundt

In Scandinavian settings, extensive research is being done on fish species like Atlantic salmon (Salmo Salar) and brown trout (Salmo Trutta), but less is known about the inland fish species European grayling (Thymallus thymallus) habituating many of the same rivers. We defined statistically significant stream characteristics for a series of vital habitats as spawning and overwintering areas for grayling in the rivers Gudbrandsdalslågen and Otta in mid-Norway.

This study used public available terrain data and a set of aerial photos along with hydrological data to set up and calibrate a large-scale 2D hydraulic model for the confluence area of the rivers Gudbrandsdalslågen and Otta. The terrain data is available as a part of a large-scale national terrain digitization project using airborne red laser for point cloud generation. Additionally in the study, airborne green laser bathymetric data and echo sounding data was used in the river sections of interest to ensure proper underwater geometry.

As a part of an environmental impact assessment of two HP-projects in the rivers Gudbrandsdalslågen and Otta, 67 European grayling were radio-tagged and positioned during the ice-free season in 2008 and 2009. The positioning of the grayling made it possible to localize the major spawning, feeding and overwintering areas in the river system.

We ran the 2D hydraulic model at flows registered during the field investigations of grayling. We then statistically compared selected bulk instream characteristics in the zones with grayling observations with zones without grayling observations. Results on European grayling preferences in terms of physical characteristics of the observation zones are presented and discussed.

As European grayling exists in many rivers regulated for hydropower, the results of this study can be used in environmental design studies by setting up flow regimes and mitigation measures that may enhance the physical instream conditions for the European grayling.

Session **SP02**

Riverscape recruitment: a conceptual synthesis of drivers of fish recruitment in rivers

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Presenting author: Amina Price

Understanding the drivers of fish population fluctuations has been a central theme of fisheries science for more than a century. Fundamentally, for a fish to survive the early stages of life there is general agreement, irrespective of the environment, that it must find enough of the right size and type of food, avoid being eaten and be located in areas of suitable water quality. However, these elements are often considered in isolation from one another, and not as interacting drivers. Furthermore, they are rarely considered in relation to the different species traits of fishes, which are at the interface of a species with its environment. Here we combine the essential components of fish recruitment hypotheses with the key abiotic (e.g. temperature, flow) and biotic (e.g. food, predation) characteristics of rivers to develop a synthesis and model that will allow prediction of relative recruitment strength for all types of riverine fishes in all types of rivers under a variety of flow conditions. A key hypothesis of the model proposes that: interactions between flow and physical complexity will create locations in rivers, at meso-scales, where energy and nutrients are enriched, the resultant production of small prey concentrated, and prey and fish larvae located (either through dispersal or retention) so that the larvae can feed, grow and recruit. It builds on aspects of Bakun's Fundamental Triad, developed for marine systems, and research carried out in rivers over several decades. We predict relative recruitment strength for fish of the three life history strategies (equilibrium, periodic and opportunistic) using Mediterranean, tropical and arid-zone rivers as exemplars. Our synthesis provides a solid rationale for considering how flow and reach physical complexity affect fish recruitment, and provides a conceptual basis from which to better conserve and manage riverine fishes globally.

Session **SP02**

Effects of side-arm reconnection in a large river on hydro-morphological conditions and main trophic levels.

Author(s): Hubert Keckeis (1); David Ramler (1); Andrea Funk (2); Elisabeth Bondar Kunze (2); Thomas Hein (2); Helmut Habersack (3); Michael Tritthart (3) & Marcel Liedermann (3)

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Presenting author: Hubert Keckeis

Changes in riverine assemblages in response to anthropogenic changes are well known, many studies describe a general loss/decrease of characteristic riverine species and a concomitant increase/dominance of generalist species. Less information is available about the reverse process, namely the effects of process-oriented restoration measures in Large Rivers on changes in the assemblages (species occurrence, -diversity and abundance) or even trophic dynamics and food web structure. This study examines short term changes (1- 3y) of the hydrodynamic conditions, sources of organic material, productivity as well as changes in the assemblages of macrozoobenthos (MZB) and fishes before and after the re-connection of a side-arm of the main stem in a free-flowing section of the River Danube in Austria. Within an interdisciplinary approach in the framework of the Integrated River Engineering Project for the Danube East of Vienna (IREP) the changes of the abiotic, hydraulic and hydrodynamic conditions as well as production and the development of two major indicator groups (MZB and fishes) after the two-end reconnection of a side arm was monitored 6 years before as well as 1 and 3 years after the measures. We wanted to know to which extent (how, how fast) the measures are reflected in the assemblage structure and trophic composition of these two important groups of organisms. The results are discussed with regard to the contribution of process oriented restoration measures (required spatial and temporal scales) to attenuate consequences of human-induced river modifications.

Session **SP03**

Long-term monitoring of springs in the Berchtesgaden National Park to determine the impacts of climate change

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Presenting author: Kurt Lichtenwoehrer

Springs are spatially limited transition zones between groundwater and surface water, being an important source of riverine systems. The uniqueness of spring habitats results in highly diverse ecotones - hotspots of biodiversity - populated by specialised animal species and plant species. Thereby, springs are seen as highly stable ecosystems. However, due to climate change, with fluctuating precipitation patterns and increasing temperatures, spring habitats may profoundly be changed. This may lead to a shift in species composition, possibly accompanied by invasions or losses. In order to record such (long-term) changes, the application of a standardized methodology for a monitoring of springs is indispensable. The here-described project aims to develop such a standardized methodology in the Berchtesgaden National Park (BNP) and in the Bavarian Forest National Park (BFNP) in Germany as reference areas. The standardized methodology includes morphological habitat descriptions, physicochemical water analysis, zoological analysis (combining traditional taxonomic methods with barcoding techniques) and botanical analysis; its applicability was tested in both national parks. Results of the developed methodology are summarized in a guideline, which additionally includes criteria for choosing best suitable reference sites and indicator species as well as recommendations for monitoring time intervals and a proposal for a sustainable long-term data storage. The objective of the developed guideline is to establish a standardized monitoring of springs within and beyond protected areas in order to use springs as indicators of climate change. We present the methodology, specific results for the applied methods in both national parks and an outline of the guideline.

Session **SP03**

Monitoring alpine rivers as a measure of freshwater biodiversity and change

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Presenting author: Leopold Füreder

Long-term observations and experiments have never been more important for testing ecological theory and for addressing today's environmental challenges. Among them, climate change processes pose a considerable threat to global biodiversity and are recognized to particularly affect alpine landscapes. The high climatic sensitivity and lack of significant human impact make alpine river basins important environments for examining hydrological and ecological response to global change. Two interdisciplinary research projects carried out in six glaciated catchments in the Hohe Tauern NP, aimed at defining climate-hydrology-ecology interactions and at demonstrating the importance of alpine river systems as indicator environments of hydrological and ecological impacts of climate change and variability. After several years of implementation, we now propose a framework of integrated, long-term ecological research in alpine rivers for monitoring freshwater biodiversity and change, and its application in other alpine areas.

Session **SP03**

Real-time warming of high altitude streams: winners and losers among the invertebrates

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Affiliation(s): University of Innsbruck, Innsbruck, Austria; University of Innsbruck, Innsbruck, Austria

Presenting author: Georg H. Niedrist

The increasing climate crisis intensifies environmental changes in high-altitude ecosystems worldwide, with rising air temperature among the main stressors. While past research in high altitude streams has primarily focused on how retreating glaciers might affect the ecology of glacier-fed streams on the long run, observations of real-time alterations in such pristine environments are rare.

Using long-term measurements of water temperature together with datasets on benthic invertebrate communities from 18 glacial and non-glacial high altitude streams in the European Alps, we illustrate significant ecological consequences of the observed real-time warming in different stream types. Besides firstly reporting multiannual warming of all observed streams during summer with a mean rate of 2.5°C decade-1 (±0.6), this work reports long-term (decades) and short-term (years) consequences to increasing water temperature and identifies winners and losers among the manifold invertebrate species.

The identified discrepancies between observed real-time effects and predicted changes using space-for-time substitutions, however, illustrate the significance of the temporal component and of co-occurring environmental changes, which are necessary to consider when estimating the consequences of climate change and glacier-retreat for alpine streams. In addition, we conclude that invertebrate groups in alpine stream networks respond quickly to environmental changes.

Session **SP03**

Building socio-ecological indicators to evaluate Global Change effects on Mediterranean river basins. The study cases of la Tordera and Besòs river basins, NE Spain

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Presenting author: Antoni Mas-Ponce

Mediterranean river basins are under different anthropogenic pressures to meet the needs of the increasing population in a changing territory, where the development of industry, water demands, intensive agriculture and touristic activities are main local factors in a global change context. In addition, these areas have strong inter-annual climatic variability mainly characterized by dry periods in summers, which represent an evident variability in (a) rivers discharge annual regime, from permanent to temporal ?? although, the wastewater treatment plants hydrological dependence in such basins has to be taken into consideration ?? and (b) in ecological quality status of fluvial systems.

In that sense, this research aims to create transversal socio-ecological indicators to assess global change effects in the Mediterranean Tordera and Besòs river basins (NE Spain) using the long-term monitoring water quality indicators, climatic variables, Land Use and Land Cover (LULC) changes and social parameters in the period 1997 - 2017.

Water quality indicators data are obtained from L'Observatori de la Tordera (ICTA-UAB), a long-term monitoring project which since 1996 carries out the evaluation of the ecological status of the Tordera river basin by the assessment of biological, hydrological and physicochemical indicators considered into the Water Framework Directive (2000/60/EC, WFD).

In 2018, this model is replicated to the nearby Besòs river basin. In this study case, data were obtained by a compilation process (literature review, interviews to local experts and biodiversity and physicochemical parameters databases) in order to build a water quality indicators database of the Besòs river basin from 1997 to 2017.

A time series regression model has been considered as the most suitable tool to build socio-ecological indicators assuming that data are obtained in a set of established long-term monitoring stations. Before running the model, a previous selection of water quality indicators is needed. In that sense, biological indicators (macroinvertebrates, riparian vegetation and diatoms) and physicochemical indicators (ammonium, nitrates, nitrites, phosphates, conductivity and water temperature) are chosen as the response variables to be correlated to LULC analysis. In addition, topographic (slope (%) and mean altitude (m)) and climatic variables (Water Availability Index (WAI), expressed as the difference between rainfall and potential evapotranspiration (PET)) and social qualitative indicators of river pressures (punctual pollutant discharges and hydromorphological alterations) were added to this model as main predictor variables of water quality indicators and LULC changes.

The result is a specific cartography which points out the degree of global change effects on the study area, ranked from 0 to 1 (0= low; 1= high). This socio-ecological cartography can be applied as a tool for management of present and future effects derived from global changhe context.

Session **SP03**

Near real-time monitoring and prediction of floodplain vegetation development on river reach scale using Sentinel-2 data and Google Earth Engine

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Presenting author: Gertjan Geerling

Aim

The floodplain vegetation in the Dutch Rhine and Meuse river branches must be strictly managed to ensure that the hydraulic roughness in the embanked floodplains will not increase water levels during a flooding. With approximately 12.000 landowners in these floodplain areas, the challenge for the National Water Authority 'Rijkswaterstaat' is to focus efforts in the management of this vegetation in good dialogue with those owners, as they are responsible for timely management. The aim of this project is to provide an easy screening tool that helps focussing this effort, using classification of readily available satellite images in dominant vegetation types.

Secondly, a prediction (roughly) of the vegetation development for the next 5 years can help in planning of these management efforts and associated budgets in time.

Methods

Classification of Sentinel2 images, in combination with information on the height of the vegetation from Lidar-data using machine learning algorithms (o.a. random forest) is carried out in the cloud-based platform 'Google Earth Engine'. The classification is compared with a legal vegetation map (the desired state), which is used in all formal flood risk analyses. If vegetation has developed to a higher roughness than is allowed according to this map, the area is flagged in red. This information is then presented in an easy access webtool, for assessments by the end-users.

Vegetation modelling is added to predict the expected vegetation development in the next 5-10 years, taking into account grazing regimes, mechanical dynamics and number of days an area is flooded. The first iteration of the vegetation development modelling is based on expert knowledge. However, to validate and improve the model, we are analysing time-series (30+ years) of LandSat data to establish succession speeds under different starting conditions and regimes.

Results

The results of the analyses are displayed in a webviewer environment (https://www.openearth.nl/vegetatiemonitor/) which also allows for downloading of the classified images for further detailing in a GIS environment. The tool has been tested in the field (using mobile phones and tablet) by end-users and found to be a suitable help in the assessment of the status of the vegetation. Accuracy of the classification is currently in the order of 70% and will be improved by implementing SAR data in 2019. The prediction of the vegetation development is currently being validated for areas with well-knows changes over time.

Session **SP03**

Status and fate of freshwater mussel biodiversity in Borneo

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Biodiversity is being lost faster in tropical freshwater habitats than anywhere else. Effective conservation requires knowledge on the spatial and temporal patterns of biodiversity and threats. However, for freshwater habitats in Southeast Asia - one of the most biodiverse regions of the world - these data are currently not available. Data on freshwater mussels (Bivalvia: Unionida) are particularly scarce. Mussels are one of the most endangered animal groups and provide crucial ecosystem services, from increasing water quality and biodiversity to providing a source of food to humans. The mussel fauna of Borneo is largely unstudied, and most of the 17 species, of which at least 11 are endemic to the island, have not been found for at least 50-100 years. Over the past three years, we surveyed freshwater mussels at 115 sites across 28 river basins in northern Borneo, spanning the Malaysian States of Sarawak and Sabah, and Brunei (study area of approximately 150,000 km2). Our data suggest that over the past five decades, four of originally five native mussel species have become very rare and some potentially locally extirpated, largely owing to wide-scale deforestation and land use change. Rectidens sumatrensis, also native to Peninsular Malaysia, Sumatra and Java, appears to be the only native mussel species from this region sustaining stable population sizes. Only one population of an endemic Bornean species could be confirmed, i.e. Ctenodesma borneensis, from a rainforest stream in the upper Limbang basin, representing the first record of this species for at least 50 years. The strong decline in native (endemic) mussel diversity concurred with the spread of the non-native Sinanodonta cf. woodiana, which is now the most widespread freshwater mussel in northern Borneo. Unfortunately, species distribution models under future climate change and land use scenarios predict a continuation of this trends as by 2050, habitat suitable for native and invasive mussels will further decrease by 20% and increase by 30%, respectively. We argue that other sites and basins across Borneo should urgently be surveyed to identify any remaining populations of freshwater mussels. Considering the presence and spread of man-eating crocodiles across many Bornean lowland rivers, this should involve alternative methods to traditional hand-sampling, including environmental DNA.

Session **SP03**

Application of Fish-based Index of Biotic Integrity of Aquatic Resources Environment: Case Study of Maengud Somboonchon Dam, Chiang Mai

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Application of fish-based Index of biotic Integrity (FIBI) of aquatic resources environment of Maengud Somboonchon Dam, Chiang Mai province, was conducted by using fish data gathered from annual report from year 2002 to year 2003.

The Fish-IBI scores was designed from separate assemblage metrics in main two categories based on I. biological parameters i.e. 1) diversity parameters viz. species richness, diversity index, dominant species; 2) fish status viz. hybrid species, endemic species, and introduce species; 3) diet viz. omnivores, insectivores, and carnivores and 4) reproductive mode viz. eggs and non-eggs and II. Environmental parameters i.e. 1) habitat viz. pelagic, water column, bottom, rocky and stone, sandy and gravel and silty to muddy 2) fish health viz. number of intolerant species, tolerant species and number of disease health or anomalies, totally 20 metrics.

This scoring was used to group data into categories to represent very poor ("1=F"), poor (“2=D”), fair ("3=C"), good (4=B) and excellent ("5=A") levels of fish community degradation. Scores for each of the 20 metrics were summed to provide an index value ranging from 20 (worst) to 100(best) for each fish community sample, which can be used to determine the relative health of the site.

Session **SP03**

Benthic communities of Bundelkhand Rivers with reference to the Proposed Ken-Betwa link

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Freshwater habitats are relatively discontinuous, and species do not disperse easily across the land barriers that separate river drainages into discrete units. In the tropical developing countries like India, species extinction, genetic loss may become severe in future due to loss of habitat, blockage of waterways, interbasin transfers and water withdrawal from rivers have negative as well as positive impacts on freshwater ecosystem. The rivers Chambal, Betwa, and Ken etc. form the life line of the Bundelkhand region. Ambitious plans are afoot to link these rivers. Execution of the Ken-Betwa link has already begun. A preliminary prelinkage survey was done with respect to diatom communities in these two Rivers. Only 39% of the flora was common to these locations, while many speceis were specific to both the Ken and the Betwa.A. m. var gracillima, G. parvulum, P. lanceolatum were domimant diatom taxa in river Ken while N. virudula, A. minutissima v. minutissima, C. exicisa, C. turgidula M. granulata diatom taxa in river Betwa. All these point towards diverse nature of these Vindhayan River and linkages could destroy the biodiversity paving way for bioinvasion, which are common in disturbed habitats as waters will be regulated as per needs of the populace.

Session **SP03**

Raiders of the Lost Sources - The PHish Database

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Freshwater ecosystems and their surroundings are not only a hotspot for biodiversity but have also been used by man since early human settlements. Thus, searching for historical information about freshwater fish species prior to most of the greatest impactful human undertakings could lead to an improvement of species ecology knowledge. For example, using historical data may be critical to understand more adequately the ecological requirements of species. Here we present the Portuguese Historical Fish Database (PHish-DB), an assembling of 2214 records resulting from a survey of 194 historical documents. To allow the inclusion of historical data with distinct degrees of spatial acuity we used a three-scale approach, meaning there are 557 records at the basin scale, 184 at the sub-basin scale and 1473 at the segment scale. PHish database covers a time span of one millennium, from the 11th until the 20th century, and 25 taxonomical groups to contain all retrieved records. This database may contribute to correctly assess the full range of conditions tolerated by species, by establishing adequate benchmark conditions, and/or to improve existing knowledge of the species distribution limits.

Session **SP03**

The Freshwater Information Platform: an online network to facilitate monitoring, data compilation and publishing

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Presenting author: Astrid Schmidt-Kloiber

Species distribution data are crucial for understanding biodiversity dynamics and the underlying drivers. This is especially the case for freshwaters, which are among the most endangered ecosystems globally. However, a huge body of data gathered by scientists and water managers is currently difficult to access: systematic data publishing practices have not been fully adopted yet and data embedded in scientific papers and research project websites are often challenging to extract. At the same time, data and knowledge generated through publically-funded research or monitoring programmes are considered a common good.

The Freshwater Information Platform (FIP) aims at pooling freshwater related research information from multiple projects and initiatives to make it easily accessible for scientists, water managers, conservationists and the interested public. The FIP consists of several major components, three of which form its "data publication unit": The Freshwater Metadatabase (1) collects data characterising and documenting actual datasets. These metadata can easily be published as open access articles in the connected Freshwater Metadata Journal. The Freshwater Biodiversity Data Portal (2) aims at mobilising and publishing freshwater biodiversity data (occurrence records) through GBIF. The use of collected datasets for large-scale analyses and models is demonstrated in the Global Freshwater Biodiversity Atlas (3) that publishes interactive online maps featuring research results on freshwater biodiversity, threats and conservation priorities.

Here, we focus on introducing these components as tool to streamline open access freshwater data publication, arguing it will improve the capacity to protect and manage freshwater biodiversity in the face of global change. We further present linkages to and cooperations with other key initiatives in the field, namely the Alliance for Freshwater Life as well as Freshwater BON.

Session **SP03**

The Alliance for Freshwater Life: introducing the initiative and ideas for freshwater biodiversity research from local to global scales

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Presenting author: Sonja C. Jähnig

Global pressures on freshwater ecosystems are high and rising. Viewed primarily as a resource for humans, current land use and water management practice have led to catastrophic declines in freshwater species and the degradation of freshwater ecosystems, including their genetic and functional diversity. An improved understanding of all facets of freshwater biodiversity is required to inform better decision making and for establishing the socio-economic context for sustainable water management. Here we introduce the Alliance for Freshwater Life (AFL), an emerging global initiative that seeks to unite specialists in research, data synthesis, conservation, education and outreach, and policymaking. The AFL aims to provide a common platform and the critical mass required for the effective representation of freshwater biodiversity at policy meetings, to develop solutions balancing the needs of development and conservation, and to better convey the important role freshwater ecosystems play in human well-being. We introduce examples of ongoing and future research aimed at developing tools and frameworks for better management, closing knowledge gaps about the distribution and status of freshwater biodiversity, and identifying the necessary data and knowledge needed to balance human needs with sustaining freshwater biodiversity.

Session **SP04**

Designing flow regimes for ecological outcomes - contrasting case studies

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Presenting author: Fiona Dyer

The regulation of rivers to provide water for food and fibre production has fundamentally and irreversibly changed the flow in rivers across the world. This has resulted in widespread impairment of freshwater ecosystems as patterns of flow are modified and flow volumes are reduced. Environmental flows seek to redress this impairment by specifically providing flows for ecological outcomes. A plethora of different approaches exist for setting environmental flow regimes ranging from setting minimum passing flows to more complex designer flow approaches which contain elements of the natural flow regime. In this paper, contrasting case studies from south eastern Australia are used to illustrate two vastly different approaches to environmental flow delivery. The first example is from the Snowy River system, an upland river system regulated for the provision of electricity generation and the inter-basin transfer of water. In this system, substantial inter-basin transfers have reduced the flow in the river to a fraction of pre-development flows. An environmental allocation is provided each year, the quantum of which is defined by a complicated set of rules, and the environmental flow regime for the entire year is set in advance using a variant of the flow scaling approach. Once the annual allocation is known, the historical flow record of a smaller analogous river is interrogated and the flow pattern from the year with the closest annual flow volume define the environmental releases. The intent is to enable a smaller river to become established within the framework of the older, larger river. The second example is from the Lachlan River system, a lowland river system of the Murray Darling Basin in which water is delivered to support food and fibre production. In this system, regulation and water use have removed small to intermediate sized floods, reducing connections with floodplains and wetlands. Spring and summer flows have increased as a consequence of irrigation deliveries. An environmental allocation is provided each year and actively managed throughout the year to provide events that target specific ecological outcomes (such as fish spawning). The intent is to protect ecological assets. Both river systems are located within the same state in Australia but are managed under markedly different legislative arrangements. The choice of environmental flow regime design reflects the human use of water in the systems. This has largely been driven by institutional structures and operational constraints around the delivery of water. While there are opportunities to learn across systems, these institutional and operational constraints limit the capacity for change and thus the environmental outcomes that can be achieved.

Session **SP04**

Implementing environmental flows: Insights from international experience

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Presenting author: David Tickner

Over the last 40 years, the decline in freshwater species populations has been more than twice that observed in the world's forests or oceans. The major causes have included a proliferation of dams, rapid increases in water abstractions from ecosystems (linked primarily to growing demands for water from agriculture), heavy pollution loads from multiple sources, and a shifting climate. The overarching purpose of WWF's Freshwater Practice is to help reverse this decline in biodiversity in rivers, lakes and wetlands globally and to help ensure that healthy freshwater ecosystems support human well-being and development. Our goals focus on 1) protecting or restoring key wetland habitats and species, and 2) safeguarding or restoring clean, flowing rivers at the basin scale. Restoring or safeguarding river flow regimes is an issue that runs through most freshwater conservation and water resource management challenges everywhere we work. As such, it has been a major focus for WWF's efforts in the last decade, especially in developing or emerging economies where river management challenges are profound and pressures on ecosystems are most acute. Most countries have e-flow policies or laws of some sort in place, but few have made significant strides towards widespread implementation of environmental flows, i.e. water in the river. Drawing on recent WWF policy research (Harwood et al, 2017) and a special issue of Frontiers in Environmental Science focused on successful environmental flow implementation, this paper will provide insights that can aid researchers, policy makers and practitioners at the interface of freshwater conservation and water resource management as they strive to safeguard river flows in the Anthropocene. It will also present the 2018 revision of the Brisbane Declaration and Global Action Agenda on Environmental Flows (Arthington et al, 2018). Finally, the paper will demonstrate how insights into environmental flow implementation can contribute to a soon-to-be-published Emergency Action Plan to bend the curve" of freshwater biodiversity loss that is intended to influence key international agreements including the Convention on Biological Diversity, the Sustainable Development Goals and the UN Framework Convention on Climate Change."

Session **SP04**

A Pan-European Environmental Flow Concept

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Presenting author: Piotr Parasiewicz

This paper presents a concept for Pan-European environmental flows, complementary to the current regulatory environment. Rules follow a standardized approach, rigorously based on biological observations of fish assemblages and physical habitat modelling to establish a benchmark for ecologically sound instream flows. Our concept follows the Natural Flow Paradigm and foresees dynamic flow adjustments according to aquatic fauna needs over a range of bioperiods. The rules define environmental subsistence, and base flow thresholds are assigned in conjunction with frequencies and allowable exceedance durations, providing dynamic flow management. The thresholds are specific to water body types according to European Fish Community Macrohabitat Types (FCMacHT), a classification system developed as part of the Adaptive Management of Barriers on European Rivers (AMBER) project funded by the European Commission Horizon 2020 program. The paper will present real-world examples of the concept, including pilot studies in Poland and in the Baltic States.

Session **SP04**

Environmental flow trials in a regulated river in southern Australia: integrating biophysical and social research

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Presenting author: Robyn Watts

Environmental flows are increasingly part of river restoration programs. In Australia, the Murray-Darling Basin (MDB) Plan aims to protect and restore water dependent ecosystems. It includes the voluntary purchase of water entitlements from irrigators, with this water allocated to the environment. However, in parts of the MDB the delivery of environmental water is constrained by established river operating rules that control the timing, duration or magnitude of flows.

This study focused on the Wakool River in the southern MDB. Prior to river regulation the average daily discharge in this system was higher in winter and spring and lower in summer and autumn. Under regulated operating rules the infrastructure delivering water to this river is usually closed during winter (ceasing the flow) and there are upper limits on discharge at other times of the year to avoid inundation of low-lying private bridges and land. Two flow trials implemented in 2017 and 2018, following extensive consultation with landholders and agency representatives, involved changes to these operating rules. A continuous base environmental flow was delivered during winter 2017, and in September 2018 an environmental flow pulse was delivered that exceeded the maximum daily discharge under regulated operating rules. Biophysical monitoring was undertaken to examine hydrological connectivity, extent of inundation, water quality and river productivity. Social research explored how landholders and water managers perceived the flow trials. The extent to which these trials could contribute to informed decision making and adaptive management of environmental water in this system was also examined.

The flow trials increased hydrological connectivity and production of carbon within the river and there were no negative water quality outcomes recorded. The social survey found a general desire for action over extended planning, and acceptance of experimenting with environmental water to ensure eventual best outcomes. There was a positive response to the winter flow trial and community observations of improvements in water quality. While the higher spring pulse did not interrupt landholder practices or result in poor environmental outcomes, it caused some concern about how river flows might be managed in the future. Indeed, the community responses to the flow trials were often framed systemically, and discussed in relation to the bigger, more complex picture of water management in the southern MDB system.

Large river restoration programs usually refer to the need for adaptive management but there are typically few examples that examine outcomes of changes to normal river operating rules. There is potential for environmental flows to improve environmental, social and economic outcomes. Undertaking experiments, sharing the learnings and including a wide range of perspectives remain the keys to achieving ongoing outcomes from delivering environmental flows.

Session **SP04**

Functional Flow Classification for Sustainable Hydropower Operations: Exploratory Applications in the Yangtze River Basin of China

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Presenting author: Anna Rallings

Modification of rivers worldwide serves human water demands for multiple objectives but often results in hydrologic flows that fail to support hydrogeomorphic processes and downstream ecosystem needs. Although much research has focused on so-called environmental flows, and with it the potential to balance environmental and human water demands, the gap between science and policy is wide and adoption of environmental flows approaches is uneven around the globe. This gap is acutely highlighted in China, where an emerging body of technical literature supports management strategies that balance human and environmental needs is coupled with rapidly expanding dam infrastructure. We highlight the global literature on environmental flows - with specific focus on a framework for representing ecosystem objectives in major hydropower systems - and review approaches to modeling, optimizing, and representing tradeoffs. We further this approach in the application of classifying basins in the broader Yangtze region of China to identify opportunities for functional flow approaches that balance management goals of supplying hydropower, flood control, agricultural and urban water demands while maintaining ecosystem functioning by providing the right amount of water at the right place and at the right time. The functional flows framework is applied to distinct geophysical basins of the Yangtze based on its sub basins and cross-examines the physical resources with the unique ecological and human demands using open-source global datasets. The analysis identifies hydropower facilities in the subregions within their biophysical context and provides guidance on seasonal ecosystem functions and expected trade-offs with other dam objectives. The proposed analysis intends to the identification of facilities with high potential to integrate environmental flows and support prioritization of implementation via a matrix of operating rules for various ecosystem objectives.

Session **SP04**

Managing environmental flows in Australia: how do we leap from science to management?

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Presenting author: Nikki Thurgate

Most Australian rivers are highly regulated systems and, with increasing conflicts for water-use, are extremely difficult to manage. In this talk I provide examples from two of the largest environmental flow programs operating in Australia: The Murray-Darling Environmental Water, Knowledge and Research program and the Long-Term Intervention Monitoring program, which are science programs designed to provide management information to the Commonwealth Environmental Water Office. These projects are designed to assess the effect of environmental flows on biodiversity and river health, and most importantly to provide scientifically robust information to water managers. After 5 years of data collection it is time to deliver final products and this talk will concentrate on the key findings from these programs. One of the most important findings is around scale. As scale increases the complexity of biota, hydrology and their interactions will also increase which means management will become more complex. There is no one correct scale at which management decisions should be made, instead we advocate for a regionally- nested design. Good management begins at the site scale and is integrated up to catchment and basin. Additionally, there is a great need for large-scale, collaborative research programs that invest in not just individual components of river health scientifically but that synthesise this information into a whole of river understanding that can be used. The inherent difficulty in these programs is to separate the effects of environmental water actions from other watering actions. To overcome this the projects have designed models, experiments and analysis that allows the full counterfactual scenario to be explored.

Session **SP04**

Stakeholder Engagement in the California Environmental Flows Framework

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Presenting author: Sarah M. Yarnell

Multiple state and local agencies across California share responsibility for setting environmental flow standards to protect and improve the health of freshwater ecosystems. Historically, these efforts were not coordinated and resulted in fragmented and inconsistent development of environmental flow criteria. To improve the scale, coordination, and effectiveness of environmental flow programs, scientists from government agencies, academic institutions, and NGOs throughout California are cooperating to evaluate methods and develop a statewide approach for establishing environmental flow standards. To facilitate interactions, participating partners have formed The California Environmental Flows Workgroup (CEFW) to strengthen linkages between research and agency program needs and provide support for resource managers working to secure environmental flow protections. The mission of the CEFW is to advance the science of ecological flows assessment and its application for supporting management decisions aimed at balancing natural resource needs with consumptive water uses to establish environmental flows. The mission will be accomplished by providing a forum for coordination and technical exchanges among government agencies, academic institutions, tribes, and non-governmental organizations in California focused on understanding environmental flow needs and establishing ecological flow criteria grounded in science. The workgroup will strive to improve agency cooperation and public access to ecological and environmental flow data, information and tools related to ecological flow assessments, and to provide a common vision for use of tools and science-based information to support sound decision making. Quarterly meetings allow open communication and collaboration on flow management with diverse stakeholders at the state and local level. Collectively, the CEFW aims to achieve consistent, scientifically defensible, and coordinated methods for assessing and managing environmental flows in the state.

Session **SP04**

Decision Support Tools for the California Environmental Flows Framework

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Presenting author: Belize Lane

California is developing a statewide framework for linking ecological endpoints with functional aspects of the flow regime to develop ecological flow criteria. This functional flows approach requires a set of decision support tools to support statewide implementation. We describe emerging open-source tools to visualize and quantify functional flows in California, including: (1) a statewide natural stream classification and water year typology, (2) dimensionless reference hydrographs, and (3) the functional flows calculator. The stream classification identifies nine natural flow classes representing distinct flow sources, hydrologic characteristics, and catchment controls over rainfall-runoff response. Dimensionless reference hydrographs characterize the distinct seasonal patterns and daily within-class variability of each natural stream class. The functional flows calculator is a hydrologic feature detection algorithm that extracts high-resolution flow metrics from any stream gauge using signal-processing techniques. It improves on existing flow metric suites (e.g. IHA, EflowStats) in that it is founded in ecological theory, hydrologically driven, and robust to immense hydrologic variability, supporting flow assessment in large heterogeneous regions such as California. These open-source visualization and assessment tools [lt]https://eflows.ucdavis.edu> allow users to explore and interact with California's natural hydrology and assess current alterations or proposed flow management scenarios.

Session **SP04**

Developing ecological flow recommendations for natives fishes when quantifiable relationships are lacking

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Presenting author: Robert Lusardi

Identifying priority taxa of concern over broad spatial scales as well as their response to changes in flow is a key step in establishing robust environmental flow recommendations for management purposes. Data that directly link individual fish species and their response to quantifiable flow metrics are currently lacking. We developed an approach to establish regional assemblages of fishes and indicator species to use for environmental flow recommendations using a functional flows approach. First, we performed a spatial k-means clustering analysis on native fish distribution data throughout California, USA to regionalize assemblages into smaller units for management purposes. We then identified a subset of species from each assemblage (indicator species) using hierarchical clustering of life history, habitat preference traits, and vulnerability to climate change. To develop relationships between hydrology and species response, we first used a functional flow approach and identified several ecologically relevant flow metrics nested within four functional flow components. Flow-ecology literature and expert opinion were then used to develop relationships between hydrological conditions and flow metrics for each indicator species within each regional fish assemblage. This method avoids a single-species approach to the development of environmental flow recommendations and allows for the development of flow recommendations when quantifiable flow-ecology relationships for a particular species are unavailable.

Session **SP04**

Establishing Environmental Flows for Urban Watersheds under the California Environmental Flows Framework

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Presenting author: Sarah Yarnell

The challenges of establishing environmental flows that protect both instream ecological needs and consumptive uses vary based on the type of demand placed on water. Urban watersheds present different challenges to balancing flow needs compared with agricultural areas or dam-regulated watersheds because competing demands are often greater and more consistent, and high-quality habitats may be more restricted. The California Environmental Flows Workgroup (CEFW), a stakeholder technical workgroup established to strengthen linkages between research and agency program needs, and to provide support for resource managers working to secure environmental flow protections, is addressing urban environmental flows through a series of case studies in the heavily urbanized southern California region. Local government agencies are advancing proposals to increase wastewater reuse, stormwater capture, and water recycling in an effort to reduce reliance on imported water, and to improve the resiliency of water supply to climate-change induced shifts in rainfall patterns (i.e., drier and more episodic conditions). These practices threaten to further degrade or eliminate remnant instream habitats that have come to rely on these artificial" flow regimes over the last hundred years. The California Environmental Flows Framework is being applied in these areas to identify priority habitats and species for protection and to model multiple scenarios of future water use practices. The resultant analysis illustrates the challenges of establishing environmental flows in highly constrained urban environments, but demonstrates that solutions are possible when a more holistic functional flows approach is adopted."

Session **SP04**

Using conservation finance to incentivize streamflow restoration: the design of an environmental impact bond in the Yakima Basin, Washington

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Presenting author: Martin Doyle

Government sources of capital for water resources infrastructure has been declining in the United States since the late 1980s. This decline limits financial resources available for maintenance and rehabilitation of aging infrastructure, and is occurring amidst a backdrop of depleting water supply due to climate change, degraded ecosystems, and declining species diversity. Simultaneously, there is growing interest by the private finance sector in water and ecosystem-related investment opportunities. This paper describes a novel finance instrument - an Environmental Impact Bond - that would provide private capital for needed infrastructure, and link the financial returns of that investment to the environmental benefits of infrastructure operations.

Rising winter temperatures associated with climate change are reducing the fraction of precipitation that falls as snow in the Yakima Basin, decreasing the volume of streamflow available in late spring and early summer for irrigation-dependent agriculture. Reduced water storage in snowpack and increased water demand make the existing reservoir storage capacity less reliable. The Yakima Basin also supports a range of important flow-dependent fish species including sockeye, spring and fall Chinook, and coho.

The proposed Kachess Drought Relief Pumping Plant (KDRPP) would supplement reservoir storage for irrigation during drought years. The pumping plant would also supplement streamflows by routing water through irrigation canal infrastructure and then into important headwater tributaries during drought years. This approach could increase flows in approximately 150 km of tributaries, of which 125 km have been designated as sensitive, low-flow reaches.

Enabling this ecologically beneficial use of infrastructure (both pumping plant and canals) would require modest modification in their design, use, and operations; the irrigators might be motivated for such adjustments if a financial incentive were available, including lower cost of capital for the project given the potential cost of the project (> 175M USD). We test the feasibility of an Environmental Impact Bond (EIB) approach to align financial and ecological restoration incentives, specifically by providing capital for financing the infrastructure, but linking the rate of return for EIB investors to ecological improvements. An EIB is a form of Pay-for-Performance debt financing where investors provide up-front capital to implement a project and are repaid according to the degree of ecological improvements (i.e., environmental returns along with financial returns). To date, EIBs have been used to finance green infrastructure for stormwater management in Washington, DC and Atlanta, GA. Proposals for other EIBs are being developed for ecosystem and wetlands restoration along the coastline of the Gulf of Mexico. Here we evaluate the EIB concept for financing the Kachess Drought Relief Pumping Plant.

Session **SP04**

Priorities of Environmental Flow Allocation in A River Basin Considering Waterbird Conservation

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Presenting author: Xinan YIN

Ensuring environmental flows (e-flows) is one basic requirement to maintain the waterbird conservation function of aquatic ecosystems. Due to limited water resources availability, it is essential to determine the priorities of e-flow allocation among all water bodies that serves as the habitats for waterbirds in a river basin. In traditional research, high priority is assigned to the water body that is suitable for rare birds and can offer the largest habitat area. However, due to the migration of waterbird among water bodies, all water bodies in a river basin form a habitat network. The water bodies that are not very large but server as important junctions in migratory routes should also be assigned with high priorities. In this research, we consider both the habitat and junction functions of water bodies in a habitat network for waterbird conservation, and develop a method to determine the priorities of environmental flow allocation in a river basin. In this method, the connectivity matrix for the water bodies in a river basin is built, and the general gravity model is adopted to measure the connectivity strength. Besides, the eigenvector centrality is used to determine the relative significance of each water body. The new method is applied to the Huai River, one of the seven largest river in China, to test its effectiveness. The results show that the e-flow allocation priority is not ordered according to the habitat size; instead, besides some large water bodies, some small water bodies (such as the Tuo Lake and Xiangjian Lake), that serves important junction function but used to be neglected, are found to be with high priority for e-flow allocation.

Session **SP05**

Groundwater-dependent ecosystems in agro-environments of the Po valley, Italy:Their role in the nitrogen cycling

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Presenting author: Raffaella Balestrini

The most spread groundwater-dependent ecosystems (GDEs) in the River Po valley are semi-natural lowland springs called fontanili". They are biotopes where groundwater emerges spontaneously mainly due to the decrease in the permeability of alluvial sedimentary deposits in the transition zone between the higher and the lower plain. In the higher plain of Lombardy (Northern Italy), the concentration of nitrates in groundwater often exceeds the regulatory limits (50 mg L-1). Due to agricultural practices, the N excess is leached to the subsoil and is therefore subtracted from the shallow environment. However, this sink is only temporary, since the fontanili return the deep groundwater, partially mixed with recently infiltrated irrigation water, and the associated nutrients back to the surface water compartment. The available data on the chemistry of the fontanili reveals high NO_3 concentration commonly in the range of 10-25 mg L-1. Within the INTEGRON project (Squaring the cycle: the INTEgration of GROundwater processes in Nutrient budgets for a basin-oriented remediation strategy) the N flux re-cycled from groundwater to surface water was estimated by an extensive seasonal monitoring of the nutrient concentrations and discharge in 50 fontanili from the catchments of Ticino and Adda rivers. The role of riparian strips and aquatic macrophytes in reducing the N contamination was studied by field campaigns in plots equipped with piezometer nests and by nutrient addition experiments. The nitrate removal effectiveness showed a large variation between the studied riparian areas including sites where we did not observe any reduction and locations where a complete NO_3 depletion always occurred. Some useful predictors of the nitrate removal capacity were factors linked to the water residence time (e.g. the hydraulic conductivity, the soil texture and the slope of the riparian profile) together with the water table depth and soil organic carbon. Furthermore, our results demonstrate that the presence of instream vegetation, together with associated biological communities, provides a considerably higher nutrient retention. Despite the chronic high NO_3 loading, the biota responds efficiently to variations in the relative availability of NH_4 and PO_4, and this suggests that some aspects of ecosystem functionality are maintained relatively intact when macrophytes can grow. Lastly, specific recommendations are made for improving the management practices in the Po valley in order to maximize the potential ecosystem services offered by the secondary hydrographic network."

Session **SP05**

Effects of macrophytes on organic carbon cycling in a groundwater-fed lowland river.

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Presenting author: Stefen Preiner

The input of organic matter to coastal ecosystems is crucial for their trophic state. Quality and quantity of these inputs are determined by upstream processes in the river systems. Though macrophytes can be found within the whole catchment, their role in organic matter transformation has obtained less attention.

We measured metabolism in three reaches with different macrophyte coverage and biomass of the groundwater-fed lowland river Fischa in Austria, studied the role of macrophytes therein, and linked it to carbon cycling and organic matter transformation in the river, which we determined via an upstream/downstream approach.

As the dominant autotrophs, we expected macrophytes to have (i) a direct effect on the organic carbon quality in the river by releasing dissolved organic matter and (ii) an indirect effect by improving the conditions for heterotrophic microbial organisms resulting in higher turnover and uptake rates.

The seasonal development of macrophytes 2017 had a strong impact on gross primary production (GPP), but not on ecosystem respiration (ER). The higher the macrophyte biomass, the higher the GPP (max. GPP: 5.4 g O2 m-2d-1). After the blooming period in July, the decease of macrophytes resulted in a high amount of dissolved and particulate organic carbon released to the water column (~0.5 g C m-2d-1). ER was highest in autumn (max. ER: 10.1 g O2 m-2d-1). Also, the quality of dissolved organic matter changed over the season and was related to metabolic rates. Significant differences in organic matter transformation between the studied reaches were found.

Our results demonstrated that macrophytes have a strong effect on organic matter cycling. Besides, the pulsing input of dissolved organic matter linked to the die-off in late summer, indirect effects are of high importance.

Session **SP05**

Effects of elevated CO_2 and DOC concentrations on growth, biomass allocation, chlorophyll content and nutrient stoichiometry of submerged macrophytes

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Presenting author: Rosanne Reitsema

Due to human-induced global change, it is expected that the frequency of extreme precipitation events and droughts will increase. This can have profound effects on riverine ecosystems: flow velocity can change, and there may be more evapotranspiration (drought) or runoff (heavy precipitation) causing increased terrestrial organic matter input, which can both result in increased dissolved organic carbon (DOC) and CO_2 levels when degraded in water. These effects of global change affect biota in riverine systems including macrophytes and especially responses of this key organism group are still poorly understood. The combined effects of flow velocity, elevated CO_2, and increased DOC have not been studied before. Firstly, a raceway flume experiment was carried out, in which macrophytes were exposed to two different CO_2 concentrations (400 and 1000 ppm), two different DOC concentrations (1.5 and 5 mg L^{-1}) and two different flow velocities (0.04 m s^{-1} and 0.4 m s^{-1}). Secondly, an experiment with standing water was carried out to test more and higher concentrations of CO_2 (1000, 10000 and 16000 ppm) and DOC (5, 10 and 20 mg L^{-1}) as well as the combination between those CO_2 and DOC concentrations. Macrophyte species Berula erecta was chosen as a model species for rooted submerged macrophytes. The growth rate, biomass production, morphology, chlorophyll content and nutrient stoichiometry (C, N and P) of the macrophytes was measured. At the time of submission, the second part of the experiment (the experiment in standing water) is still ongoing and not all results are in. From the flume experiment it can be concluded that B. erecta responded strongly to the treatments. The relative growth rate was larger in the high CO_2 treatment, but lower in the high DOC treatment. Plants were shorter when exposed to high flow velocity and high DOC concentrations. In the high DOC treatment plants also produced fewer stolons with new ramets and stem diameter was smaller. The concentration of chlorophyll was lower when plants were exposed to high CO_2 concentrations. In many parameters there were interaction effects between CO_2, DOC and flow velocity. How macrophytes in rivers respond to global change will of course depend on the extent of the increase in CO_2, DOC and flow velocity. Still, this study suggests that global change can have a pronounced effect and this may not only affect macrophytes themselves, but also other aquatic organisms that depend on them.

Session **SP05**

Longitudinal distribution of Egeria densa in a gavel river channel and the ecosystem engineering process for the higher colonization

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Presenting author: Takashi Asaeda

River channels in mountainous areas are steep and filled with gravel. Submerged macrophytes generally prefer slow velocity zones with fine substrates to form colonies thus, they cannot form large colonies in high velocities and gravel channels. Egeria densa is an often-found invasive species in Japan, which has spread widely in the past two decades in gravel rivers, where no submerged macrophytes found before. As a result, gravel bed ecosystems have now dominated by this noxious invasive macrophyte. In order to investigate the E. densa adaptation in the riverine conditions field experiments were conducted at different seasons and locations. Tissue Hydrogen peroxide (H_2O_2: a reactive oxygen species) concentrations of E. densa was adopted as the stress indicator under varying conditions in rivers and also in laboratory conditions. The H_2O_2 contents were quantified under both light exposed and 30 min dark adapted conditions to distinguish the effects of environmental stresses from the photosynthesis. The H_2O_2 concentration under dark adaptation is proportional to the flow velocity, and the surplus H_2O_2 concentration of the light exposed condition corresponded to increase with increasing photosynthetically active radiation intensity (PAR). When the H_2O_2 concentration exceeds 16 µmol/gFW plant tissue starts to deteriorate, and the chlorophyll a concentration and biomass decline, indicating the critical values required for survival of particular macrophyte species.

H_2O_2 concentration of E. densa was predicted from the relationships between H_2O_2 concentration and velocity or light for different slopes and depths of channels; it was found that the value increases in steeper channels and exceeds the critical value for slopes above 1/100, however, is the lowest at around 0.6 to 0.8 m deep in any slopes. These results agree with the observed results where colonies were not found in channels with slopes exceeding 1/100 and biomass was largest at depths of 0.6 to 0.8 m in milder slope channels.

Once colonized, E. densa colony traps large quantities of suspended sand and alters the gravel bed to sandy with its complex stem structure. This process enables colonization of E. densa in formerly desolated, steep gravel channels.

Session **SP05**

Does silicon content of aquatic macrophytes affect bacterial and herbivore decomposition?

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Three macrophyte species (Elodea nuttallii, Potamogeton lucens and Vallisneria spiralis) were grown under different temperature treatments (10, 15, 20 and 25°C). Plant samples from this temperature experiment were tested for their decomposition rate in presence of a natural bacterial inoculum and in presence or absence of the macroinvertebrate species Asellus aquaticus. We used the Decotab method which is a disk made form agar, cellulose and powdered plant samples. This way, plant morphological traits cannot influence the decomposition, and the effect of nutrient stoichiometry can be measured separately. Mass loss of the Decotab was measured (as a proxy for decomposition), nutrient concentrations in the water column were analyzed and the bacterial community present was measured using Biolog Ecoplates. In this way we were able to measure the effects of plant nutrient stoichiometry on (i) palatability by macroinvertebrates and (ii) the effect on bacterial biomass and community. From the mass loss, it is clear that presence of macroinvertebrates has a major influence on the disks which break down more rapidly than without macroinvertebrates. Silica concentration in the plants - differing along temperature treatments - had a positive effect on Decotab decomposition by bacteria and fungi and in absence of macroinvertebrates. Grazing by macroinvertebrates facilitated (functional) diversity and activity of bacteria. Decotabs from plants grown under low temperatures led to a higher activity of bacteria as well in the absence of macroinvertebrates. This effect was not visible with macroinvertebrates present.

Session **SP06**

Climate change impact assessment on the hydrological regime of rivers and the availability of habitats important for water birds

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Presenting author: Joanna O'Keeffe

This research combines knowledge from the field of hydrology, ecology and nature protection and uses modelling to analyze the impact of climate change on habitats relevant for waterbirds. The following were defined as research objectives: (1) diagnosis and analysis of hydrological regime characteristics important for waterbirds nesting on river islands and sandbanks, (2) projection of changes in the hydrological regime characteristics in the future using climate change scenarios and the SWAT model, (3) analysis of impact of climate change on the functioning of selected habitats relevant for waterbirds.

Common gull (Larus canus), little tern (Sternula albifrons) and black-headed gull (Chroicocephalus ridibundus) are threatened in Poland by the loss of breeding habitats as a result of changes in the hydrological regime of rivers, changing the frequency and length of inundation in river valleys. The features of inundation or flooding of river islands and sandbanks that are beneficial or unfavourable for birds as well as quantitative relationships between flow (duration, frequency, term) and the welfare of the species studied was determined.

The next step included an estimation of bankfull flow in chosen 18 locations with suitable habitats on the Vistula river in Poland with the use of acquired data on river channel cross-sections. The values of bankfull flow in given locations will be compared to the flow data obtained from the SWAT (Soil & Water Assessment Tool) model calibrated and verified for the Vistula basin. The base period for simulations driven by climate models is 1971-2000, while future projection horizons are near (2021-2050) and far (2071-2100) future. The projections contain two scenarios of changes in greenhouse gas concentrations in the atmosphere: RCP4.5 and RCP8.5. Projections were prepared on the basis of nine "adjusted" regional climate models and the EURO-CORDEX collection. Analysis of historical data, ie daily flows generated from the SWAT model for the period 1971-2000, allowed to determine the values of hydrological characteristics such as: the start date and duration of the inundation, percentage of flooded area during the culmination of the inundation (using DEM), etc. Indicators of Hydrological Alteration (IHA) were used to aid this process. Prediction data for the years 2021-2050 and 2071-2100 enables the assessment of the significance of changes in the value of hydrological characteristics under the conditions of climate change. In addition to statistical significance analysis, modelling uncertainty was performed. By determining the optimal hydrological conditions for given species and using the projections of changes in the hydrological characteristics caused by climate change, it is possible to undertake the assessment whether these changes will be beneficial or unfavorable for the species concerned.

Session **SP06**

Integrated scenario analysis of water quality policies in Austrian agriculture under climate change

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Presenting author: Martin Schönhart

Climate change, technological inventions, markets and policies are major drivers of agricultural land use and therefore impact the quality and quantity of water resources. Integrated modelling frameworks (IMF) have been proven valuable tools to analyze quantitatively Driver-Pressure-State-Impact-Response (DPSIR) relationships of climate-land-water systems using scenarios. Scenarios typically combine alternative developments of climate change, markets, technologies and policies and frame the drivers of change and options of response. Stakeholder knowledge and research needs can be embedded in the scenario developments to increase relevancy for administration and policy planning.

We present experiences and results of IMF applications and scenario processes from one finished and one ongoing interdisciplinary research project in Austria. The applied climate scenarios represent uncertainty ranges from climate change, while stakeholder driven water protection policies cover agri-environmental programs and legal standards typical to Austrian agriculture. They include management measures such as restrictions in fertilizer, soil management and crop rotations as well as establishment of buffer strips. A unique feature of the scenario process is the use of the novel Eur-Agri-SSPs, a set of storylines about European agriculture that ensure consistency with the global shared socio-economic pathways applied as standard scenario framework in climate change science.

Several IMFs have been developed at watershed and national scale. They typically link disciplinary models such as biophysical process models and economic land use models to quantify different cause-effect relationships in a DPSIR context. Defining system boundaries and consistent interfaces between models is as important as defining proper spatial and temporal scales of drivers, processes and responses. Collecting and processing of multi-disciplinary data requires knowledge and skills as well as collaboration among the scientists in the team and data providers. Validation of data and model results as well as assessing uncertainties is as crucial in IMFs as communicating these to stakeholders and policy makers.

Session **SP06**

A novel integrated modelling framework to assess the impacts of climate and socio-economic drivers on land use and water quality

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Presenting author: Matthias Zessner

Changes in climatic conditions will directly affect the quality and quantity of water resources. Further on, they will affect them indirectly through adaptation in land use which ultimately influences diffuse nutrient emissions to rivers and therefore potentially the compliance with good ecological status according to the EU Water Framework Directive (WFD). We present an integrated impact modelling framework (IIMF) to track and quantify direct and indirect pollution impacts along policy-economy-climate-agriculture-water interfaces. The IIMF is applied to assess impacts of climatic and socio-economic drivers on agricultural land use (crop choices, farming practices and fertilization levels), river flows and the risk for exceedance of environmental quality standards for determination of the ecological water quality status in Austria. This article also presents model interfaces as well as validation procedures and results of single models and the IIMF with respect to observed state variables such as land use, river flow and nutrient river loads. The performance of the IIMF for calculations of river nutrient loads (120 monitoring stations) shows a Nash-Sutcliffe Efficiency of 0.73 for nitrogen and 0.51 for phosphorus. Most problematic is the modelling of phosphorus loads in the alpine catchments dominated by forests and mountainous landscape. About 63% of these catchments show a deviation between modelled and observed loads of 30% and more. In catchments dominated by agricultural production, the performance of the IIMF is much better as only 30% for cropland and 23% for permanent grassland dominated areas have a deviation of more than 30% between modelled and observed loads. As risk of exceedance of environmental quality standards is mainly recognized in catchments dominated by cropland, the IIMF is well suited for assessing the nutrient component of the WFD ecological status.

Session **SP06**

Global Dam Watch - a one-stop shop to provide critical information on the location and characteristics of dams and reservoirs on a global scale

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Presenting author: Christiane Zarfl

There are millions of reservoirs and dams on the planet, ranging from tiny farm ponds on small streams to multi-year storage facilities on major rivers, and many new ones are under construction or planned. The common goal of these facilities is to tackle the uneven distribution of water in space and time by storing water for a broad spectrum of purposes. These range from irrigation, flood control, electricity production, and municipal water supply to more specific ones of navigation, recreation, industrial purposes, or fisheries. The importance of dams and reservoirs is exemplified in the multifaceted role they play in various Sustainable Development Goals (SDGs) and in relation to global climate change, e.g. dams provide critical contributions to food security and sustainable agriculture by providing water for irrigation (SDG 2 - zero hunger); reservoirs store and provide important water resources for domestic, industrial, and agricultural sectors (SDG 6 - access to safe and affordable drinking water and reduction of water scarcity); and dams contribute to the renewable energy mix by providing ~20% of global electricity production through hydropower (SDG 7 - affordable and clean energy).

While these barriers have been built to benefit society within the frame of the water-energy-food nexus, they also impact social and environmental systems. Dams and reservoirs can displace human settlements, disconnect aquatic ecosystems, and alter natural flow, thermal, and sediment regimes. These effects are propagated over long distances, including to the river deltas. Deltas are not only important regions for human civilization with some of the most productive agricultural land in the world, but also provide habitat for an exceptionally rich biodiversity. Despite the recognized importance of reservoirs and dams, global datasets describing their geographical distribution and characteristics are largely incomplete, unreliable, or inaccessible.

To address this shortcoming, the Global Dam Watch initiative will build upon three existing, scientific global datasets that provide the location and size of major dams of all purposes as well as hydropower dams that are under construction or planned. This initiative, driven by leading academic institutions and NGOs, brings together and curates a variety of published, archived, or individually reported data across the globe. Global Dam Watch also works with experts to incorporate dam and reservoir data that have been detected using remote sensing and machine learning. It makes this information freely accessible to a user community to enable advanced assessments of the role and effects of dams within the global river network, and to support strategies for mitigating ecohydrological and socioeconomic costs.

Session **SP06**

Quantifying ecosystem services in floodplains on landscape scale - under consideration of floodplain condition and catchment characteristics

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Although the ecological importance and major endangerment of floodplains are known and acknowledged worldwide, measures are still taken which deteriorate the status of floodplains and services in an unknown dimension. One reason for that is the missing understanding of interactions between floodplain status, anthropogenic measures, natural processes and ecosystem services (ES) on different spatial scales. River basin management plans necessary for implementing the Water Framework Directive are developed on the landscape scale where approaches for estimating ES are scarce. Small scale approaches derived from detailed case studies are however too complex and data requirements are too high to enable an implementation on the landscape scale. Likewise, approaches on the global scale are too simple to transfer them to the landscape scale. They rely on large-scale land cover data with low resolution and inadequate land cover to represent floodplains such that current status and current hydrologic conditions of the floodplains are neglected.

This project proposes an approach that integrates the current condition of the floodplain regarding hydrology, landuse, morphology and biology under consideration of catchment characteristics including the societal need in Germany.

First, the floodplain condition of more than 15,000 1-km-segments for 79 large rivers in Germany is derived from the Federal Agency for Nature Conservation. Statistical methods are carried out to analyze the effect of floodplain conditions on selected functions for each 1-km-segment. Within the spatial extent of the floodplain (according to flood hazard maps with frequent statistical occurrence) ES typically found in floodplains (naturally or human made by changing landuse) are selected for further consideration. For each ES indicators are developed. Appropriate geodatasets are used to finally quantify ES on the basis of these indicators in floodplains. Various existing ES databases are reviewed to evaluate the transferability of international monetary values to middle European countries.

Results show, that the floodplain condition strongly affects the performance of ecosystem functions. Nine important floodplain ES are identified and analyzed with respect to their relevance for society in the catchment: regulating services (hydrological, water quality and climate services, protection from natural hazards), provisioning services (food, construction and energetic material production) as well as cultural services (recreation) and biodiversity. By considering their exclusive but also combined performance it is possible to compare floodplains regarding possible multifunctional uses for human well-being (e.g. recreational services within a floodplain forest relevant for biodiversity and flood retention versus intensive crop farming). However, temporal changes in ES provision as induced by flooding dynamics will be considered in the next step.

Session **SP07**

Quantitative Assessment of Floodplain Functionality Using an Index of Integrity

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Presenting author: Ryan Morrison

Floodplain integrity can be defined as the ability of a floodplain to support essential functions that maintain biodiversity and ecosystem services. Humans alter floodplain integrity by changing the physical landscape of the floodplain or by changing river flow regimes and therefore floodplain inundation. The typical approach to evaluating the integrity of a natural environment requires comparison of the environment in question to a reference" environment that is considered to be free of human influence. However, identifying a suitable unaltered reference floodplain is often infeasible due to the pervasiveness of development in floodplains. This research develops a novel framework to quantitatively evaluate floodplain integrity by assessing anthropogenic alterations to hydrology and landscape which disturb critical floodplain functions. Critical floodplain functions include attenuating floods, storing groundwater, providing habitat, and regulating sediment, organic matter, and solutes. For each floodplain function, measurable stressors that inhibit the specific function were identified. The prevalence of each stressor variable in the floodplain was quantified using datasets that are publicly available at large spatial scales. The index of integrity for a given floodplain function was determined by the density of all stressors which inhibit the given function. The overall index of floodplain integrity for a given floodplain unit was calculated using a geometric mean of the indices of integrity for each of the five floodplain functions. This research then applied this methodology for assessing floodplain functionality to all floodplains in the state of Colorado. An index of floodplain integrity was computed, mapped, and analyzed for each of the five floodplain functions and the aggregated overall integrity. By quantifying anthropogenic reductions to floodplain functionality at broad spatial scales, the index of floodplain integrity can help target restoration efforts towards the most affected functions and areas."

Session **SP07**

A broader perspective of floodplain ecosystem functions. Applying measures of multifunctionality in a riparian restoration project.

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Presenting author: Agnieszka Sendek

River floodplains supply multiple ecosystem functions ranging from flood control and water purification to the provision of habitats and recreation areas. Synergies and trade-offs are frequently observed between functions provided by natural ecosystems. Consequently, environmental management and conservation programs are often challenged by the need to consider a multitude of potentially contradictory functions. Quantifying ecosystem multifunctionality (EMF), i.e. simultaneous delivery of multiple ecosystem functions, could provide a working solution to this problem. In addition, EMF provides information beyond the knowledge gained by investigating individual function separately. This approach is particularly valuable in complex systems, like riparian habitats. Calculating EMF measures and defining their drivers can simplify decision making and help to advise land managers on how to optimize management tools to enhance overall ecosystem function.

Within the framework of a multidisciplinary riparian restoration project "Wilde Mulde", we examined the influence of environmental drivers on single ecosystem functions and EMF provided by the floodplains of the river Mulde (Germany). During field surveys in 2017 we quantified 18 ecosystem functions and 7 environmental drivers. Ecosystem functions describe sediment and nutrient retention (e.g. amount of sediments, amount of nutrients and pollutants in plant biomass and sediments), biodiversity (e.g. plant species richness, number of endangered and alien species) and productivity (plant biomass). Environmental drivers refer to plot location relative to the river bed, ground water availability and flooding characteristics. We described relations between functions using Pearson correlation coefficient. As measures of EMF we used the averaged value of the standardized functions and the number of functions performing over thresholds of 25%, 50%, 75% and 100% of estimated maximal functioning. We used structural equation models (SEM) to examine potential mechanisms driving single ecosystem functions and EMF measures.

Results underline the role of environmental drivers for particular functions and ecosystem multifunctionality. Moreover, they reveal positive and negative relations between single functions and thus identify synergies and trade-offs between functions. The presented approach demonstrates how multifunctionality measures in combination with mechanistic modelling can synthesize results of multidisciplinary restoration projects and thus support the evaluation of restoration.

Session **SP07**

Assessment of provisioning and regulating riverine ecosystem services under different network topology

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Riverine ecosystem exhibits unique forms and functions and underpin the delivery of important riverine ecosystem services (RES). In this research, we examined the influence of the shape of the river network itself on delivery of RES. Because impact of land cover change, climate change and growing economies on availability and delivery of RES are some of the known freshwater issues. But the effect of an important aspect of river form called river network topology, on delivery of provisioning and regulating services are less known. This impairs river conservation and restoration efforts. Therefore, this paper compares the capacities of river network topologies that deliver RES.

We tested the influence of river network topologies on delivery of RES by applying simple functional equations. Three synthetic river network topologies - inland dendritic, coastal dendritic and long trellis were chosen to model selected riverine ecosystem services: water supply, hydropower generation, sediment retention, nutrient uptake, flood attenuation and aquatic habitat provision.

Results showed that three different synthetic topologies deliver different level of RES. All the three topologies showed a higher capacity of sediment retention (more than 90%). Inland dendritic pattern performed better in removing nitrate, retain sediment, attenuate flood and offered a suitable environment for aquatic habitat. Coastal dendritic indicated a good supplier of water for consumptive as well as non-consumptive use than inland dendritic and long trellis. However, both long trellis and coastal dendritic topologies showed a poor performance to attenuate flood and offer a less conducive environment for aquatic habitat.

The performance of different river network topologies in delivery of RES is relevant to conservation, management and restoration approaches of degraded river basins. The next step is to investigate these relationships in real case studies rather than synthetic examples. This would provide information on topology affected riverine ecosystem services at catchment scale, that are applicable for water related disaster preparedness and mitigation plans, strategies to adopt for ecological corridor restoration and adoption of suitable technology and infrastructures to enhance RES on time.

Session **SP07**

A new approach to assessing river ecosystem services and its application to rivers with and without nature conservation designations

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This paper will describes a new approach to evaluating the potential for rivers with different physical habitats and land cover type to provide river ecosystem services. Notable developments on previous approaches included the full integration of cultural ecosystem services alongside provisioning, regulating and supporting services, the introduction of confidence levels to river feature-ecosystem service linkages, and the incorporation of valley floor surface area into one of the two scoring systems. Ecosystem scores were calculated for 500 m reaches along 8 rivers in Scotland from source to mouth, with the results showing high reach-to-reach variability within individual rivers and significant differences between paired rivers. The four rivers with statutory nature conservation designations supported higher ecosystem service scores than the four with few or no designations - a result that has significant implications for river conservation and for framing environmental policy.

Session **SP07**

The River Ecosystem Service Index RESI - a new tool for sustainable floodplain management tested along the Upper Danube

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Presenting author: Barbara Stammel

Intact rivers and floodplains offer many ecosystem services like flood risk prevention, timber, recreation or habitats for species and biotopes typical for floodplains. These provisioning, regulating and cultural ecosystem services (ES) are provided in different ways depending on the land use intensity in the floodplain and the management of the rivers. An intensive river and land management can be a major pressure on the ecosystem and related services. So, the drastic regulation of the Upper Danube in the 19th century, the use for hydropower production and the intensification of the land use in the last decades have led to a reduction of various ES, e.g. habitat provision, water and nutrient retention. On the other hand, arable land use and food production have increased, whereas for other ES like recreation the trend is not strictly linear.

The multiple uses of rivers and floodplains are reflected in several sectoral legal frameworks, for Europe for instance the Water Framework Directive, Bird and Habitats directive and the Floods Directive. So far, these policies are mainly individually managed (e.g. flood risk management, nature conservation or agriculture), rarely regarding potential synergies or trade-offs between sectors. The ecosystem service concept is capable to jointly evaluate all services, but until now, it is mainly used to protect natural assets against economic interests, not to proactively suggest different activities holistically.

The River Ecosystem Service Index (RESI) was developed by a German interdisciplinary research project to significantly improve sustainable river and floodplain management by the identification of synergies between the relevant ES, which reflect the sectoral interests and targets integratively. This tool can support decision makers to find the most sustainable solution. For the assessment of different management options, the variety of ES are all scored from 1 to 5 by methods based on already existing data. Scores are elaborated separately for the river channel and the segments of the active floodplain and the former parts (now separated by dams). This uniform scaling of ES availability allows the elaboration of uniform maps for all ES, and an easy integration of various ES to the River Ecosystem Service Index (RESI).

In a case study floodplain of 80 km along the Upper Danube in Bavaria (Germany) the RESI was tested to evaluate the effects of different scenarios (flood risk prevention, nature conservation, and considerable change of intensive land use to more natural conditions). 16 different ES relevant in floodplains were assessed for the status quo and for the other scenarios and were compared with each other. Synergies and trade-offs between the different ES could clearly be identified for the different scenarios. Here, the framework of the RESI assessment as well as the results and the practical experience of the RESI in the case study will be presented.

Session **SP07**

River Ecosystem Service Index RESI -method and application of regulating ecosystem service „habitat provision"

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Presenting author: Christine Fischer

The joint research project RESI aims to improve the current basis for decision-making by developing the so-called "River Ecosystem Services Index" (RESI). RESI represents an innovative and cross-sectoral platform that enables an interdisciplinary economic-ecological assessment of development scenarios. For the first time, ecosystem services of river corridors are quantified across sectors and are wherever possible evaluated and visualized synoptically, which enables the comparison of management strategies.

The ecosystem service "habitat provision" is defined as the functional and structural quality of characteristic riverine and alluvial habitats and their species communities as a basis for multiple human uses of the landscapes and its resources. These habitats provide a diversity of animal and plant biocoenoses typical for rivers and floodplains of natural and cultural landscapes under characteristic site conditions.

Depending on the scale considered (nationwide or local), different methodological approaches are used due to the different resolution/accuracy of spatial data and information about species and communities. Regardless of the scale, the individual evaluation criteria are transferred into a five step scale (1-5). The resulting habitat index describes the importance of floodplains for typical species and habitats in 5 classes from "very high" (= 5) to "very low" (= 1).

The methodical approach is tested for the River Nahe on local scale. The evaluation was addressed in three steps: First, a type-related evaluation based on biotope data using a RESI biotope values was performed. In a second step individually biotope related assessment based on specific characteristics of the biotope or biotope complex was calculated. In a third step these data were area weighted and aggregated at 1 km floodplain section. The aim is to provide a tool for planners and decision makers to compare and analyze already implemented measures as well as possible consequences of future options for action.

Session **SP07**

River hydromorphology and ecosystem services: the HyMoCARES approach

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Presenting author: Mauro Carolli

Rivers and their floodplains support human activities with several important ecosystem services (ES), defined as "direct and indirect contribution made by ecosystems to human welfare". In particular, Alpine rivers flow into densely populated and intensely used areas, they have been historically exploited for their services, but their hydrology and morphology have been profoundly regulated and modified for e.g. flood protection and hydropower production. The hydromorphological processes have a fundamental role in shaping and maintain river habitats, river landscapes and the related ecological functions and their alteration have consequences on the provisioning of ecosystem services.

The HyMoCARES project aimed to identify the linkages between fluvial hydromorphology and the ecosystem service provisioning, and how river management measures may affect those linkages. We elaborated a conceptual framework relating management measures on river hydromorphology with the ecosystem services concept. HyMoCARES is a project funded by the EU Interreg Alpine Space which involves thirteen partners from six different countries.

Here we present a) the conceptual network to qualitatively link management actions and ES, which enables to predict which hydromorphological functions, and, consequently, ES will be probably influenced by management actions; b) relevant examples of how the hydromorphological functions may affect river ecosystem services and how, in some cases, it is possible to quantify and predict river ecosystem services variation.

Hydromorphological functions represent a set of the interactions between ecosystem structure and processes that influence the capacity of an ecosystem to provide services. In total, we identified ten functions and eighteen services for Alpine rivers and three usages of abiotic natural capital. Moreover, we choose nine typical management or restoration actions which may influence processes, functions and ES. The relations among actions, functions and services are based on the expert opinion (presence/absence) of the project partners and have been summarized as an interactive online network. This network has been applied to the thirteen project case studies, characterized by different river management actions, to quantify the variation of the ecosystem services. Here we briefly present with some practical examples the effects on river ecosystem services in the Alpine area (case studies from Austria, France, Germany, Italy, Slovenia, Switzerland) of hydropower production management, of artificial sediment replenishment and of morphological change.

The framework can be applied by decision makers to identify and target which ecosystem services can be affected by management and river restoration actions.

Session **SP07**

Challenges in using Ecosystem Services in Floodplain and River Restoration: Example of the - Case Study Lebendige Luppe" - Revitalization Project in Leipzig's Urban Floodplain Forest - Elbe Catchment"

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Presenting author: Mathias Scholz

In the Elbe catchment already many projects for floodplain and river restoration have started, but only a few have been finished. One of the larger projects in Central Germany is the revitalisation project "Lebendige Luppe" started in 2012. The objective is the revitalization of more than 16 km of a former river course in Leipzig's northern floodplain ecosystems, with one of the largest urban floodplain forests in Germany. One of the main objectives is to improve floodplain dynamics by inundation to increase the quality of the habitats for plants and animals, and to maintain and increase its ecosystem functions and services for people. Unexpected events like the flooding events in January 2011 and in June 2013 inundated the study area and showed the potential of the former river dynamics in the project area.

The presentation will give a short overview of floodplain restoration projects in the German Elbe catchment and presenting more in detail the project "Lebendige Luppe" with its planning challenges and related ecosystem services in a strongly modified hydrological river and floodplain network in an urban context.

To measure the effects of the river and floodplain restoration a scientific monitoring design was established and indicators for restoration success were identified. First results of an ecosystem service approach dealing with the quantification and assessment of ecosystem service which are important in floodplains will be presented. The results are describing the current situation of the performance of selected ecosystem services. Possible hydrological scenarios describe the future situation and allow estimating the future performance of thees ecosystem functions and services (e.g. habitat provision, flood and nutrient retention, carbon sequestration or cultural services like nature based recreation). A very importing is, that the restoration scenario compared to the current situation is showing better performance for nearly all analysed ecosystem services and serve already as a tool for decision making.

Session **SP07**

Putting riparian ecosystem restoration and flood risk management together: Analyzing ecosystem services in the context of the Danube Floodplain Project

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Presenting author: Bernd Cyffka

Riparian ecosystems along the Danube are not only hotspots of biodiversity but provide also manifold ecosystem services for people. However, they are under a huge pressurealong European rivers due the disconnection of river and floodplain by dams or the modification of hydromorphological dynamics by hydropower plants. There is a consensus about the need for the protection of the ecosystems within the European rivers and theirfloodplains. Important legislative measures include the Water Framework Directive and the Habitat Directive of the European Union. On the other hand, the Danube Basin experienced several severe flood events over the past decades making it necessary to performmeasures for flood risk reduction. Thus, there is the need to bring the needs for the protection and restoration of riverine ecosystems and their services together with flood risk management. This is also the aim of the project 'Danube Floodplain" foundedwithin the Danube Transnational Programmeof the European Union. The hypothesis of this project is that thinking floodplain restoration and flood risk management together leads to a win-win situation combining an increase of riparian ecosystem services with a reduction of flood risk. To obtain bestpractice examples, detailed evaluations of flood risk reduction and ecosystem services are made within five pilot areas along the Danube or its tributaries. In this presentation, we give an overview over the ecosystem service assessment in the five pilot areasKrka (Slovenia), Morava (Slovakia/Czech Republic), Middle Tisza (Hungary), Begecka Jama (Serbia) and Bistret (Romania). Based on stakeholder workshops, we mapped the actual use and useintensity of these services. The output serves on the one hand to increase the awareness of local decision makers of the relevance of riparian ecosystems in their region. On the other hand, ecosystem services will be integrated in a cost-benefit analysis evaluatingthe floodplain restoration/flood risk reduction measures in the pilot areas. For this task, selected ecosystem services have to be monetized in order to be included in the calculations. The hypothesis is that the inclusion of ecosystem service values in theevaluation of floodplain restoration/ flood risk reduction measures will foster the consideration of riparian ecosystems in planning and make measures beneficial for ecology more attractive.

Session **SP07**

Stakeholders participation in the process of development of protected area management plans using the Analytic hierarchy process - AHP and the concept of ecosystem services

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Presenting author: Laszlo Galambos

Management of protected areas in floodplains is a complex task. There are many parties (stakeholders) having different and sometimes conflict interests, including recognition of the goals related to nature protection. Linking human activities, wellbeing and the conservation and restoration of natural ecosystems in floodplains is difficult. The ecosystem services concept is the link between benefits for humans and nature protection.

Involvement of stakeholders is a proven mechanism for helping effective protection and management of nature reserves. Collaborative management which includes both management authority and local stakeholders may contribute to resolve direct and indirect conflicts and lead to feasible and sustainable management plans. The objective of this research was to examine possibilities of the Analytic hierarchy process (AHP) method to incorporate stakeholders' group preferences related to the planning of the management of a protected area and to support the integration of their priorities in consistent and harmonized environment.

The Koviljsko-petrovaradinski rit (KPR) is a Special Nature Reserve protected area with preserved floodplain habitats and hydrological regime in north Serbia (Vojvodina Province) along the Danube River. It is selected as a case study area for assessing modes of participation of different stakeholders in developing KPR's long-term management plan. The AHP is used to support group decision-making about importance of most important ecosystem services (ES) on a long-term base.

In our case study, 8 stakeholders (2 representatives from the sector of nature protection, and one from forestry management company, local government, NGO, farmers association, society of anglers and one academic from water management research field) were the decision makers included in the planning process from the start. They started with the identification of key ESs in KPR. The 8 most important services were identified (grazing, fishing, tourism, flood mitigation, forestry, groundwater, biodiversity, recreation) and assessed within the AHP group decision framework. Preferences of stakeholders are elicited by performing pair wise comparisons of ecosystem services. The final aggregation of sets of weights of services is performed by weighted geometric mean method; all stakeholders were by assumption equally important and received equal weights during aggregation.

Our results show that the AHP can successfully formalize public participation in the decision making process related to defining management plans for protected areas by valuating ESs for a given nature reserve (in this case, KPR). Identification of actions in the management plan will thus be also based on stakeholders opinion and their preferences regarding the importance of ESs.

In a way, the proposed approach is innovative concerning defining actions for implementation which will be supported by stakeholders and enable satisfactory provision of most important ESs in KPR.

Session **SP07**

Ecosystem services - an integrative approach to link river landscape management with society's demands

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The Ecosystem Service (ES) concept links landscapes with society and can therefore be of multiple value for improved river landscape management as well as for residents' well-being. The perception of ES by stakeholders can feed discussions and improve management and participation processes. Based on this consideration we investigated people's perceptions of ES of river landscapes at three case studies in Austria that included near-natural, restored and impaired river sections.

At the rivers Enns and Drau the focus was on the perspectives of stakeholders with a professional relation with the river and recreational river users; at the river Traisen we focused on the perception of youths. The results from the first two case studies revealed that all involved stakeholder groups perceived a broad range of ES as highly important, which is most likely due to various participation processes in the past that fostered mutual understanding and acceptance. Among the interviewed youths at the river Traisen we found a generally high-perceived importance of cultural, regulating and supporting services. Their views have the potential to improve future restoration planning and management

The results from the survey with youths were combined with a survey of riverine residents to assess functions and services of the Traisen river landscape. The survey outcomes, together with publicly available geodata and expert evaluations lead to an identification of hotspots of regulating and cultural ES. As an exemplary regulating ES, the flood protection potential was analysed. This was based on an expert evaluation of land use categories in the Traisen catchment and the calculation of landscape metrics, which displayed whether the flood protection potential is reflected in the structure of landscape elements. The results served as a good basis for an overview assessment of the retention potential of the river landscape Traisen. With regard to cultural ES, the focus lay on the recreational function of the river landscape. The combination of survey- and geodata resulted in a map displaying hotspots for recreation in the catchment. These were found in river sections that combined a good water quality, trees along the river, floodplain areas, meadows, good infrastructural facilities and a near-natural character.

These investigations were the basis for the third case study dealing with an evaluation of socio-cultural effects of planned restoration measures at the Danube east of Vienna. Based on existing data, mapping activities and expert interviews the status quo of cultural ES were assessed and scenarios on the changes of their availability due to the planned measures were developed.

The application of the ES concept in the described case studies proved that it can be a useful assessment tool, supporting at the same time communication and education as well as argumentation purposes.

Session **SP08**

Challenges in the implementation and scientific monitoring of restoration measures along large rivers using the Lower Mulde as an example

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Presenting author: Christiane Schulz-Zunkel

Dynamic riverine landscapes are habitats of exceptional importance for species diversity, habitat connectivity and the provision of ecosystem services.

The joint project "Wilde Mulde - restoration of a dynamic riverine landscape in Central Germany has implemented restoration measures on three river sections of the Lower Mulde with the aim of improving the interactions of the river with its adjacent floodplains. At the same time, scientific studies are being carried out to assess the effects of the measures on the basis of hydraulic, hydromorphological, biological and functional parameters. In addition, it will also be investigated whether the implemented measures can make a significant contribution to maintaining and restoring ecosystem functions (biodiversity, nutrient retention) in riverine landscapes.

Both, the final implementation of the restoration measures as well as the realisation of the scientific investigations are associated with various challenges: the coordination with the authorities and land owners, the inclusion of the interests of the local population, the regular flow of information to the public on the project status and last but not least the synthetisation of the interdisciplinary scientific data from the research network.

In this paper the challenges of the Wilde Mulde project will be examined and the following questions asked:

(i) How can the scientific interdisciplinary investigation of concrete restoration measures be planned and coordinated before, during and after their implementation?

(ii) How can interdisciplinary data evaluation take place?

(iii)How can restoration projects be consolidated and what long-term tasks or responsibilities result from them?

Session **SP08**

Organic matter sources in riverine food webs: Importance of hydromorphology and season

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Presenting author: Mario Brauns

Determining the origin and significance of particulate organic matter that fuels benthic food webs remains a central goal of ecological research in large rivers. We compared resource use by macroinvertebrate primary consumers as quantified from stable isotopes of carbon (?13C) and nitrogen (?15N) among three different riverine mesohabitats (point bar, thalweg, cut-bank) and two seasons to test if mesohabitat type was the more important driver of resource use in the Mulde River (Germany). We also tested if hydromorphological degradation by bank stabilization (rip rap) affected these patterns. Mixing models in combination with a comparison of dietary proportions revealed that mesohabitat was the more important driver for macroinvertebrate diets than season. Resource use at rip-rap stabilised banks differed substantially from natural banks. Our results add to the debate about the sources of organic matter fuelling benthic food webs of large rivers and we conclude that human alterations to the hydromorphology of large lowland rivers are an important regulator of organic matter flows in food webs.

Session **SP08**

Understanding the effects of hydrology on nitrogen cycling and nitrous oxide emissions in riverine landscapes

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Presenting author: Renata Pinto

River restoration measures aim to improve and sustain ecosystem services of degraded river systems. Typically, these measures increase the hydrological connectivity between the river channel and the floodplain water bodies, enhancing nitrogen retention and processing, affecting the in situ nitrous oxide (N2O) production.

To improve our understanding of these effects, a study was conducted in River Traisen (Austria), where the LIFE+ Traisen ecological restoration project took place. In the frame of this project, large-scale flooding zones were restored, converting the formerly regulated river into a diverse floodplain landscape. At the restored area, transects were defined to cover a flooding-frequency gradient, including dry and periodically flooded plots. Samples were collected on a monthly basis to assess N2O fluxes and nutrient status of water, sediment and soil and to evaluate the environmental drivers leading to changes in intermediate and end products in the riverine landscape.

We hypothesized that more resilient habitats (intermittently flooded plots in the aquatic-terrestrial interface) would present higher activity and N2O emissions, compared to dry habitats. First results suggest a change in behavior between dry and intermittently flood plots, with the later emitting more or less N2O than the dry habitats. The dissolved organic carbon content (DOC) appears to have a significant effect on these changes, suggesting that the system is carbon limited.

To further investigate the effects of repeated drying and re-flooding on N cycle, stable isotope techniques were used to identify the key processes contributing to N2O emissions during these events. A mesocosm experiment was conducted, with soil and sediment cores collected from the previous sampling site. The cores were collected along a gradient covering un-flooded, intermittently flooded and flooded habitats (soil, sediments in the aquatic - terrestrial interface and permanently flooded sediments, respectively) and were subjected to 3 consecutive dry and re-flooding cycles. The cores were labeled with 15N and key processes (nitrification, denitrification, anammox, DNRA) will be identified by their contribution to the N2 mixture (gas measurements) and from 15NO3 and 15NH4 pool enrichment (soil and sediments).

We hypothesize that the sediments previously experiencing intermittent flooding conditions (aquatic - terrestrial interface) will present higher N2O fluxes due to a higher diversity of processes and will be more resilient to the repeated drying and re-flooding cycles. Preliminary results point to changes between NH4+ and NO3- concentrations, possibly indicating shifts between nitrification and denitrification during cycles.

Knowing the nutrient dynamics and N2O emissions from restored river - floodplain areas allows for a better understanding of the role of restoration in nutrient management and N2O production, and to better predict the impact of human activity in freshwater ecosystem

Session **SP08**

A novel scaling concept to relate abiotic diversity to biodiversity in lotic ecosystems

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Presenting author: Christine Anlanger

The habitat heterogeneity hypothesis posits that species diversity increases with increasing habitat heterogeneity in space and time because structurally complex habitats provide more physical niches as well as higher and more diverse supply of resources. Furthermore, it is supposed that increasing species diversity has a positive effect on ecological functioning such as nutrient retention in streams. Lotic habitat properties like riverbed roughness and associated turbulence and their effect on benthic plants and animals have been subject to many studies. However, knowledge on relevant spatial-temporal scales for biodiversity are insufficient. We propose a novel concept based on variance partitioning of physical parameters allowing the estimation of abiotic and biotic diversity at identical spatial and temporal scales. The inspiration for the proposed concept stems from ecology where diversity is usually expressed from species richness and abundance. Diversity on a regional scale (gamma diversity) is expressed as sum of alpha (variability on the spot scale) und beta (variability between spots) diversity. The concept is tested on the basis of near-bed flow measurements at a meander bend of a large lowland river (Mulde River, Germany) in combination with quantifications of macroinvertebrate communities. We show the predictive nature of the concept for biodiversity and demonstrate the concept to be an integrative tool for biodiversity research in stream ecosystems.

Session **SP08**

River Mulde, Germany - Transient storage of wake flows induced by large woody debris

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Presenting author: Ingo Schnauder

Transient storage is an important process in rivers. It's a major contributor to the transport and retention dynamics of sediments and matter and thus the biological and physico-chemical productivity of rivers.

Transient storage exists in a variety of types and across different spatial and temporal scales - from hyporheic flow to large flow recirculations in river bends or bank cavities (review in Schiemer & Hein, 2007). At intermediate scales, large woody debris (LWD) has been recognised as important transient storage (review in Jackson et al. 2013). This coincides with river restoration practice, where LWD has become increasingly important to achieve the goals of the EU water framework directive (EU-WFD). One example is river Mulde, a tributary of Elbe in central Germany.

Hereby, the main research challenge lies in an appropriate structural parameterisation of LWD. It determines the induced flow and turbulence structure of the near and far wake and thus the storage efficiency. While fundamental research on wake flows focused on idealised cylindrical objects, which may hold for simpler configurations of LWD, we still lack a generalised concept for most LWD real-world cases. Our contribution gives an overview of real-world cases, including river Mulde, and reviews approaches to parameterise the geometric structure and wake properties of LWD with regard to transient storage.

Session **SP08**

River restoration using wood: Does the use of quantified and monetized ecosystem service information increase acceptability for the measures?

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Presenting author: Cedric M. Gapinski

As target 2 of the European Biodiversity Strategy 2020 shows, the concept of ecosystem services (ES) receives already great attention in science and politics. Numerous papers have been published on mapping and valuing of ES so far, but there is still a lack of knowledge on the integration of individual benefits and those for the public and private sector in planning practice. The same applies to explaining such benefits to stakeholders. It is assumed that policy makers prefer economic arguments to nature conservation, but systematic studies on the effects of ES information are missing. Furthermore, little is known about acceptability of economic ES arguments by the public. In this context we investigate, which types of ecosystem service information formats (ESIF) are understood and preferred by different stakeholders and the public. We also investigate whether the communication of selected ES changes in diverse formats could lead to a higher acceptance of nature conservation objectives.

Our research is embedded in a river restoration project at the Mulde river (Wilde Mulde", Dessau-Roßlau, Germany). In a first step, we concentrated on the broad public's acceptability for the measures implemented in the project. For this purpose, we conducted a nationwide survey (n =2100), including a discrete choice experiment (DCE), to investigate whether different ESIF influence the perception and acceptability of river wood introduction. In the DCE, three groups of participants were shown different variants of a river section with various amounts of river wood. Additionally, each group received information on ES of this river in a different format: ordinal, cardinal (quantified) or economic (monetized). The results show that all three ESIF, depending on the ES considered, are suitable for communicating benefits of river wood introduction. But the acceptance was by far highest in the group with ordinal information, the format commonly used in landscape planning. Differences in response behavior regarding different socio-demographic factors could also be observed. Here the age and frequency of river visits were the most important factors. In addition, experience with floods seems to increase sensitivity to both the potential benefits and dangers of river wood. This supports the experience gained in the Mulde project, according to which public relations work can be especially challenging in populated areas that have already been affected by heavy flooding."

Session **SP09**

Fish-eDNA sampling strategy in river: sampling effort and spatio-temporal representativeness

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Presenting author: Didier Pont

Environmental DNA (eDNA) is emerging as a very effective technique for studying fish biodiversity in rivers. The emergence of next generation sequencing platforms and the use of universal primers (e-DNA metabarcoding) make it possible to identify a complete fish community via a single analysis. Recent results show that not only the list of taxa can be obtained, but also the relative abundance of species. As with all new techniques, the sampling strategy and representativeness of the eDNA sample must be analysed prior to its use for the study of the fish biodiversity patterns and the development of eDNA based bioassessment method. The probability of detection of a species depends on several factors: the sampling location of the sample (in relation with the spatial heterogeneity of the sampled water body), the volume of water sampled (in one or more samples), the amount of sample analysed, the number of PCRs per sample, and the sensitivity of the markers. In addition, one of the main problems with the application of this new method to the river system is the downstream transport of eDNA. The previous results show that the detection distance of the e-DNA varies from a km to several tens of kilometres depending on the size of the river. Downstream eDNA transport simulations are presented to discuss the spatial and temporal representativeness of the results.

Session **SP09**

Use of DNA-metabarcoding for diatom monitoring: from proof of concept to routine use.

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Presenting author: Frédéric Rimet

DNA-metabarcoding of benthic diatoms has shown its potential for water quality assessment. We present here the proof of concept and several optimizations that enabled its comparability to microscope analyses: taxonomic resolution of DNA barcodes, efficiency of DNA extraction methods, completion of barcode reference database, and use of a correction factor to obtain taxa quantification similar to microscopy. These improvements make the DNA-metabarcoding approach an interesting alternative to microscopy for quality assessment of rivers from monitoring networks. We tested this innovative approach using the diatom rbcL barcode, at the scale of several river monitoring networks in France. The DNA-metabarcoding approach appeared to be a viable economic alternative to the morphological one for quickly processing a large number of samples. Molecular-based quality index values were highly correlated to morphological ones and congruent with the river quality status. Correlations between molecular and morphological based indices were improved by the completion of the reference database and the use of correction factors. Those results confirm the potential of DNA-metabarcoding for bioassessment, but also raised questions about the need of standardization and harmonization prior to its implementation into biomonitoring campaigns.

Session **SP09**

Using eDNA surveys to map distributions of non-native fishes in river basins

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Presenting author: Phil Davison

Environmental DNA (eDNA) has proved a useful tool to inform decisions and strategies for non-native fish management, both in still waters and increasingly in water courses. Such applications of eDNA surveying include detecting the presence of newly-arrived species, plotting the distribution of established non-native species, and assessing the success of eradication attempts. Water samples were collected from two river basins in southern England (River Test, Hampshire; River Ouse, Sussex) to assess the current distribution of three non-native fish species known previously to occur in these catchments: topmouth gudgeon Pseudorasbora parva (currently the subject of a national eradication programme), sunbleak Leucaspius delineatus, and pumpkinseed Lepomis gibbosus. A recently-developed nested PCR protocol was used to provide a high degree of sensitivity. Samples were collected at locations from headwater streams (with intensified sampling downstream of still waters likely to hold source populations) to the estuary of these two river catchments. The results corroborated recent knowledge of fish distributions gained from conventional survey methods. Pumpkinseed and sunbleak were both detected downstream of an angling venue known to contain both species, with sunbleak eDNA also at a few upstream locations, suggesting range expansion. The lack of detections of topmouth gudgeon in the River Test supports the idea that recent eradication attempts there have been successful.

Session **SP09**

Scenario and action plan for the deployment of genomic for water quality biomonitoring in France

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Presenting author: Philippe Blancher

The French-Swiss project SYNAQUA (INTERREG France-Switzerland 2017-2019) focuses on the development and validation of genomic tools for water quality biomonitoring based on diatoms and oligochaetes. As part of the work-package dedicated to stakeholders and public awareness and involvement, three participative seminars were organized in Lyon and Paris in early 2019. These seminars aimed to identify various feared and desired scenarios of genomic tools development in France (and to a lesser extent in Switzerland), then to build an ideal but realistic one, favouring a better biomonitoring. The outcome of the seminars included an action plan along six fields of action: the development, experimentation and normalisation of methods based on eDNA; the regulation and organisation of biomonitoring allowing a good implementation of these tools; the training and mobilisation of professionals; the awareness-building and involvement of policy and decisions makers; the awareness-building and involvement of civil society; the set-up of an implementation mechanism for the overall plan, insuring a steady and consistent progress.

The ideal scenario", based on a good complementarity between genomic and traditional methods, requires a strong collaboration between all the concerned professionals, especially between researchers and operators, as well as political will and funds to support the process of development. To secure such an involvement, it is necessary to demonstrate how these methods will improve the preservation and restauration of aquatic environments and the overall quality of life, with an optimized use of financial resources."

Session **SP09**

Fish diversity assessment in the headwaters of the Volga River using eDNA metabarcoding and species-specific qPCR

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Presenting author: Tamara Schenekar

The headwaters of the Volga River retain large reaches of lowland river characteristics with near pristine conditions providing a rare ecosystem to conserve in its own right, but also to serve as a reference study area for broader-scale biological assessments. An eDNA metabarcoding survey for ichthyofaunal diversity was carried out in the upper Volga catchment area, encompassing 48 samples across 11 sampling sites ranging from small tributary rivers to the main Volga river. Three barcode markers (16S and 12S rRNA, cytochrome b) were utilized for the genetic analysis. A total of 23 fish species were detected throughout all samples using the metabarcoding approach. For re-evaluation of their apparent absence, we applied species-specific TaqMan qPCRs using the same samples as for the metabarcoding effort for 1) catfish Silurus glanis, 2) European eel Anguilla anguilla and 3) Sterlet Acipenser ruthenus. Catfish and eel were detected in two and one location, respectively, using this single-species approach, whereas we got no detection signal for sterlet. Furthermore, after extension of the genetic reference database by 12 additional species, we could detect one additional fish (Cobitis sibirica/Cobitis melanoleuca) and one lamprey (Ukrainian brook lamprey Eudontomyzon mariae) species that was not detected in the metabarcoding effort. In silico-analysis of the metabarcoding primer efficiencies revealed considerable variability among primer pairs and among target species that could lead to potential false-negatives in metabarcoding studies if not properly compensated for.

Session **SP10**

Ecological status and morphological impairment: the evaluation of invertebrate response in rivers affected by bank and channel reinforcement and resectioning

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Presenting author: Stefania Erba

Hydromorphological pressures pervasively affect riverine environments worldwide. From a management perspective there is the need for effective and practical tools able to quantify the effect of morphological impairment in a biologically meaningful way, remarkably in relation to the planning of specific measures to achieve environmental goals set out by the Water Framework Directive (EC/2000/60). Also, to ascertain the relationship between biotic community assemblages and morphological alteration, it is crucial to define ecological potential in heavily modified rivers, at present one of the subjects still to be fully implemented within the WFD. Notwithstanding the interest in developing specific assessment tools based on invertebrates to detect hydromorphological impact, response of invertebrate assemblages to hydromorphological alteration is often considered weak or unclear. Following this context, we aimed at evidencing invertebrate response to selected morphological impairment descriptors in order to verify metric sensitivity to such alteration. The study considered Italian river sites in different stream types and covering a morphological alteration gradient. Effects of morphological impairment were investigated with emphasis to the STAR_ICMi index, which is routinely used for ecological status assessment in Italy. Morphological impairment was quantified by means of Habitat Modification Score (HMS) calculated from the application of the CARAVAGGIO (a River Habitat Survey based method). Spearman rank correlation was applied to provide information about the relationship between biological metrics and morphological alteration. Spearman results evidenced strong correlations between biological metrics and morphological impairment. To quantify the response of the STAR_ICMi to the presence of artificial structures/morphological impairment (HMS), linear mixed-effects models (LMM) were adopted. Most STAR_ICMi variation was assigned to HMS gradient as expressed through LMM. We were able to verify biological metrics sensitivity to morphological alteration. We were also able to affirm that information resumed with RHS-like approaches (namely here the CARAVAGGIO method) is meaningful for the biological community and simple tools (i.e. HMS) exist to support the interpretation of ecological status in rivers. We also briefly present and discuss which habitat features were relevant for benthic invertebrates in a heavily modified river context. We investigated via non-metric multidimensional scaling invertebrate communities gradients recognizing type and quantity of measures significant for benthic invertebrates and applicable in lowland heavily modified water bodies.

Session **SP10**

Assessing the impact of hydropeaking utilizing 2D-hydraulic models

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Presenting author: Ana Juarez

Energy transition is a fundamental step towards sustainability. In this frame, hydropower is expected to play a key role to balance the load of other renewable resources. Hydropeaking refers to releases of water retained in storage reservoirs to generate electricity in response to variations in market demand, for instance because of intermittent electricity generation from solar and wind energy. The fluctuations caused by hydropeaking usually have a high impact on the downstream natural morphology and biological conditions, particularly related to stranding of fish and other species. Modelling and quantification of ecological effect of hydropeaking are a main issue in for optimization and decision making in order to select appropriate mitigation methods.

This research is part of the H2020 project HydroFlex. The HydroFlex project aims to develop new technology permitting highly flexible operation of hydropower stations. Flexibility of operation here means large ramping rates, frequent start-stops and possibilities to provide a large range of system services. All this while observing strict environmental and social regulations and being economically competitive compared to alternative solutions. The present work develops a calibrated two-dimensional hydraulic model in Nidelva, Norway, for evaluation of hydropeaking operation.

The work in this report is carried out on the 9 km of the river from the confluence of the lowermost hydroelectric powerplant outlets and the bypass reach (Nedre Leirfoss) to the mouth of the river in the Trondheimsfjord. The river topography was collected as a compilation of data from previous projects and original surveys. Most of the bathymetric data were collected using Acoustic Doppler Current Profilers (ADCP) from a variety of platforms including motor boat and kayak.

The program HEC-RAS 5.0.7 was used to create the 2D hydraulic model. The model calibration was performed by altering the manning roughness coefficient. The results were compared against 42 RTK-GPS measurements and aerial pictures. An additional 1D model was developed and calibrated to model fluctuating temperatures.

The results show that the simulation are dependent on the manning number calibration. The error on water surface elevation modeled and measured was reduce to 6 cm after calibration. Additionally, areal picture show similar patterns in the river channel. Therefore, we can conclude that this model is well calibrated and it will be a significant tool to evaluate the flow fluctuation and mitigation measures suggested for present and future scenarios. The results will help to evaluate drying areas at different flows and dewatering speed, which can identify critical areas on the river. These results will be related with previous studies on fish stranding and mortality, which have shown that the hydropeaking affects the trout population and suggest mitigation measures.

Session **SP10**

Assessing the role of weirs and riparian cover on river longitudinal temperature profiles using airborne TIR in a lowland agricultural catchment

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Presenting author: Baptiste Marteau

The study of river temperature has gained interest over the last few years, given the pace at which global change is occurring. Scientific advancement has made the study of river-scale processes possible, especially with the improvement of remote sensing techniques and data processing. Airborne InfraRed Thermal sensing (TIR) is an example of such improvement, and it is now considered as a common tool available for temperature studies (see recent reviews). However, most of these studies usually focused on rivers showing little human alteration, with a particular interest on groundwater-surface water interactions. Lowland streams are scarcely considered when it comes to studying temperature behaviour, despite their widespread occurrence, their relatively high degree of disturbance and the risks that they face in the light of temperature rising following climate change. Indeed, some of these streams are already subject to high summer maximum temperature. Conditions are likely to worsen in the future, putting all compartments of biota at risk, and this is also not without consequences regarding the contribution of freshwater bodies to the release of greenhouse gases.

With this project, we aimed at testing the applicability of airborne TIR on a large scale to study the thermal behaviour of a set of lowland, slow-flowing stream reaches draining agricultural catchments. The main purpose of the work was to understand the role of different environmental factors on driving river temperature during the warmest days of the year. Stream rectification, clear-cutting of riparian trees and existing weirs are likely to influence the longitudinal temperature profile of such streams. By choosing rivers with no or limited groundwater inputs, we were able to quantify the relative role of each of the three tested factors and identify stream sections showing critically high maximum temperature over the summer. In addition, we combined the results of these airborne surveys with high resolution land-cover data to identify sections of streams showing high risks of reaching critically high summer temperature at a regional network scale. Identification of the risks in relation with the relative contribution of the different factors is key to process-based river management. This type of output is valuable to river basin managers and decision makers as it can be used to implement targeted restoration initiatives or remediation actions in areas where these have higher chances of being effective.

Session **SP10**

Assessment of potential thermal refuges based on UAV thermal imagery: a case study of the river Ovens, Australia

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The forecast of warmer weather, reduced precipitation and stream flow under climate change, makes freshwater ecosystems particularly vulnerable. Aquatic organisms such fish are able to seek thermal refuge in areas of water which are persistently cooler than the surrounding river and provide local-scale shelters from warmer waters in the summer months. These cold-water refugia have been identified as critical conservation areas to support keystone species persistence. Therefore, understanding their dynamics is key to inform river management strategies. The formation of cold-water refugia has been extensively described in previous studies and associated with identifiable physical geomorphic features and adjacent landscape. This study aims to investigate the relationship between thermal heterogeneity and physical morphological drivers in promoting the occurrence of cold-water refugia in riverine systems.

Using a case study in the river Ovens in Australia, the combination of UAV-based Thermal Infra Red (TIR) and photo (RGB) surveys were used to identify the spatial distribution of cold-water refugia and their relationship with physical geomorphic features. We carried out extensive field surveys in summer 2017, during extreme low flows, covering 50 km of the Ovens River. We aimed to address three objectives: (i) to identify spatial patters of thermal heterogeneity, (ii) to assess the relationship between cooler water spots (CWS) and geomorphological attributes, and (iii) to assess the extent of groundwater influence in such areas.

Preliminary outcomes identified broad scale patterns driven by channel patterns, riparian vegetation strips and land-use. Groundwater-driven CWS were most abundant but tributary confluences resulted in highest temperature differences when compared to the average temperature in the main stream. This study provides a combined high-resolution analysis of spatial patterns in stream temperature, carried out at a large river scale and it highlights the need for better understanding spatial patterns of stream temperature and their relationship to fluvial geomorphic features. The findings are significant with regard to the management and mitigation of climate change, with the aim of preserving freshwater biota.

Session **SP10**

Coupling thermal-infrared remote sensing and hydrological modelling to study surface-subsurface water exchanges of a restored side channel of the Rhine River

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Presenting author: Laurent Schmitt

Ecohydrological processes are critical in functional river restoration, notably because groundwater exfiltration may enhance adaptation of aquatic and riverine ecosystems to climate change. We have investigated the potential of airborne thermal-infrared remote sensing to map surface-subsurface water exchanges and to identify their driving factors in relatively small channels (maximum width of 20 m), which are rarely surveyed by this type of techniques. Additionally, an integrated hydrological model has been applied to better understand surface - subsurface water exchanges. The model was calibrated using piezometric data. Simulated patterns of water exfiltration have been checked against the information derived from thermal infrared (TIR) imaging. In the framework of a LIFE+ European restoration program, we focused our attention on an anastomosing channel located in an artificial Island of the Upper Rhine River (Rohrschollen Island). A new channel has been excavated from the floodplain to reconnect an older channel to the Rhine in its upstream part. These hydraulic works led to an increased inflow from the Rhine, with a maximum discharge of 80 m3.s-1. During inflow events, about half of the Rohrschollen Island is flooded because the bankfull discharge of the new channel is only 20 m3.s-1. This induces groundwater feeding, and triggers exfiltration by the channel network, during low flows. Here we propose an original data processing chain to (i) georeference TIR and visible datasets in a GIS, (ii) detect and correct data errors, and (iii) identify and locate thermal anomalies attributed to groundwater inputs and hyporheic upwellings. Infrared observations, which have been compared to morpho-sedimentary data, show that groundwater upwelling in the new channel is controlled by riffle-pool sequences and bars. This channel is characterized by important bedload transport and morphodynamics, forming numerous riffles and bars. In the old channel, where riffle-pool sequences no longer exist due to impacts of engineering works and insufficient morphodynamic effects of the restoration, thermal anomalies appeared to be less pronounced. Groundwater inputs are controlled by former gravel bars outcropping on the banks, as well as by local thinning of the low-permeability clogging layer on the channel bed. At the scale of the whole Rohrschollen Island, the model shows that a flooding event of 1 day induces an increase of exfiltrating areas over more than 1.5 months. This significantly strengthens the adaptation of ecosystems to climate change, especially since the (snow-melt driven) Rhine floods occur at the beginning of summer.

Session **SP10**

Modification of regional river water-air temperature relationships by landscape and hydrological controls

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Presenting author: Aurélien Beaufort

The determination of the main controlling factors of the stream temperature (Tw) variability is important to target streams vulnerable to global change. The thermal sensitivity (TS), based on relationship between air temperature (Ta) and Tw, represents the relative sensitivity of Tw of a given stream to environmental change and can be used for quantifying the streams sensitivity to future climate change. This study aims at providing a comparison of TS for a wide range of temperate streams located in a regional catchment (110 000 km^2) based on 4 year-hourly data (2008-2012). To cluster stations sharing similar thermal dynamics and to identify environmental key drivers that modify TS at the regional scale, two successive classifications were carried out: (i) a first based on Ta-Tw relationship metrics including TS; (ii) a second to establish a link between a selection of environmental variables and clusters of stations. On the basis of weekly Ta-Tw relationships, four clusters were identified with significantly contrasted annual Tw in terms of magnitude and amplitudes in comparison with Ta. The second classification succeed to link each clusters to different environmental controlling factors. Streams influenced by both groundwater inflows and shading are the most moderated with the lowest TS and an annual amplitude of Tw twice less than the annual amplitude of Ta. Inversely, stations located on large streams with a high distance from source and slightly or not influence by groundwater inflows or shading showed the highest TS and are very climate sensitive. The results of this analysis can be used to determine the climate sensitivity of different streams and their vulnerability of to the effects of climate change in order to guide stakeholders for thermal moderation of streams.

Session **SP10**

Simulating water temperature at a regional scale to study the spatial structuration of aquatic communities (The Case of Loire Catchment)

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Presenting author: Hanieh Seyedhashemi

In streams, thermal regimes determine water quality and are critical to the health of aquatic ecosystems. Impact of climate change on the distribution of different aquatic species at large scale have been classically assessed using air temperature as a proxy for stream temperature, mainly due to the lack of extensively recorded water temperature data. However, air temperature is not the only factor that influences thermal regimes of streams. The role of other determinants such as riparian cover, geomorphology and groundwater inputs (and their interaction with air temperature) in shaping thermal regimes has to be investigated as well.

The present study has employed a coupled semi-distributed hydrological model (EROS) and a physically-based thermal model, T-NET (Temperature-NETwork), to simulate daily discharge and water temperature at the scale of the Loire basin in France (10^5 km^2). The performance of this model was assessed at about 250 stations located in streams of different sizes (from Strahler order 1 to 8) by comparing different metrics of simulated stream thermal regime (such as magnitude, frequency, duration and timing of changes in water temperature) with observed data from 2009 to 2018.

We also studied the influence of spatial variability of discharge and water temperature on the spatial successions of aquatic communities (i.e. fish and benthic invertebrates) at large scale (the Loire basin). For this, we related the structure and composition of aquatic communities to the inter-annual mean of different environmental metrics computed on modelled data from T-NET over the period 1990-2010. These metrics, such as mean values, 90th and 10th percentiles, were used together to characterized local thermal and hydrological regimes and made it possible to demonstrate their deep influence on the spatial structuration of aquatic communities. This study highlights that finer environmental descriptors improved our understanding of biodiversity patterns at large scale.

Session **SP10**

Not cool but less warm: An empirical study on the effects of woody riparian vegetation on water temperature

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Presenting author: Jochem Kail

Woody riparian vegetation along rivers provides shading and reduces direct shortwave radiation input, the main driver of water temperature in summer. There are several empirical studies but most compare water temperature in fully forested (100% shading) to non-forested or harvested (0% shading) river reaches. The few studies investigating the effect of different shade levels consider rather large riparian buffers beyond of what realistically can be restored in densely populated regions like Central Europe. In this study, the relationship between the shade level (%wood) in rather narrow (10m) as well as wide (30m) riparian buffers and daily maximum water temperature of heating-event days was investigated. Water temperature data were measured over a 1-year period in 30 sections with different shade levels located in seven small Central European lowland streams. Results indicated that (i) water temperature steadily increased along rather unshaded sections but reaches a new lower equilibrium temperature after a rather short adaptation length of about 0.4 km in shaded sections (ii) woody vegetation directly adjacent to the streams (10m buffer) had a larger effect on water temperature compared to a 30m buffer, indicating that single lines of trees were most important in these small streams; (iii) the change in water temperature along the sections (DeltaTmax) was related best to the change in woody vegetation cover compared to upstream (Delta%wood), indicating that the potential for heating and cooling depends on the upstream conditions; (iv) the effect of Delta%wood on DeltaTmax was highest in early summer when minimum temperature at night was still low compared to daily Tmax, indicating that the minimum water temperature at night might be considered a kind of "maximum shading" effect. This maximum potential for cooling by woody riparian vegetation of water getting heated during the day by direct solar radiation decreases over the summer period from May to August. Based on this study and results from literature, a conceptual and related Bayesian Belief Model for the effect of woody riparian vegetation on water temperature was developed.

Session **SP10**

Local river water temperature dynamics of an Alpine river under hydropeaking conditions: a modelling approach

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Presenting author: Davide Vanzo

River water temperature is a fundamental physical property of flowing waters and it plays a key role in several ecological processes that occur within river corridors. Among others, water temperature influences the rate of biogeochemical processes and the behavior of macroinvertebrates, and it affects different fish lifestages. The river water temperature is the result of multiple heat exchanges that depend on the hydraulic regime, atmospheric conditions, riparian vegetation, hyporheic and groundwater exchanges, and river morphology. Hydropower production might affect the natural thermal regime at different spatial and temporal scales. In particular, hydropower generated sub-daily flow fluctuations (hydropeaking) can significantly alter the river water temperature (thermopeaking). However, little is known about the response of local thermal heterogeneity to hydropower stress. Understanding and modelling the water temperature variability at local scale under hydropeaking conditions, i.e. the presence and persistence of thermal niches and refugia, can positively contribute to a better characterization of physical habitat dynamics. Moreover, the development of modelling strategies to quantify the thermal dynamics in hydropeaking rivers will allow to infer future trends under changing hydropower and climate scenarios.

The main goal of this study is to model and quantify the thermal dynamics in a local widening of Moesa River (Canton of Grisons, CH), subjected to hydropeaking. In doing so, we integrate in-situ (thermal sensors) and remotely sensed (TIR imagery) data with two-dimensional numerical modelling. First results provide insights on the magnitude and seasonality of both hydraulic connectivity and thermal alterations.

Session **SP10**

Hydropower thermal effects on the early life stages of brown trout

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Presenting author: Kunio Takatsu

Large hydropower plants are known to cause downstream effects on a river's thermal regime. In general, hydropower plants cause water temperatures to decrease during summer and increase during winter. Given that almost all riverine organisms are ectothermic, it's highly probable that river ecosystems are sensitive to the thermal effects of hydropower. This considered, our knowledge of how hydropower plants may thermally affect river communities is still limited. In this study, we experimentally examined how hydropower thermal alternations affect the early life stages of brown trout: a representative keystone predator in river communities.

Brown trout provide a unique opportunity to examine the effects of hydropower thermal alternations, in both an ecological and evolutionary time scale. They exhibit a wide altitudinal distribution, which may result in local thermal adaptation. Thus, by examining the link between local temperature and early life history traits in the trout, we can also examine the possible evolutionary effects of temperature. In addition, since local thermal adaptation may be acquired over thousands of years, each locally adapted population may respond differently to an altered temperature regime. Therefore, by using locally adapted populations, we can identify which populations are most vulnerable to hydropower thermal effects.

In this experiment, we collected trout eggs from 15 wild populations along a wide altitudinal range (300-2000 m). Eggs were then divided between two temperature treatments (i.e., with- and without- hydropower temperature treatment) and many traits were measured throughout the early developmental stages. We focused on the early life stages, since they are more vulnerable to temperature fluctuations, due in part to the allometric relationship between volume and surface area, as well as these life stages generally being less mobile and more fragile.

We found significant effects of both the temperature treatment and the local river temperature on several of the measured traits. While brown trout lay their eggs in early winter and hatch in early spring, an increased temperature during the period (i.e., hydropower thermal alternations) enhanced the rate of trout development. In addition, there was a positive relationship between temperature and the metabolic rate of hatchlings. It's probable that this increased metabolic rate is linked to the faster developmental rate. In contrast to the temperature treatment effects, trout that originated from colder rivers had higher metabolic rates and developed faster than trout from warmer rivers, regardless of our temperature treatment. Because developmental rate is reduced in relatively colder environments, it may be that embryos with a higher developmental rate are selected for. The contrasting effects of our temperature treatment and local river temperature suggests a complexity in predicting ecological and evolutionary consequences of hydropower thermal effects.

Session **SP11**

Requiem for a Migratory Dream - Functional connectivity impairment of diadromous fish species historical distribution throughout the 20th century

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Presenting author: Gonçalo Duarte

Rivers are organized as dendritic networks, and river flow is the ruling force driving multiple functions and components of freshwater systems, meaning that the longitudinal dimension of connectivity is the most pertinent for the ecological processes involving fish species. For diadromous fish species and their life-cycle migratory requirements, this is even more noticeable. In this work, we aim to assess the functional connectivity impairment occurring in Europe, from dam construction along the twentieth century, using the historical distribution of 14 diadromous fish species and one species complex. Historical data was obtained by consulting and combining multiple European databases and sources. Afterwards, the historical data was used in a framework that allows managing the disparity of geographical extent and distinct scales of sources and databases, providing a consistent output dataset of historical occurrence at the segment scale. Information about European large dams was obtained via the GranD database and integrated into the Catchment Characterisation and Modelling- River and Catchment database v2.1 (CCM2). Results show that, historically, longitudinal connectivity impairment increased severely in the second half of the 20th century, and by the beginning of the 21st-century functional connectivity impairment existed for all species analysed. Over 47% of large basins showed potential distribution losses and in some cases, a given species may have had more than 60% of their river length distribution impaired. The construction of mainstem dams tends to be paired with the decline of several diadromous fish species stocks and occurrence, indicating that large dams may have contributed decisively to the European decline of diadromous fish species.

Session **SP11**

What has remained of the former Alpine rivers?

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Presenting author: Severin Hohensinner

Numerous case studies on Alpine running waters have been published in recent decades. To date, surprisingly, no survey on the diverse morphological characters of the waterbodies in the whole European Alps prior to industrialization has been elaborated. The present paper aims to fill this gap in knowledge. The historical channel patterns of the 143 largest Alpine rivers with a catchment area of more than 500 km² (total length almost 12,000 km) were reconstructed based on numerous historical maps from 1780 to 1850 and supplementary sources. Analogous, the current channel patterns that reflect manifold human interferences, such as channelization, damming or water abstraction, were identified. The resulting GIS dataset enables a first Alpine-wide overview of historical and current fluvial forms.

Around 1820 a third of the investigated rivers can be classified as multiple-bed rivers including various morphological subtypes, such as bar-braided, island-braided, anabranching and anastomosing rivers. Oscillating river sections that shifted between the valley sides were surprisingly frequent in the Alps, covering 28 % of the total analyzed river length. About a quarter of the rivers showed straight channels. Sinuous and even more meandering waterbodies were much rarer in the Alps, making up 7 %, respectively 5 %.

What has remained of the former Alpine rivers? Until today, about 510 km, 4.3 % of their historical extent, have disappeared due to channel straightening. Multiple-bed (braided) stretches, 34 % of the river courses two hundred years ago, are currently a mere 15 %. Expectedly, straight bedrock-confined rivers were least frequently altered by human interference. The percentage loss of previous course length was greatest for meandering waters: They were reduced by as much as 80 %. On the other side, today, new man-made forms of river courses that did not originally exist at all are widespread in the Alps: arch-shaped regulated, linear straightened and dammed-up river stretches. While the first two types of channel patterns cover 17 % and, respectively, 16 %, dammed-up sections amount to 12 % of the total river length. Moreover, waterbodies that are currently still braided or oscillating are in fact hydrologically regulated and/or stabilized. Although their general morphological character has remained, the lateral extension of the river systems has been limited significantly.

Session **SP11**

The Industrialization of River Ecosystem Services - Danube fish and Vienna's fish supply 1880 - 1914

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Presenting author: Gertrud Haidvogl

For centuries, fish stocks have been altered by various river uses. Industrialization was in the 19th century an important turning point in this development, both in terms of the nature and intensity of the interventions. The diverse ecosystem services of the pre-industrial era - among others the provision of fish - changed with the possibilities fossil energy resources offered. Steamships triggered new demands on the design of watercourses. In connection with changed flood protection practices, which relied on protection dikes, this led to the systematic regulation of many large and medium-sized rivers. Comprehensive habitat changes and reduced fish stocks were an anticipated side effect. Professional and artisanal fishing as well as fish supply from local waters came increasingly under pressure. However, as new and faster means of transport enabled e.g. to transport marine fish over long distances securing regional and local ecosystem services became less important. In their efforts to safeguard fish stocks, professional and sports fishing associations could also benefit from the progress of industrialization. Fish farming was promoted, steamboats and railways made it possible to import non-native fish species for stocking.

Based on historical data, this development can be analyzed for the Austrian and especially for the Viennese Danube in conjunction with Viennese fish supply. Historical maps as well as annual and partly even monthly time series of the urban fish market from 1880-1914 allow depicting the changes in the Danube fish fauna. The development of the fish fauna of the Austrian Danube between the systematic regulation in Vienna from 1870 to 1875 and the 1910s can be investigated against the background of habitat change through regulation and fishery management practices. Written historical documents on urban food provision show the opportunities Vienna has chosen to supply a fast growing population with fish. Marine fish, caught now with steam trawlers, cooled with newly developed machinery and imported via railways, compensated for the lack of local resources.

By combining a variety of sources, the paper provides an interdisciplinary investigation of the relationship between the development of individual fish species, river engineering measures, fishing practices and the industrialization and urbanization of Vienna.

Session **SP11**

Model based reconstruction of the succession dynamics of a large river floodplain

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Most large rivers in Europe and North America suffered flow regulations and channelization in the 19th and 20th century. To study the effects of the altered site conditions on the development of floodplain vegetation and create a benchmark map for their restoration we calibrated and applied a dynamic floodplain vegetation model that accounts for the processes recruitment as well as morphodynamic disturbance and physiologic stress on vegetation to reconstruct the succession dynamics of the floodplain vegetation of a segment of the Rhine river from shortly after it was channelized (1872) until today (2016). The model calibration was based on historical maps and hydrologic data.

Our simulation demonstrated a steady, one-way progression of the vegetation communities toward mature phases without regression to younger stages. It was possible to attribute this development to a lack of morphodynamic disturbances strong enough to reset succession and to identify physiological stress caused by long inundation periods as the most relevant controlling factor of succession. The resulting vegetation distribution (2016) can be considered an estimation of the potential natural vegetation (PNV) under altered site conditions. It showed good agreement with an expert-based PNV map for the same year. In comparison to the traditional method for creating benchmark maps for floodplain restoration our dynamic modeling approach has the strength to allow for analyses of different points in time, for projections under different environmental scenarios and to be reproducible.

Session **SP11**

Defining hydrogeomorphological changes related to urbanization: the making of a typology of sections from peri-urban watercourses in Paris' region.

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Presenting author: Lucile De Milleville

Only few researches have been done on Parisian peri-urban rivers, still they constitute 80% of the fluvial system of the region. These rivers are small and characterized by low energy and morphological adjustment on the long run. One of their foremost particularities is not to be state-owned, another one is to belong to different types of landscape. The two main pressures that affect peri-urban areas are: the intensification of agricultural practices and urban sprawl. Studies show that the latter comes with the development of dense rainwater networks and impermeable surfaces, which increases the risk of runoff, despite the recent policies trying to overcome their extension. The result is a sharp hydrogeomorphological degradation through an increase of agricultural and urban runoff. On small rivers, this implies bankfull width and depth larger than those of the regional reference models (CarHyCE), i.e. very high banks (1.50 to 5 m), sometimes steep, sometimes bordered with benches (subactual aggradation). Riverbeds are therefore often strongly incised, with limited bedloads and geometric dimensions generally disproportionate compared to the reference systems.

All these observations motivated a modeling of the longitudinal and transversal trajectory of three small peri-urban rivers chosen according to an urbanization gradient: the Biberonne River (13.5 km - 56,91 km²) mostly agricultural, the Morbras River (19 km - 48,20 km²) mostly urban and the Mérantaise River (13.5 km - 32,27 km²) in a mid-way context. The method applied is a survey of riffles and pools, systematic measurements of cross sections (bankfull width and depth and length of the riffle) on each identified riffle.

Our results show a wide variety of hydromorphological sections enabling to propose a typology, based on the degree of artificialization of the system studied. Such typology will allow a better understanding of the relations between hydrogeomorphological alteration and biological potential and will be used to plan restoration projects. In our case, five sections types have been defined.

Session **SP11**

Artificial fish shelters: a solution for urban rivers?

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Presenting author: Emilie Schoofs

"River bed and banks artificialization due to human activities led to microhabitats loss and/or simplification. This includes a loss of fish shelters which are essential structures allowing fish population to be protected from biotic and abiotic disturbances such as predation or flooding.

Our goals were to develop artificial shelters as fish habitat improvement tool in highly urbanized rivers and to maintain or create ecological continuity. First, natural refuges of two New-Zealand rivers with none or little human pressure have been studied to determine natural shelter features preferred by fish. Then, their use by fish and efficiency were compared to the artificial structures we built. Features of around one hundred natural shelters were characterized. Fish abundance and diversity were assessed by electric fishing. Statistical analyses helped to evaluate shelter efficiency and highlight tendencies about natural shelter features correlated with highest fish density. In natural environment most of river banks linear is composed of diversified structures which can be used by fish as refuges. Our artificial shelters and the natural shelters made of woody debris seem to be the more appreciated by fish. Species diversity has not been shown to vary between shelter nature. Natural structures dimensions or water velocity appears to be important features sought or avoided by fish when hiding. Based on these results, our artificial fish shelters have been set in Europeannrivers. Shelter occupancy was about sixty percent and ten different species were observed using underwater video footages, including threatened species such as the European eel (Anguilla anguilla) or bullhead (Cottus sp.). In highly constrained urban rivers, artificial shelters seem to be a seductive alternative to protect fish fauna against disturbances. Artificial shelters can also be a tool for immediate mitigation of human triggered disturbances like with hydropower schemes."

Session **SP12**

Historical changes in the ecological continuity of the Seine River for diadromous and freshwater fish: focus on physical and chemical discontinuities since the middle of the 18th century

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Presenting author: Céline Le Pichon

Before human intervention, the native fish fauna of the Seine River basin was likely to include 23 strictly freshwater species and 11 diadromous species. The Seine River was also a migration route for these species to access growth or spawning habitats. The fish community of the Seine River, as in several other European Rivers, has evolved during centuries but has greatly suffered from overfishing, pollution, habitat destruction and disruption of their migration routes since the 18th century, followed by a dramatic decline of diadromous migratory fish. For nearly five decades now, thanks to regulation, planning and management efforts, water quality has improved and more recently, several fish passages have been built on the Seine River and its main tributaries. The fish diversity has improved and some salmonids and shads individuals are returning up to 450 km from the sea. The CONSACRE project Ecological continuity of the Seine River and interest of stakeholders in its restoration" (2018-2021) aims to propose avenues of action to strengthen the sustainable recovery of migratory fish populations in the Seine Normandy Basin, which are included in numerous regional and national planning documents. One aspect focuses on understanding the historical evolution of the ecological continuity, with regard to major periods of fish species evolution, in order to propose concrete measures compatible with global change. Using historical written sources of multiple types (river engineering projects, navigation maps, paper-based database on oxygen and temperature, etc...), we conducted an historical analysis of physical and chemical discontinuities in the Seine River since 1750, from the sea to Paris. The technical modifications of the navigation dams and locks and the construction of fish passes have been documented in order to evaluate their potential impact on runs of several migratory fish species (salmon, shads, barbel...). Similarly, the evolution of oxygen availability and temperature is considered for the needs of fish migration. These data are integrated in a GIS-based database to calculate cumulative functional distances from the sea to upstream targets, integrating distance, costs and risk of travelling. This spatial analysis provides knowledge of the combined effects of physical and chemical barriers for five large periods and results will be confronted with fish species historical distribution."

Session **SP12**

The Danube WILDislands Ecological Corridor - Protection, Management and Restoration

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Presenting author: G. Frank

The Danube is a hub of biodiversity and an ecological corridor of outstanding relevance for Europe. Its large number of Natura 2000 sites and protected areas impressively shows Europe?s commitment to preserve this natural heritage. Rivers form ecological networks and often build the backbone for bio-corridors. This pertains to the Danube in particular, due to its outstanding role as a link between more bio-geographic regions than any other corridor in Europe.

Islands are flagship habitats in vital river ecosystems. They showcase the dynamics of river morphological processes, like the re-allocation of sediments. Also, islands have an outstanding role for characteristic indicator species (e.g. over 80% of Little-ringed Plovers breed on islands).

Within the DANUBEparksCONNECTED project, funded by the Interreg Danube Transnational Programme, the first inventory of all Danube islands was established: over 900 islands form the Danube Wild Island Habitat Corridor, covering a total area of over 138,000 hectares. The highest number of islands can be found in Hungary (254); Romania hosts the largest area of islands with around 76,000 hectares.

After a first definition and characterization (size, habitats, origin, hydro-morphology, human impact), all islands were classified in their natural character: 147 islands (16%) were attributed to category A (pristine islands representing real river wilderness); category B refers to islands with high naturalness but some human alterations (238 islands, 26%); category C refers to all other islands. The results are presented at the interactive online tool wildisland.danubeparks.org

Based on this Danube-wide inventory, DANUBEPARKS - The Danube River Network of Protected Areas launched the WILDisland initiative. The vision of WILDisland is to maintain and restore ecological connectivity and preserve the riverine wilderness in the heart of Europe. The character of these islands benefits from the Danube river dynamics and its partly still intact sediment regime. Furthermore, the WILDisland campaign promotes and demonstrates good practice for cross-sector and cross-border cooperation.

For further developing and strengthening the coherence of the Natura 2000 Network, the EU Nature and Biodiversity Directors recognised the WILDislands as an EU model for Green and Blue Infrastructure. Facing their responsibility for this joint natural heritage, the DANUBEPARKS Directors committed themselves to jointly work for the conservation of the WILDislands. In some countries, commitments for non-intervention management were signed on political level for WILDislands. Several pilot restoration projects were already executed.

Most management actions require a cross-sectoral approach with the waterway and forestry sectors. A Danube-wide follow-up LIFE+ project was submitted by DANUBEPARKS to bring together the different stakeholders and to further strengthen the Danube Wild Island Habitat Corridor.

Session **SP12**

Modelling of potential sturgeon habitats in the Danube river and its tributaries

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Presenting author: Maroš Kubala

Out of five sturgeon species, there is only one sturgeon species left in the Middle and Upper Danube being sterlet (Acipenser ruthenus, Linnaeus 1758). All sturgeons are generally characterised by complex development cycle that involves the use of multiple specific habitats within the watercourse. These habitats can be roughly described as feeding, wintering and spawning grounds, and their availability is considered key for sturgeons to complete their life cycle. Degradation and decline of these habitats are often considered as one of the major causes for the decline in sturgeon populations, alongside with construction of migration barriers, overfishing and poaching. Despite this fact, the availability and carrying capacity of such habitats were not precisely documented before. In recent years, the consideration of rivers as migration bio-corridors is broadly increasing. This involves multiple studies addressing either removal of barriers or construction of complex fish passages to overcome them. With the connectivity restoration rising, it is necessary to identify and monitor whether there are potential habitats in the disconnected parts of the Danube and its tributaries. This task can be accomplished by combining historical records with modern techniques. To identify the potential occurrence of such habitats we can use conventional navigation maps available with the combination of the autecology of given species and historical records of occurrence. However, to confirm these habitats there is a need to incorporate a precise position telemetry and tracking systems, such as acoustic or radio telemetry through different times of the year (e.g. spawning period, wintering period). Identified sites can be further documented using a high precision side-scanning sonar units and velocimeters to gain valuable information about their morphology, depth and water velocity. However, the tagging process is unavailable in some parts of the Danube and its tributaries due to sturgeons being locally extinct. Therefore, identification of habitats can be subsequently facilitated using software to identify a different variety of RGB colour spectrum from satellite pictures. This could be of big help for sections where there are no sturgeon populations left to discover their reintroduction potential. To this date, such software (e.g. Natura_SAT) is still under development and outputs need to be further calibrated using all data available for confirmed habitats extrapolated from other studies on different sturgeon species.

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Session **SP12**

Reconnecting potential of the river sections with the historical occurrence of sturgeons in Slovakia

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Presenting author: Ladislav Pekárik

Free flowing parts of the rivers, which are crucial for the migratory fish species, are increasingly rare worldwide. Construction of migration obstacles has led to a decline in fish stocks, with some of these species are facing extinction. Sturgeons, generally characterized by a complex life cycle that involves the use of multiple specific habitats, are considered as an umbrella species indicating the quality of ecological corridors. At present, the Danube and its Slovak tributaries are fragmented by several barriers that prevent fish migration. Facilities providing fish migrations are still projected without real prioritization with regard to migratory fish there. The aim of this study is to evaluate the potential of existing barriers in Slovak rivers in regards to fish migration with the historical occurrence of sturgeons, especially the sterlet. The first most important barrier is the Gab?íkovo Dam, which consists of three dams and a disconnected sidearm system. The area of its sidearm system is also known as the historical spawning area of some sturgeons. The Little Danube, which is the last functional, 128 km long sidearm of the Danube River in Slovakia, is separated by three barriers. The river Váh, the largest Slovak tributary of the Danube, historically provided suitable habitats for sturgeons almost up to 150 km upstream in the past, although the highest proven record of the sterlet is up to 340 km upstream. Two large dams are now situated at 60 km and 112 km, and further upstream, the river is derived to a derivation channel, creating a cascade of derivative channels used for energy purposes. Nevertheless, the old channel still provides suitable conditions for at least other key species such as the barbel, nase, vimbra bream and cactus roach. There are also historical sturgeon records from the Morava River. Two other larger tributaries, such as Ipe? and Hron, sturgeons have been found exceptionally in the lower sections, although the Hron River is important for the nase, barbel and vimbra bream. In the eastern part of Slovakia, sturgeons were found in the Tisa River, where the Slovak section is only 7 km long and in the Latorica and Bodrog rivers, which are connected with Tisa River. These lowland streams are also suitable for cactus roach, but barbel, nase and vimbra bream are distributed more upstream in rivers stretch that are often isolated by several barriers preventing fish migration. For sturgeons themselves, it is important to restore the connectivity at the Danube River and at the Little Danube. For cactus roach, the Vah River 150 km would be interesting, while for other migratory fish species, facilitation of their migrations over other barriers on the rivers with the historic sturgeon occurrence is needed.

Session **SP12**

From Source to Sea – Comparing Driver-Pressure-State Relations in the Upper, Middle, and Lower Danube

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Affiliation(s): University of Natural Resources and Life Sciences - BOKU, Vienna, Austria

Presenting author: Daniel Trauner

With over 2800km length, the Danube is the second largest river in Europe, and the most international river basin in the world. On its way from the source in Schwarzwald, Germany to the Romanian Danube Delta the river shapes the landscape, creates important habitat for flora and fauna, and provides humans with important provisional and other services since millennia. In terms of biota, the river represents an essential migration corridor, connecting crucial longitudinal and lateral habitats. As fish have the habit of travelling between different habitats for reproduction throughout their life stages, they are excellent indicators for the integrity of these environmental corridors. However, fish populations are under major pressures caused by human activities within the river and in the catchment, which resulted in declining numbers over the last decades. Long distance migratory fish like the once abundant but now highly endangered anadromous sturgeon species represent a historic, economic and natural heritage of the Danube region that used to migrate from the Black Sea up to the floodplains around Vienna to spawn. To save these species from extinction, mitigate pressures, and address the fragmentation of the ecological corridor integrated management is essential. The DTP Interreg project MEASURES addresses these challenges by using sturgeons and other migratory fish as a flagship species and identifying key habitats to initiate protection measures and assess the current status and potential of the ecological corridor along the Danube and its main tributaries.

This study takes data from the MEASURES project and the AQUACROSS project and creates a Linkage Framework (LF). The LF is a set of interlinked matrices that can show connections between components by creating multiple impact chains. It is a valuable tool for decision makers that can depict interrelations in a system and is a recommended ecosystem-based management method. We link stakeholders to their related activities in the Danube, these activities are linked to different pressures they induce (physical, chemical, biological), and lastly they are linked to migratory fish species affected by these pressures. To increase the explanatory power of these impact chains, the activities and pressures are weighted according to a spatial and temporal component. A preliminary investigation revealed over 200 stakeholders in the region, therefore the results from the LF analysis will provide valuable information about the role, importance, and impact of these stakeholders for the migratory fish species. The study will compare the different situations in the Upper, Middle, and Lower Danube to each other. The outcomes can contribute to future drafts of policy and management plans into sustainable measures aimed to restore the function of the Danube as an ecological corridor.

Session **SP12**

Challenges in the management of large rivers – the importance of floodplains at whole river scale

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Presenting author: Thomas Hein

Large rivers are key ecosystems providing a multitude of ecosystem services that are vital for human societies. Moreover, rivers have a high strategic importance for global ecological functions and biodiversity. As many large rivers in the world, the Danube River is a highly complex socio-ecological systems and a hotspot of biodiversity and ecosystem services, especially considering the floodplain systems, but is also affected by multiple human activities like navigation, hydropower, urban development or agriculture, making river-floodplain systems to one of the most threatened ecosystems worldwide. Conservation and restoration of the systems biodiversity and ecosystem service provisioning is an important task, but challenging because the diversity of human activities and policy targets (including WFD, Habitats and Birds Directive, Flood Risk Directive, Biodiversity Strategy or Green Infrastructure Strategy), scarcity of data compared to the complexity of the systems, heterogeneity of environmental problems and strong differences in socio-economic conditions along the Danube. Therefore, in this presentation we provide an overview on the status of Danubian floodplains, their biodiversity and their strategic importance at larger whole river network scales and present examples how combined assessment approaches for biodiversity and ecosystem services could support restoration planning and furthermore, the effect of implemented restoration measures on these floodplain properties. In future also emerging issues such as climate change and invasive non-native species will need careful consideration in ecosystem management of floodplains to minimize unintended effects.

Session **SP13**

Spatio-temporal dynamics of brown trout dispersal at different life-stages: combining several sources of evidence.

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Presenting author: Maria Alp

Dispersal plays an important role for population viability and persistence in stream networks. Understanding its extent, phenology and drivers is an important prerequisite for sustainable management of stream landscapes which are today subject to pressures potentially disruptive to dispersal: from barrier introduction and water abstraction to flow regulation. Importantly, movement frequency and spatial extent vary between life stages and may be to a different degree affected by network configuration and connectivity, flow direction, and environmental conditions. Dispersal patterns within a (meta-) population may be tracked by both direct (e.g. movement observation) and indirect (e.g. gene flow) methods, allowing to capture consequences of movement at different spatio-temporal scales. Combining different approaches in a single study case is a promising way to reinforce our understanding of timing, frequency and extent of dispersal using several independent lines of evidence.

Here we investigated the movement patterns of resident brown trout (Salmo trutta fario) in a second-order mountain stream with natural hydrological regime located in the French Pyrenees. Many studies of movement patterns in resident salmonids have used mark-and-recapture experiments and telemetry tracking but conclusions based on these approaches have been criticized for their bias towards animals with low mobility (the "restricted movement paradigm" discussion). Taking into consideration several spatio-temporal scales, we compare the estimates of individual trout mobility based on a multi-annual telemetry study (pit-tags) with the patterns of population genetic structure based on microsatellite analysis and, in particular, parentage patterns. We specifically aim to quantify yearly patterns of space use by resident brown trout and, in particular, the extent and direction of dispersal at young stages ([lt]2 years), which, compared to the reproductive migrations of adult salmonids, has been relatively understudied.

Finally, in view of increasing pressure on mountain streams related, in particular, to hydropower production, we discuss how the results of this work could be translated into recommendations for stream management.

Session **SP13**

Proliferative kidney disease - PKD, a new threat for native brown trout - Salmo trutta - populations in Austria

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Presenting author: Günther Unfer

Proliferative kidney disease (PKD) is a temperature dependent parasitic disease affecting wild and farmed salmonid fishes worldwide. The first evidence of PKD in an Austrian river was documented in 2016. At that time, no information on the PKD infection status of trout in other rivers was available. Since then, brown trout (Salmo trutta), as well as rainbow trout (Oncorhynchus mykiss) from various Austrian rivers have been examined. The study will give an overview of recent results concerning prevalence rates, underlying water temperature developments and risk assessment models regarding PKD outbreaks in the near future. Latest results exhibit that PKD already is a widespread problem exacerbated by global change. The combination of increasing temperatures and the occurrence of PKD will supposedly sharply reduce vital brown trout populations specifically in Austria's pre-alpine river reaches, calling for adapted management- and conservation strategies.

Session **SP13**

Ecological Responses of Fish to Engineered Mitigation Measures at the Danube Hydropower Impoundment Vienna, Austria

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Presenting author: Paul Meulenbroek

For several centuries, most of the River Danube shoreline has been modified mainly for navigation, flood protection and hydroelectric power generation. These man-made shorelines, primarily ripraps, do not provide the essential requirements of riverine fish to build up self-sustaining stocks. In the recent decades restoration measures followed to improve the situation with some reconstructed gravel banks, riparian side arms, lateral connections of backwaters or fish by-passes. Riverine fish are good indicators for the quality of habitat structure as well as for the ecological integrity of river systems due to rather complex habitat requirements needed at different stages of their life cycles. A nature-like fish by-pass system, gravel banks and riparian side arms were assessed for their functioning as fish habitats for different life stages. The study was conducted 15 years after implementation of theses mitigation measures. In total more than 30,000 fish of 48 species - including several protected and endangered species - in all life stages, including eggs, larvae, juveniles, and adults were sampled. The indicator species of the free-flowing River Danube, nase (Chondrostoma nasus) and barbel (Barbus barbus), migrated into the near-nature fish by-pass and successfully spawned before returning. A heterogenic habitat configuration provides conditions for all ecological guilds and, consequently, increases biodiversity. The chosen solution of the constructed by-pass system exhibits similar functions as a natural tributary. Besides this, the effect of constructed gravel bars and riparian side arms on species-specific fish larval dispersal (identified via mt-DNA barcoding) were investigated over a 20-km stretch at the River Danube in Vienna by sampling with drift nets. Cyprinids became dominant at sites downstream of gravel bars, whereas in riprap sections, the majority of the larvae consist of invasive Gobiidae. Side arm habitats were identified as multifunctional sites, providing spawning and nursery grounds for a variety of species. Finally, recommendations and management aspects are discussed.

Session **SP13**

Effect of seasonal variation on abundance and sex ratio distribution of the fish fauna of Ikere Gorge, Oyo State, Nigeria

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Presenting author: Festus Idowu Adeosun

The study determined the effect of season on abundance and sex ratio of fish fauna from Ikere-gorge. Fish composition, distribution and abundance were determined. Sexes were also determined and sex ratio calculated. 5,736 fish specimens were caught, identified and classified into 34 species, from 13 families. Chrysichthyes nigrodigitatus was densely and least distributed in station IV (29.98%), and III (19.87%). Lates niloticus was more in station III (3.81%) but significantly lower (p<0.05) than C. nigrodigitatus and Tilapia melanopleura in station 2. C. nigrodigitatus and Sarotherodon galilaeus were present in all sampling months. Sex ratio was skewed in favour of the female populations for C. nigrodigitatus, T. melanopleura and S. galilaeus but towards male for L. niloticus population. No seasonal variation was observed in sex ratio of the species. Conclusively, C. nigrodigitatus, T. melanopleura and S. galilaeus are not threatened in this water but same could not be said for L. niloticus.

Session **SP13**

Catfish density estimation using unnamed aircrafts census and underwater observations

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Presenting author: Catherine Boisneau

The Loire basin has a wide variety of fish species including one of the richest diadromous fish communities in France, 10 out of 11 species. Only the European sturgeon (Acipenser sturio) is no longer present. Since the beginning of the 20th century, fish communities have shown various trends under the pressure of anthropogenic factors such as eutrophication, bed incision, the spreading of invasive fish species. Diadromous fish communities undergo the same processes and have all seen their numbers decreasing with variable velocities related to their life history traits and the managements of the different watersheds. In an ecosystem, the introduction and establishment of an exotic species changes the structure of communities and their functioning. The introduction of a predator, larger in size than native predators, such as European catfish (Silurus glanis) leads it to become a new top predator for native species. In France, adult catfish can be two to three times larger than native predators such as pike (? 1m) and modify the refuge size of prey. Although most anadromous species have a large adult size, 30 cm to 120 cm, they are no longer immune to predation pressure exerted by this new species. This predation occur downstream of dams, at the temporary blocking points but also on open parts of rivers. This consumption during springtime confirms the great plasticity and the great food opportunity of catfish and raises questions about the impact of this species on the migratory fish community in the Loire. In this context, the challenge was to assess the feasibility of a method for estimating catfish densities in the wild, in an open river section without obstacles, in order to subsequently estimate its predation pressure on migratory fish. Two methods of census, by air from photos taken by a small unnamed aircraft system and by underwater observations, were combined over a 20km section. Automation of catfish recognition on photos using deep learning methods applied to crowd recognition is not currently possible, particularly due to the great color variability of the substrate. However, visual counts of 20439 images and underwater observations allowed 711 catfish observations. Their summer resting habitats are the pools downstream of sedimentary bars and the banks where they prefer logs and trunks. Single individuals or pairs are the most frequent but groups of several dozen of individuals are also present. Sizes range from 0.1m to 2.8m. Densities of individuals larger than 0.4m range between 19.5 and 31.1 ind/km of river length. Thus, it is possible to estimate the catfish densities, in the wild, without obstacles. This work can be used as a basis for estimating the predation pressure of catfish on anadromous migratory fish and for management operations of this invasive species, particularly near dams and obstacles where they accumulate during their migrations.

Session **SP13**

Eurasian otter Lutra lutra population estimates in Carinthia and Styria: a success story and a dilemma – reflections on predator-prey relations in a cultivated landscape

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Presenting author: Steven Weiss

The Eurasian otter (Lutra lutra) is listed on both Appendix II and IV of the European Habitat Directive (EHD), and thus is strictly protected but also an animal for which EU member states are obliged to carry out certain conservation measures and produce status reports at 6 year intervals. Recovery of the otter has also been met with some controversy, from stakeholders involved in both commercial and recreational fisheries. To aid decision as well as meet the demands of a conservation status report following Article 17 of the EHD, objective data on distribution and population densities are needed. To this end, population distribution and density estimates were carried out in two Austrian provinces (Carinthia and Styria) based on a combination of scat-based mapping, genetic analyses and extrapolation or modeling. Evidence of otter presence was found at 86% (N = 823) of controlled bridges in Carinthia and 92% of controlled bridges (N = 656) in Styria. In Carinthia, based on a province-wide recapture model, the population of otters was estimated to be 361 (95% CI 341-509) and in Styria, based on density estimates of 18 stream reaches and extrapolation 1141 (95% CI 798-1485). These results are discussed in light of the controversy surrounding otter recovery in Austria, but also considering the past, present and future perspectives on predator-prey balance and social controversy in a cultivated landscape.

Session **SP14**

Shifting e-flows Determination Paradigm in Run-of-River Hydropower Plants

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Presenting author: Alban Kuriqi

Small-scale hydropower plants (SHP), particularly run-of-river ones, are considered as one of the cleanest and sustainable renewable energy sources. This positive perception has resulted in the massive development of these hydropower plants. However, they are also associated with several ecological consequences in the diverted river reach. Therefore, e-flows constitute an essential instrument to mitigate the environmental impact in such hydropower plants schemes. This study focuses on the influence of the flow regime on the e-flows releases and energy production considering eight hydrological based e-flows methods (EFM). For this purpose, 20 run-of-river SHP up to 10 MW, from five main basins over Spain were analysed. Newly proposed, Downstream Diversion Index (DDI) was used to characterise, on a monthly basis, the water diversion ratio regarding each EFM. Flow alteration due to each EFM applied in this study was also assessed by five global indexes derived from indicators of hydrological of alteration. The results of this study showed that static EMF, e.g., the percentage of Mean Annual flow (%MAF), Minimum Mean Flow (MMQ), percentiles of flow duration curve (Q75, Q95) strongly depend on the flow regime and, in general, cause high seasonal flow alteration and allow for less energy production. While dynamic approaches, such as percentage of mean daily flow (%Q-Daily), and particularly the combination of the %Q-Daily with MMQ, maximise energy production and preserve some of the essential hydrological parameters (i.e., timing, frequency, duration, and rate of change), which are among the main drivers of several biological processes in the riverine ecosystem. The results obtained in this study may serve as the starting point to a new discussion on the methods and criterion that should be established regarding e-flows determination in SHP. Finally, the methodology presented in this study can be a useful decision-making tool to help consultants and water managers to choose the method for e-flows determination, particularly in the case of run-of-river SHP.

Session **SP14**

A national assessment of the response of European grayling, Thymallus thymallus, in hyporhithral rivers to hydropeaking

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Presenting author: Daniel S. Hayes

In light of a future low carbon economy, storage hydropower plants are a valuable energy source. However, their operation scheme may entail unnatural short-term flow fluctuations which adversely affect riverine organisms such as fish. As the majority of hydropeaking rivers in Austria are classified as hyporhithral (i.e., the grayling zone), it is necessary to assess in detail the effects of hydropeaking in this river type to derive the most-suitable mitigation measures. We, therefore, aimed to assess the effects of sub-daily flow alterations on populations of the European grayling (Thymallus thymallus), which is the dominant species (Leitart) in this region and is highly important in terms of conservation. To fulfill these objectives, we used an Austrian-wide database containing biological (e.g., fish population samplings), hydrological and morphological data. We analyzed the response of grayling populations to hydropeaking along a hydrological and morphological gradient, whereby sites ranged from natural flow regimes to heavy hydropeaking and from nature-like to heavily degraded channels. We present first results from the database analyses and discuss potential options to mitigate the negative impact of hydropeaking operations on hyporhithral fish populations.

Session **SP14**

Hydropeaking mitigation through a diversion Hydropower plant scheme: the GKI study-case [Tyrol, Austria]

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Presenting author: Miguel Moreira

Hydroelectric power plants managed in response to sub-daily changes of the electricity market undergo rapid variations of turbine discharge, entailing quickly fluctuating water levels downstream. This operation regime, called hydropeaking, causes numerous adverse impacts on river ecosystems, where it is stringent to develop suitable mitigation measures over these impacts. The hydrological alterations which affect hydropeaking rivers can be described by five parameters that change over space and time (magnitude, rate of change, frequency, duration, and timing), where each parameter may be correlated with distinct environmental impacts and therefore may be used to set targets for mitigation strategies. To reach this goal, direct measures can be implemented, such as operational as well as structural measures (e.g. the construction of retention basins or hydropeaking diversion hydropower plants). The GKI diversion hydropower plant, which is under construction, is located in the Inn river (Tyrol, Austria), and intends to mitigate hydropeaking impacts along a 28.3 km stretch, based on the conjugation of both direct operational and structural measures. Thus, to our knowledge, with this study we present a novel hydropeaking mitigation approach, where we developed the operational scheme for GKI's weir and diversion tunnel, concerning the Grayling species (Thymallus thymallus) spawning season (1st of May to 15th of July), with new insights over hydropeaking impacts. The operational rules were based on around 20 years of hydrological local data from four gauging stations, where the defined criteria included the most recent findings from literature, such as the species tolerance thresholds to downramping, and were established concerning the stretch hydromorphological characterization. For that purpose, we analyzed the most recent stretch topographic data, represented by 188 cross sections, carrying out the hydrological assessment based on 1D unsteady modelling. With our results, we intended to develop different operation scenarios taking into consideration:

- Vertical ramping analysis based on grayling stranding thresholds found in literature for critical downramping velocities;
- Lateral ramping velocity assessment (wetted width variation) for grayling species' spawning grounds dewatering and stranding risk.

We have found that hydrological parameters are highly influenced by hydromorphological characteristics, such as slope, bank steepness and river geometry, which should be taken into account when designing a hydropeaking operational mitigation scheme. Thus, with the GKI study-case, we propose an operational framework for hydropeaking mitigation, based on the multiple biological and hydromorphological factors that should be considered for its design.

Session **SP14**

Macroinvertebrate drift following hydropeaking simulations considering trait-specific responses

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Stream organisms have evolved behavioural and morphological traits as well as life history strategies in direct response to natural flow regime types which are thought to be essential ecological triggers. However, many Alpine rivers are found to be subject to artificially induced discharge fluctuations, commonly referred to as "hydropeaking", resulting in a sudden change of hydraulic conditions and modifications of hydrological characteristics such as the wetted width, water depth, flow velocity and bottom shear stress. Specific taxa are adopted tocertain flow velocity thresholds and time spans of being exposed to increased discharge. Exceeding these taxa-specific thresholds leads to the detachment of the organisms and consequently to increased drift. There is evidence that hydropeaking leads to a selection of taxa owning morphological and behavioural traits to resist high flow. Rheophilic species have adaptions like hooks, suckers or a flattened body shape, whereas limnophilic species lack such adaptations.

Quantification of this assumption is still lacking, therefore we present an experimental approach, addressing trait-specific macroinvertebrate drift response following hydropeaking events with varying ramping velocities and peak discharges. We analysed "traditional" classifications for macroinvertebrate ecological preferences from the freshwaterecology database (e.g. current preference) as well as new classifications (taxa associated to lentic/lotic or interstitial/surface habitats).

Macroinvertebrate drift generally increased significantly in comparison to parallel control runs. The results showed that drift responses increase with increasing peak discharge and corresponding flow velocities. The drift rates of taxa associated with lentic zones and of taxa dwelling at the bottom surface were strongly related to peak discharges but not to up-ramping velocities. Rheophilic and taxa living in the interstices were less sensitive to hydropeaking events. This study indicates that measures addressing the flow amplitude and up-ramping velocities (such as the construction of compensation basins) can have strong mitigating effects. Basic behavioural patterns of macroinvertebrates should be emphasized in future studies to establish a profound database that can be used for the enhancement of existing hydropeaking impact assessment approaches.

Session **SP14**

A framework to identify cost-effective mitigation measures using Bayesian Networks

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Presenting author: Ana Adeva-Bustos

Impacts that hydropower may cause on the aquatic ecosystem and the benefits that hydropower generates as a renewable energy source have been widely recognize and investigated. However, how to find the most cost-effective mitigation measures to maintain sustainable fish population is still a challenge. This challenge is in part triggered by the uncertainties related to the lack of data, the challenges related to find an indicator for effectiveness and to the transferability of data from different case studies to a more general context. To deal with these challenges and as part of the EU-funded research project FIThydro (Grant Agreement number 727830, duration 2016-2020) which focus on develop methods, tools and devices for solutions to improve conditions for fish while maintaining the hydropower production, a cost-effective framework will be developed.

We have developed a framework for the identification of potential combinations of mitigation measures that are most likely to succeed and most important that are cost-effective. In recent years, the use of Bayesian Networks (BNs) as a decision tool for water management has increased. They have been used to support the prioritization of flow and catchment restoration options including the cost-effectiveness of the interventions, to diagnose the factors limiting stream trout fisheries, and to support cost-effective decisions for environmental flow and physical mitigation measures. In addition, the literature acknowledges the potential of BNs to deal with uncertainties. Therefore, the cost-effectiveness framework will be developed as a Bayesian Network (BN) using HUGIN. Data for the BN will be collected from other reports and partners in the FIThydro project, data from literature will be weight according to the effectiveness evidence and it will be used when no previous data is available. In addition, data from expert knowledge will be used to update the probabilities belief in the BN under an elicitation process.

This paper aims to have a detailed description of the framework methodology including the evidence weighting from literature-based data, the elicitation process, the data implementation and the challenges found through the process. The cost-effective framework will be applied to four cases studies which are part of the FIThydro project: Anundsjø in Sweden, Iller in Germany, Las River in France and Guma/Valdecondes in Spain. Therefore, BNs are expected to be used to identify the potential combinations of mitigation measures that are most likely to succeed and that are more cost-effective in each of the case studies.

Session **SP14**

Ecohydraulics of non-uniform flows in Vertical Slot Fishways

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Presenting author: Paulo Branco

Longitudinal connectivity is paramount for the maintenance of freshwater fish populations. The construction of instream barriers severely affects the system's structural and functional connectivity by fragmenting the river network into unconnected subnetworks. This precludes several fish species from completing their life cycles, severely altering population structure and distribution, promoting genetic bottlenecks that may lead to localized extinctions and to unforeseen ecosystem-level impacts. The traditional way to minimize such harsh impacts is the construction of a fish transposition device - often termed fishway. These structures are designed to be operationally optimized for a predefined discharge. In highly dynamic environments, hydrologic changes can be drastic and those are usually translated into an impossibility of fishways operating at their design operation discharge. This results in non-uniform flows and usually to non-optimal fishway operation, and, concurrently, to less than desirable fishway effectiveness. In this study we took an experimental approach to this problem and worked with 3 flow regimes (uniform, drawdown and backwater) in an experimental vertical slot fishway flume with wild caught adult Iberian barbel (Luciobarbus bocagei). Hydraulic variables were measured and evaluated using and Acoustic Doppler Velocimeter and a Lateral Line Probe (mimicking the natural fish sensory system), fish were tracked using video cameras, and variable importance for fish behavior (movements and space usage) was evaluated trough zero-inflated generalized linear models. Results show that the spatial distribution of hydrodynamic variables is significantly different between uniform and non-uniform flows, which significantly affected the fish distribution within pools. This may have relevant repercussions in fish navigation of fishways as it may increase their energy expenditure. Further research on fishways should integrate the analysis of their effectiveness under different boundary conditions, to understand if in conditions different from the design operational flow the fishway is not a problem instead of being part of the solution.

Session **SP14**

Passage performance of potamodromous cyprinids negotiating low-head ramped weirs

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Presenting author: Susana D. Amaral

River fragmentation by small engineered structures, estimated as 2-4 orders of magnitude more numerous than dams, has led to severe declines or local extinctions of many fish populations, by blocking important upstream movements. In Portuguese rivers, more than 8000 small weirs were identified. Along with small broad-crested weirs (downstream face vertical), low-head ramped weirs, with inclined faces that fish may be able to overcome by swimming, are the most usual design. Fish passability of these structures, where water passes over but does not generate a waterfall, is primarily related to ramp length and slope, but their relative contribution has seldom been assessed. This study aims to assess the upstream passage performance of a medium-size potamodromous cyprinid, the Iberian barbel (Luciobarbus bocagei), negotiating an experimental low-head ramped weir with varying ramp length (L), slope (S), and discharge (Q). A total of 4 configurations were initially tested contemplating different combinations of L (1.50, 3.00 m) and S (10, 20, 30 %), with a constant Q of 110 L.s-1. The configuration with the lowest number of successful upstream passages was then assessed for a new Q of 55 L.s-1. Fish movements, like the number of times fish approach the ramp (Ap), number of attempts to negotiate it (At), and the number of successful upstream passages (N) were monitored by direct observation and recorded by a video camera. Metrics of passage performance, such as attraction efficiency (AE%; quotient of number of attempts per number of approaches), and passage efficiency (PE%; quotient of number of passages per number of attempts), were also calculated. Water velocity along the ramp, as well as upstream and downstream, was characterized with a flow probe. Results revealed that both factors L and S, as well as Q, influenced passage performance of Iberian barbel. The total number of N and, consequentially, values of PE% mainly decreased with the increase of tested L and S, where values of water velocity above 3 m.s-1 were observed. However, values of AE% increased with both L and S. Concerning the effect of Q, although its reduction contributed to the presence of a smaller water column on the ramp, which could have hindered fish passage, the number of N increased significantly. Nevertheless, in terms of efficiency, in this lower Q that displayed water velocities below 2 m.s-1, lower values of AE% and PE% were registered. These results are in line with the "fish passage paradox" - fish were attracted to the ramped weir by high values of water velocity but, at the same time, it might have been a limiting factor for the successful upstream passage. These results can be useful for designing appropriate passage structures for low-head instream obstacles. Future research should also consider the retrofitting of low-head ramped weirs to provide improved fish passage and restore connectivity at these small barriers.

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Session **SP14**

Improving fish transit times: An experimental approach to develop a holistic fish passage

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Presenting author: Paulo Branco

Pool-type fishways are currently the main technical mitigation solution used to restore longitudinal connectivity in regulated rivers throughout the world. These hydraulic structures are of chief importance since they provide a pathway for moving fish and, thus, contribute to the genetic flow between populations. By combining hydraulic and ecological expertise, several fishway designs were developed and applied so far, from the pool-type with orifices and/or notches to vertical slots (VSF) or more recently the multi-slot fishways (MSF). In general, VSF is considered one of the best types of technical fishways because i) fish can move between pools at their preferred depth; ii) they can handle significant variations in the up-and-downstream boundary conditions, making them suitable to undergo variations in discharge; and iii) they are less prone to clogging with debris and sediments than pool-type with orifices and/or notches. However, when compared with other designs, VSFs require higher discharges (Q) which increases the operational costs. Therefore, to reduce these costs, MSFs seem to provide a cost-effective solution that gathers the best features of VSFs but operate with lower discharges. In the present study, four different fishway configurations [MSF - 1 (Q = 36 l.s-1); MSF - 2 (Q = 56 l.s-1); VSF - 1 (Q = 81 l.s-1) and VSF - 2 (Q = 110 l.s-1)] were tested in laboratory conditions in a full-scale fishway model to assess the transit times of two fish species with different ecological traits: the Southern Iberian chub Squalius pyrenaicus (Gunther, 1868) and the Iberian barbel Luciobarbus bocagei (Steindachner, 1864). Results from the fish trials (N = 40 trials) revealed no interspecific differences within each configuration tested. Nevertheless, the chub transit times were significantly different between MSF - 2 and VSF - 1 (P < 0.05) and between the latter and VSF - 2 (P < 0.05). For both species, the same tendency was identified: configurations operating with lower discharges promoted lower transit times. Additionally, the lower velocities and turbulence magnitudes found in the pools also seem to support this passage behavior. These findings are valuable when designing new fishway solutions or retrofitting existing ones with low passage efficiencies. Overall, to develop fishways towards a holistic concept, increasing water cost-effectiveness while reducing transit times, a key factor is to account for suitable hydrodynamic conditions capable of improving the passage performance of multiple species with different ecological traits.

Session **SP14**

Modelling existing and future fish habitat under variable management scenarios in a large regulated river

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Modelling the linkages between physical habitat and aquatic organisms on multiple spatial scales has become a valuable tool in the management of regulated rivers. Particularly, the distribution and structure of fish communities can be significantly influenced by the physical environment. Traditional approaches are operating at the microhabitat (point)-scale, simulating physical habitat parameters at a high spatial and analytical resolution. The mesohabitat (local)-scale represents an intermediate resolution in modelling that bridges the gap between available resources and conservation efforts for riverine species. In large rivers, a combination of micro-scale and meso-scale analysis has been recommended, acknowledging a higher proportion of functional habitat that may be important for specialized fish species or life stages. The current study is conducted along a 20 km reach of the Saint John River, downstream the Mactaquac Generating Station and uses a multi-scalar modelling approach to assess spatio-temporal changes in habitat conditions as a function of flow. Mesohabitat types are associated to discrete fish assemblages (i.e. fish habitat guilds). Habitat requirements for fish guilds are defined by local fish experts and habitat suitability is derived using the fuzzy- rule based MesoCASiMiR habitat model system. A fuzzy logic approach is also used to quantify the uncertainty associated to the hydrodynamic and biological component of the model. Specialized habitat requirements at summer flow condition for single species or life stages are analyzed at the microhabitat scale and compared to mesoscale simulations to identify strengths and weaknesses of both approaches. Ecohydraulic metrics are derived from the model and translated into a habitat time series, to discuss potential changes in fish habitat conditions related to different management options of the Saint John River.

Session **SP14**

Spawning channels - an innovative restoration concept to secure key habitats in heavily modified water bodies?

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Due to human activities, rivers have been altered in their hydromorphological characteristics, which led to a lack of suitable habitats for sensitive life stages (spawning, egg, larvae, juvenile) of native fishes. Significantly altered water bodies (e.g. dam cascades) are classified as heavily modified (HMWBs) according to the EU Water Framework Directive.

Implementing standard habitat restoration measures is often not possible within such river stretches, because present conditions (e.g. impoundment, hydropeaking affected stretches) exclude those options. Consequently, the availability of habitats for sensitive life stages often represent a bottleneck in HMWBs.

Spawning activities of native species have been documented in constructed fish ways in Austria, indicating that artificial channels can potentially serve as spawning habitats for various species. Artificial spawning habitats focusing on salmon species already have been implemented in North America since the 1960s.

Based on these experiences we introduce an innovative restoration concept, aiming at establishing key habitats for reproduction by man-made "spawning channels". These channels mimic natural habitat conditions by providing hydrologically and morphologically optimized conditions (e.g. flow velocity, water depth, sediment composition) for specifically rheophilic fish species (e.g. nase, barbel, grayling, trout) including the sensitive life stages of reproduction, egg and larval development. These channels have the potential to support self-sustaining fish populations in HMWBs without significantly affecting the plant's operational mode. For successful implementation, river type- and population-specific considerations may be required in terms of channel dimensions and operation modes. Spawning channels may be implemented stand-alone or in combination with nature-like fish ways.

To evaluate the potential of "man-made" spawning channels as an effective measure, it is aimed to conduct a pilot study in HMWBs. This study should serve the development of guiding principles for case-specific planning and implementation of spawning channels.

Session **SP15**

Pros and cons of the use of land reclamation systems for increasing water retenction capacity in a large lowland catchment

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Presenting author: Mateusz Grygoruk

Increasing frequencies and durations of severe droughts which has already been observed in Central Europe in the last two decades pose significant threats to ecosystems, agriculture and domestic/industrial water supply. According to the most up to date advances in modeling climate change impacts on various socio-ecological systems, this trend is likely to continue in the years to come. Increasing water retention became a challenge in a large scale. Single reservoirs, even the ones of a large capacity, due to their limited influence on adjacent and downstream-located areas (resulting from e.g., evaporation, technical constraints and the other roles they play) were already diagnosed a tool that allows to mitigate the risk of drought only to a very limited extent. That is why their role in increasing water retention must be supported by the other, spatially discrete and nature-based tools.

In our study we analysed technical and theoretical feasibility of land reclamation systems that might be used as efficient tools improving water retention in a scale of a large lowland catchment of Oder in Poland. We hypothesized that controlled blocking of outflow from ditches may allow for water storage increase. Applied GIS-based tools and hydrological assumptions allowed for calculation of water retention volume in land reclamation systems located in the study catchment that reached average roughly 165 mln m3 of water (from 36 up to 373 mln m3, depending on the scenario calculated). Results of our calculations allow to state that water retention in wisely managed land reclamation systems remains at least of the equal importance to technical measures applied for water retention enhancement or drought mitigation purposes. Volume of water that might potentially be stored in different scenarios of water retention in land reclamation systems is high enough to mitigate majority of the discharge deficit (e.g., allowing for the 22 cm increase of average water levels for approximately 36 days, that would allow to mitigate the most severe drougts of Oder).

The proposed wise water management in land reclamation systems, although it likely remains a efficient solution, faces challenges related to the management. However, together with the other policy-based mechanisms related to subsidizing appropriate agricultural practices (e.g., floodplain subsidy), we find the proposed solution of storing water in land reclamation system a feasible tool in drought mitigation in a catchment scale.

Session **SP15**

Methodology of Landscape Valorisation for Planning of Natural Small Water Retention Measures

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Valorisation of the environment is a method of assessing its usefulness and attractiveness for the realization of selected environmental functions or economic activities based on its natural features or potential. It gives an opportunity to directly compare the analysed areas according to the scores they obtain. The results of environmental valorisation are significantly influenced by the selection of the planning unit, range of indicators used, method of sub-score calculation for individual indicators and the method of aggregating sub-scores into a general assessment. In addition, the quality and resolution of the data used to calculate the indicators are very important elements. The aim of the environmental valorisation in planning natural (small) retention measures (N(S)WRM) is to identify areas where their implementation would bring the greatest benefits. Two approaches to the assessment were proposed: i) usage of existing planning studies to counteract the effects of drought and flood risk management, and ii) usage of physical and geographical characteristics of the studied area. The proposed indicators included climatic, hydrological, hydrogeological and soil characteristics, topographical characteristics and those related to the impact of anthropopressure on the quality of ecosystems. Depending on the purpose of planning N(S)WRM - mitigating the effects of drought, preventing floods, slowing down erosion processes, improving water quality and biodiversity or broadly increasing the retention of the area - sets of recommended indicators were defined. It was assumed that the existing (often publicly available) spatial data and analyses carried out in the GIS environment would be used to calculate the valorisation indicators. However, some indicators, e.g. climatic and hydrological characteristics, required pre-calculations based on the multiannual observations. The methodology was developed as part of the Interreg Central Europe project (acronym FramWat) and was tested in six pilot catchments (Kamienna (PL), Asist (AT), Bednja (HR), Nagykunsági (HU), Blh (SK), Kamniska Bistrica (SI). An important challenge was to take into account the diversity of environmental conditions and problems specific to individual countries, as well as to agree on the scope of data and their preparation for test use. The methodology has been applied in the Fro-GIS online application (RetencjaWod.sggw.pl). The method is universal and can be used in various locations, but requires individual selection of indicators and valorization scales. The methodology is developed to be used for planning purposes, not for developing a project. Therefore, when designing specific measures, the needs of water users and environmental protection requirements, including environmental flows, should be taken into account.

Session **SP15**

Static Tool - a concept for assessing the effects of natural, small water retention measures

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Natural, also called "small", water retention gains attention in recent years as a method of mitigating the effects of direct or indirect anthropogenic impact on the quantity or quality of water resources. The goals of small retention plans enclose counteracting the drought effects, reduction of flood risk, improvement of landscape biodiversity or slowing down the cycling of nutrients and protecting water quality. One of the obstacles to widespread use of this type of solutions is the lack of available information on the their effects. The rational method of assessing these effects is simulation analysis using hydrological models, however, work inputs, financial resources and the range of skills necessary to build models often go beyond the capabilities of local / regional stakeholders.

The Static Tool is an expert-knowledge-based system to support planning of small / natural water retention measures in rural landscapes. Its main goal is to enable the estimation of the effects of the plan (NSWRMP) in a simplified way, which does not require a time-consuming and costly setup of a detailed hydrological model. The Static Tool is a part of broader decision support system for development of NSWRMP (DSS-SWRMP) currently elaborated within the FramWat project of the Interreg Central Europe Programme. The DSS includes also GIS-based valorisation tool of the catchment area in terms of the needs for the development of small water retention measures and structured approach to planning. Assessment of the effects of NSWRMP is expressed as the improvement of valorisation results.

The tool includes a catalogue of small water retention measures defined as individual actions, such as afforestation, construction of polders, ponds and small water retention reservoirs or as aggregated activities, e.g. agricultural practices that allow water retention enhancement, such as mulching and intercropping, or renaturalisation activities, such as wetland and floodplains restoration and management. The core element of the Static Tool is a set of relationships between measures' intensity and expected change in water retention properties of a catchment. Due to scarce available data on quantitative impact of small / natural water retention measures implementation on hydrological phenomena, it is based mainly on expert judgement, and a few modelling studies and reports. The tool can be universally used for different size of the analysed area and different regional climatic and geographical conditions, however involvement of experts in planning of small water retention measures is necessary for tuning the tool for local conditions.

Static Tool was used to estimate the effects of the action programs for the pilot catchments in the FramWat project. The results of subsequent modelling studies and the observed effects of the implemented measures will allow to upgrade the tool.

Session **SP15**

Coupled hydrological and hydraulic model as a tool to assess NSWRM for flood mitigation - the Kamienna River case study in Poland

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Natural (small) water retention measures (N(S)WRMs) are becoming increasingly popular solutions addressing various water-related problems such as floods, droughts or water pollution. There exist comprehensive catalogues of different types of measures with detailed descriptions of their potential benefits, such as the website nwrm.eu, but quantitative assessment of efficiency of different combinations of measures at the catchment scale for e.g. flood or drought mitigation has been rarely undertaken to date. Within the Interreg Central Europe project FramWat a coupled hydrological and hydraulic modelling approach is being developed in the Kamienna catchment located in south-central Poland. Dangerous floods have experienced this densely populated region several times in the recent years. Popular, open-source models have been selected for this study: Soil & Water Assessment Tool (SWAT) for simulation of land-based hydrological processes and 1D/2D version of the Hydrologic Engineering Center's River Analysis System (HEC-RAS) for simulation of flood wave propagation in the Kamienna River. The main benefit coming from the model coupling is taking the best of the capabilities of each tool: SWAT is designed for evaluating scenarios of N(S)WRM application in the catchment area, whereas HEC-RAS transforms the signal originating from SWAT and can provide more sophisticated outputs related to flood characteristics than SWAT. Both models were set up, calibrated and validated using available local data sets and own field measurements. The goodness-of-fit in calibration and validation was assessed as good, so the coupled models could be applied for quantifying the effect of N(S)WRMs on flood mitigation in the Kamienna catchment. Two stakeholder-devised scenarios were developed: one assuming application of different combinations of agricultural N(S)WRMS (such as the buffer strips, land cover change, no-till agriculture, catch crops) and one assuming application of small 'technical' measures (such as sedimentation ponds, constructed wetlands or small reservoirs). The process of placement of measures was informed by the outputs coming from the FroGIS tool (http://waterretension.sggw.pl/) developed within the FramWat project. Preliminary results suggest that simulated efficiency of measures was influenced by the timing and type of precipitation events as well as the spatial extent of applied measures.

Session **SP15**

Catchment scale implementation of natural small water retention measures to improve river habitat and reduce siltation risk

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Pressures acting at different spatial scales are detrimental for river ecosystem quality. Climate change, land use change, as well as agricultural and forestry practices can affect in stream habitat quality and availability. Natural small water retention measures (NSWRMs) are receiving increasing attention in the European Union because of the multiple ecosystem services they can provide, ranging from flow regulation, nutrients and sediment control to habitat improvement. However, impacts on in-stream habitat and siltation risk are less investigated because of the coarse resolution that is provided by the catchment scale ecohydrological models. Recently proposed, ecohydrological modelling cascades can provide a useful tool to downscale the ecohydrological catchment response to the microscale (1 - 10 m2).

Thus, an integrated modelling cascade is proposed that links the ecohydrological model, Soil and Water Assessment Tool (SWAT), for catchment scale hydrology, the 1D Hec River Analysis System (Hec-RAS) for reach scale hydraulics, a siltation risk module, and a generalized linear model to assess species distribution that uses the abovementioned models outputs as multi-scale predictors. The models have been calibrated and validated for the pre-alpine Aist catchment in Austria (650 km2) with the aim of predicting the in-stream, catchment scale distribution of the sessile macroinvertebrate species the Freshwater Pearl Mussel (FPM, Margaritifera margaritifera), the siltation risk and assessing the potential NSWRMs effectiveness for improving river habitat. Some NSWRMs were tested in the agricultural land, in the forested area and in rivers (hydromorpological modification) via scenario analysis.

Preliminary results show 1) the ecohydrological modeling cascade is suitable to incorporate different spatial scales in a coherent framework; 2) the ecohydrological modeling cascade is suitable to predict the spatial distribution of the target organism and of the extent of the siltation risk for the baseline condition; 3) the changes in the hydrograph and in the sediment loads out of the SWAT can be downscaled to the microhabitat and used to assess the relative changes in habitat availability and siltation risk.

Session **SP15**

Spatial, temporal and institutional integration of water retention measures in complex catchment

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Water retention measures are widely recognized as important key type measure anticipated by Water Framework Directive as well as Floods directive. They also play a significant role in the climate change adaptation process. Their implementation is however not a straightforward process. The complexity of the domain is the main challenge, where already every single process: flood hazard and risk identification, identification of possible measures, optimization of possible measures, prioritization of measures, implementation of measures, monitoring the efficiency and effectiveness of implemented measures, maintenance of measures is challenging task by itself, as it is confronted with scaling issues, effectiveness under different scenarios. Added to this one has to address the temporal dimension integrating the measures, which could be performed in a short time horizon with those with long time horizon (and those in between). All these dimensions are additionally confronted with plethora of institutions on the catchment with different decisional procedures and optimisation criteria. The dimensions listed above were addressed in the framework of Framwat project on the Kamniška Bistrica catchment. In the article approaches, tools, models, and processes will be presented that start to enable integration of the listed dimensions starting with the joint awareness which is incorporating the concept of multiple perspectives. Basis integration framework is developed as shared WEB-GIS platform which creates both joint understanding of the existing status as well as potential measures - some of them already implemented, while some of them still in the planning and programming process.

Session **SP16**

DANUBIUS-RI: A pan-European Research Infrastructure for Advanced Studies on River-Sea Systems

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Presenting author: Sina Bold

DANUBIUS-RI, the International Centre for Advanced Studies on River-Sea Systems, currently brings together around 30 partners from over 15 countries coordinated by the research institute GeoEcoMar in Romania. DANUBIUS-RI is a long-term, distributed and interdisciplinary research infrastructure (RI) integrating studies of rivers and their catchments, transitional waters, such as estuaries and deltas, and their adjacent coastal seas (i.e. River-Sea Systems). The overall aim is to facilitate and provide interdisciplinary knowledge for sustainable management of River-Sea Systems by (1) providing research facilities linking freshwater, transitional and coastal waters, (2) advancing process and system understanding, (3) enhancing stakeholder engagement, and (4) enabling the development of integrated management options and environmental policy-making. In 2016, the European Strategy Forum for Research Infrastructures (ESFRI) included DANUBIUS-RI in its Roadmap highlighting the relevance of a pan-European research infrastructure for River-Sea Systems. The Horizon 2020 project DANUBIUS-PP (Preparatory Phase) has build the scientific, legal and financial foundation to implement and operate DANUBIUS-RI (www.danubius-pp.eu).

The Science & Innovation Agenda is guiding the research infrastructure's evolution from preparation through implementation to operation. It describes our vision, mission and approach, as well as provides a framework for DANUBIUS-RI's research and highlights DANUBIUS-RI's research priorities. The framework includes interrelated key challenges in River-Sea Systems, such as climate change and extreme events, quantity and quality of water and sediment transported along the river-sea continuum as well as the structure and functioning of associated ecosystems. The Science & Innovation Agenda will be published in November 2019 and will thereafter be regularly updated.

DANUBIUS-RI is composed of Hub, Data Centre, Technology Transfer Office, as well as Nodes and Supersites. Nodes provide the best available methods and expertise regarding observation and analysis, modelling and socio-economic impact. Supersites provide access to a River-Sea System at locations of scientific relevance and political opportunity to study the functioning of these systems, to assess impacts and risks from various human activities, as well as to develop and test potential measures to address common challenges. The current set of 12 Supersites covers a wide range of River-Sea Systems along climatic, environmental and socio-economic gradients, as well as along a gradient of human impact across Europe. DANUBIUS-RI provides access to facilities, standardised methods and tools, as well as data and samples related to several River-Sea Systems. Furthermore, DANUBIUS-RI brings together relevant expertise and provide expert support, as well as train students and early career researchers.

Session **SP16**

Effectiveness of Vertical Slot Fishways under experimental non-uniform flows

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Presenting author: Mario Eckert

Worldwide freshwater fish species are being affect by the presence of instream barriers that preclude them to freely displace themselves along river networks. This longitudinal connectivity breach has long been circumvented by the construction of fishways to ameliorate this impact by enhancing, albeit partially, connectivity. These structures are built to be operational under a specific design flow that provides a uniform regime. But, in the field, these structures are rarely functioning at their optimal discharge, creating non-uniform flow regimes that create unevenness in the pool-to-pool conditions. This is, although only seldom approached, thought to be severely deleterious to fish movements. In this work we pursued and experimental approach to test the effect of non-uniformity vs uniformity (Drawdown - hm 0,74 m/Q 50 l/s ; Uniform - hm 0,8 m/Q 81 l/s and Backwater - hm 0,62 m/Q 81 l/s) in a full scale vertical slot fishway experimental flume, working with 5 replicates of schools of 5 wild caught Iberian barbel (Luciobarbus bocagei). Hydraulic parameters were evaluated by preforming measurements with an Acoustic Doppler Velocimeter at different water planes parallel to the fishway bottom, and water pressure was measured with an artificial Lateral Line Probe - mimicking fish sensory system. Significant differences in passage success and behaviour were observed between the regimes, demonstrating that deviations from the design discharge may change the effectiveness of the fishway and concurrently affect the maintenance of fish populations at a given site. This study illustrates how testing non-uniform scenarios is important to determine design criteria to allow fishways to maintain effectiveness in multiple situations.

Session **SP16**

Linking Rivers to Seas: key challenges in developing a research infrastructure spanning freshwater and marine systems.

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Presenting author: Chris Bradley

Research at the interface between terrestrial, riverine, estuarine and marine environments is frequently constrained by significant disciplinary and geographical boundaries. This complicates the development of an over-arching research infrastructure that spans the river-sea continuum. This paper discusses these challenges in the context of the United Kingdom and Republic of Ireland, as partners in the pan-European DANUBIUS-RI: an initiative to develop a pan European research infrastructure dedicated to European river - sea systems (www.danubius-ri.eu). Drawing upon example catchments in England (the Thames and Tamar), Scotland (the Tay), and Northern Ireland / Ireland (the Foyle), the paper outlines the scope of the research that spans the environmental, social and economic sciences and which form part of the UK and Ireland contribution to DANUBIUS-RI.

Session **SP16**

An Investigation of Restoration Alternatives in the Colorado River Estuary

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The Colorado River Estuary was once known to be one of the most biologically diverse ecosystems in the world. The estuary was shaped by dynamic interactions between coastal and riverine processes. The system was strongly influenced by large floods, driven by melting snow pack high in the watershed. The development of water resource infrastructure in the Southwestern United States, including Hoover Dam and Glenn Canyon Dam, all but eliminated flood pulses from the system and severely reduced base flows. Water shortages over the past 20 years have nearly eliminated the delivery of freshwater to the estuary. The result has been the devastation of the ecosystem and a complete interruption of natural fluvial processes. In spite of these bleak conditions, restoration-minded organizations have continued to strive for environmental improvements to the estuary including direct interventions and the implementation of two experimental flow releases. However, questions remain as to the how to best invest limited resources to achieve ecological improvements in this highly degraded ecosystem. The objective of this study was to investigate physical restoration and alternative freshwater flow delivery alternatives to assess potential ecological uplift in the estuary. This was achieved by applying a two-dimensional hydrodynamic model (DFLOW-FM, Deltares, Netherlands) to assess changes in inundation patterns, water circulation, and salinity concentrations under the various restoration scenarios. The hydrodynamic and salinity conditions were then compared with habitat suitability criteria for target aquatic organisms. The model was executed in parallel format at the high-performance computing center at the University of New Mexico. The results reveal that water and salt dynamics are sensitive to potential geomorphic modifications and thus target habitat conditions can likely be improved through carefully designed restoration efforts. The results were summarized with respect to the potential to increase aquatic habitat and the results are being used to inform the design of restoration projects. Current efforts are focused on assessing the potential benefits or additional freshwater deliveries.

Session **SP17**

Interdisciplinary Opportunities in River Microbiome Research

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Presenting author: India Mansour

Microbial communities, or consortia of microorganisms including bacteria, archaea and fungi, inhabit a wide range of riverine niches and drive, or contribute to, many important ecosystem processes such as river metabolism, pollutant fate and transport, nutrient cycling and geomorphology. Changes to the river microbiome could thus alter function with consequences for resilience of the system (in the context of climate change) or provision of ecosystem services. Innovations in molecular technologies provide the opportunity to survey microbial community composition and function with increasing resolution. Thus many recent studies, largely published in biology- and ecology-centered journals, present results of investigations of spatio-temporal patterns in river microbiomes. Some catchment-scale longitudinal studies have revealed shifts in composition and diversity from headwaters to estuary for both bacteria and fungi, and factors such as water and sediment chemistry, land use and season have been reported to shape the river microbiome. Hydrological and geomorphological drivers are highly pertinent: geology, water depth, residence time, mixing of water bodies with different chemical signatures and hydrological regime and connectivity have all been found to correlate with riverine microbial community structure. Therefore interdisciplinary collaboration is well-suited to provide deeper insights and perspectives into the drivers and mechanisms underlying riverine microbial community compositional and functional changes. The aim of this contribution is to synthesize recent river microbial ecology research and successful interdisciplinary collaborations, and to highlight some literature gaps and emerging theoretical frameworks that provide opportunities for interdisciplinary research.

Session **SP17**

Assessing effects of nocturnal LED illumination on aquatic primary producers

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Presenting author: Maja Grubisic

Rivers are increasingly illuminated at night, due to the continuous expansion of artificial lighting. As light-emitting diodes (LED) are increasingly used in outdoor illumination, rivers are more and more frequently illuminated by LEDs. Exposure to broad-band LED light at night is expected to increase ecological effects of nocturnal illumination. While LED was found to affect numerous organisms and processes in a range of ecosystems, its effects on aquatic ecosystems remain understudied.

In small and mid-sized rivers and streams, primary production is dominated by benthic primary producers in periphyton. Primary producers use light as a key source of energy for photosynthesis and a source of information to regulate their circadian rhythms. Light emitted by LED lamps has a significant amount of photosynthetically active radiation and typically a high content of blue light that is known to entrain circadian clock in almost all living beings, including primary producers. Nocturnal LED illumination is therefore likely to have complex impacts on the physiology of periphyton, and net effects are hard to predict.

We studied effects of nocturnal blue-rich white LED light on periphyton in field and laboratory experiments. In field experiments, we found that exposure to nocturnal LED light of an intensity commonly found in urban and suburban waters (20 lux) can decrease periphyton biomass and alter its community composition by changing relative proportions of diatoms and cyanobacteria. To identify critical thresholds of impacts, we performed controlled laboratory experiments where we exposed ALAN-naïve periphyton to a range of LED intensities as found in urban and suburban waters at night (from 1 to 40 lux) and assessed its effects on biomass and photosynthetic efficiency relative to communities that experienced no light at night.

Our results contribute to our understanding of ecological impacts of artificial illumination on aquatic ecosystems. As periphyton forms the base of the food web and plays an important role in nutrient and carbon cycling in aquatic ecosystems, the changes induced by nocturnal LED illumination may cascade to higher trophic levels and influence important ecosystem functions. Our results can help inform lighting policies to minimize ecological impacts of nocturnal illumination on riverine ecosystems.

Session **SP17**

Diversity and risk patterns of freshwater megafauna: A global perspective

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Presenting author: Fengzhi He

Freshwaters are amongst the most diverse and dynamic ecosystems globally. At the same time, they are subject to intense and growing threats but remain underrepresented in both biodiversity research and conservation actions. Consequently, one third of all classified freshwater species are considered as threatened (i.e. classified as Critically Endangered, Endangered or Vulnerable) on the International Union for Conservation of Nature Red List of Threatened Species (IUCN Red List). From 1970 to 2012, populations of vertebrates in freshwaters declined by 81% - the decline rate being twice of that reported for terrestrial or marine ecosystems. Freshwater megafauna comprise animals with a body mass of 30 kg and more that spend an essential part of their life in freshwater or brackish ecosystems. They are particularly susceptible to extinction owing to their intrinsic characteristics such as large body size, complex habitat requirements and late maturity. Although many freshwater megafauna species - including river dolphins, sturgeons, crocodilians and giant turtles - are reported as being threatened, a synthesis of diversity and risk patterns of freshwater megafauna is lacking at a global scale. Therefore, based on the 30 kg threshold, we identified 207 extant freshwater megafauna species (i.e. 130 fishes, 44 reptiles, 31 mammals, 2 amphibians) and collected information on their distribution, conservation status and population trends, as well as on anthropogenic threats within their distribution ranges. Our results show that 54% of all classified freshwater megafauna species are considered as threatened according to the IUCN Red List. They are subject to intensive and increasing threats (e.g. overexploitation, dam construction, habitat degradation, pollution and species invasion) in many diversity hotspots of freshwater megafauna such as the Amazon, Congo, Mekong and Ganges-Brahmaputra river basins. Consequently, global populations of freshwater megafauna declined by 88% from 1970 to 2012. Higher rates of population decline in Indomalaya (-99%) and Palearctic (-97%) realms, and in mega-fish (-94%) were detected for this period. In addition, 42% of all freshwater megafauna species in Europe have lost more than 40% of their historical distributions. Our study highlights the dire situation of global freshwater megafauna and addresses the lack of respective monitoring and conservation actions which reflects the highly threatened but underrepresented status of freshwater ecosystems. In addition, we discuss the potential of megafauna-based approach to promote freshwater biodiversity conservation.

Session **SP17**

Streams fed by active rock glaciers: habitat, biota and conservation value

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In the present deglaciation scenario, the influence of mountain permafrost, which is shrinking at lower rates than glaciers, on Alpine stream ecosystems, is quickly increasing.

We present a research conducted in the European Alps (Solda Valley, Italy), aimed at characterising the habitat and biota of streams fed by active rock glaciers, evident form of mountain permafrost.

We compared the habitat conditions and zoobenthic communities of rock-glacial streams with those of groundwater- and glacier-fed streams, and recorded a unique habitat setting, with stable streambed and clear waters influenced by permafrost (constantly cold water [lt]1.5°C, high electrical conductivity and high concentrations of major ions and trace elements). The composition, abundance, biomass and diversity of invertebrate communities were comparable to those of non-glacial reaches, but included also cold-stenothermal species.

Thus, rock glacial streams may be considered as a unique alpine stream habitat, shaping the hydrochemistry, biodiversity and ecosystem functions of deglaciating catchments. They may act as stepping stones for the colonisation of upstream reaches, and simultaneously act as refuge areas for cold-stenothermals under increasing water temperature conditions in downstream reaches. These so far underinvestigated stream type therefore hold high conservation value, and should be the focus of research and conservation priorities in the extant state of increased exploitation of mountains by human activities, and changes in hydrology due to climate change.

Session **SP17**

Effects of an ecological flood on the mesohabitat of an Alpine regulated river

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The Spoel-Aqua Granda (Switzerland, Canton Grigione) is an Alpine river strongly impacted by 2 dams. The main impact is the flow regulation while sediment supply, despite the lack of longitudinal continuity, remains abundant due to the inputs from the steep hillslopes of the confined sections. However, because of the loss of natural floods, the residual flow is incapable of transferring the sediments downstream, thus causing bed clogging and fines accumulation. Moreover, in the less confined sections, the lack of regular disturbances led to the loss of the typical riparian vegetation.

In the late summer of 2018, an ecological flood was released on the Spoel river from Ova Spin dam. This river has a relatively long history of ecological floods dating back to 1999, however, for the reach object of this study, this was the first one. The flood wave and the discharge mimicked shape and magnitude of a slightly less 1-year return-period natural flood. The objectives of the flood were the flushing of fines and more generally the improvement of the habitat conditions for the aquatic communities.

This paper focuses solely on the fish community and more specifically, on its habitat. The day before and after the flood, a mesohabitat survey was conducted on a reach of the river. The measures encompassed: type of hydromorphological units, their depths and flow velocities. As ancillary data, also pre and post-flood drone flights were available for analysis. The surveyed data were used to infer the effects of the flood on the habitat suitability for local fish-target species and more generally to understand the response of the hydromorphological dynamics to such a type of flood.

The results show that the magnitude of the witnessed flood was not sufficient to activate significant morphological changes which, on the multi-annual temporal scale are needed to maintain fluvial dynamics. In terms of fish-habitat suitability, the flood promoted only a slight improvement. Nevertheless, flow variability improved and so did the substrate as the fines were largely flushed.

The modest effects detected are not unsurprising for this was a low magnitude flood and moreover, it was the first one, of ecological genesis, released on this reach. For the future years, regular flood releases have been planned and the reach will be monitored.

Ultimately, the ecological flood we witnessed can be addressed as "functional" for it contributes sustaining several ecological functions by enhancing habitat heterogeneity.

Session **SP17**

Understanding how hydrogeomorphological factors influence fish habitat: a case study of the River Wandle, UK.

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Presenting author: Giuditta Trinci

Flow dynamics play an essential role in the life cycle of plants and animals and are important controls on the biodiversity of river ecosystems. However, river habitat assessment focuses largely on spatially and temporally averaged flow properties rather than dynamic ones such as turbulence. This research explored the scales of variability in turbulence intensity and its links with river morphology and dissolved oxygen (DO) levels in a lowland chalk stream recently restored to improve fish habitat. We used the Modular River Survey (MoRPh) to provide a biophysical assessment of the reach and combined this with detailed topographic and hydraulic surveys and measurements of water temperature and DO to gain insights into how fish select their habitats. These combined techniques might provide a useful approach for assessing fish habitats for management.

Session **SP17**

Rivers and Plants: Perspectives on their interactions from the SMART programme

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Presenting author: Angela Gurnell

The crucial influence of plants on river form and function has been an increasing focus for research in the first two decades of the 21st century. This paper outlines advances in this research area and its relevance for river management. It illustrates these advances with reference to the SMART programme. Advances in scientific understanding of the role of plants at different spatial and temporal scales will be illustrated with reference to numerical modelling, field measurements, laboratory and field experiments, and the mining of historical information that has been conducted by SMART PhD students.

Session **SP17**

Influence of invasive Himalayan balsam on the structure of native vegetation communities and morphological processes on river banks

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Study of the impact of invasive Himalayan balsam was undertaken on eight sites at the River Brenta in Italy. The main aim was to clarify the interaction of Himalayan balsam dominance as an invasive species and morphological activity (erosion and deposition) on river banks. In order to achieve this aim, a combination of transect-based surveys and measurements of individual plants characteristics was used and three main groups of results were obtained. Firstly, Himalayan balsam dominance over native vegetation differed between sites, from partial cover to full dominance. This gradient was quantified and it was revealed that it varies widely depending on the microhabitat conditions and native plants present on each site. Secondly, transect-based measurements of morphological activity established no conclusive difference in erosion and deposition between transects covered by native vegetation and Himalayan balsam. While this finding was unexpected, it is at least partially influenced by the destruction of two sites during a mass flooding event that occurred in the middle of the survey. Thirdly, in contrast to the previous finding, measurements of individual plant traits that are known to influence the impact of vegetation on morphological activity demonstrated significant differences between native vegetation and invasive Himalayan balsam. In light of these results, the potential impacts of Himalayan balsam on geomorphological processes are discussed.

Session **SP17**

An introduction on the Biot-Savart law applications in open-channel discharge estimation

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Presenting author: Seyed Hossein Mohajeri

Discharge and mean velocity are almost the most crucial concepts in monitoring and management of any hydraulics system. Due to this fact, accurate estimation of these quantities is always a main concern. In this study, at first, a novel framework for mean velocity based on the Biot-Savart law, a common equation in electromagnetism that describes the magnetic field created by a current-carrying wire, and law of the wall will be presented. Then, applications of the developed method for estimation of river discharge in different situations composed of rectangular open-channel, compound open-channel and natural rivers will be presented and discussed. The present study observations imply the applicability of this framework in the challenging situations in river and hydraulic engineering.

Session **SP17**

Coupled morphodynamics of river bifurcations and confluences

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Presenting author: Marco Redolfi

Channel bifurcations represent key unit processes for the morphodynamic evolution of multi-thread systems, such as braided, wandering, anabranching, and anastomosing rivers. The large number of theoretical, experimental and numerical studies carried out the last two decades have provided a clear picture of the stability conditions for a single bifurcation. However, channel bifurcations are often not isolated but rather part of a complex river system characterized by its own, global dynamics. In this context, each individual bifurcation can be affected by backwater effects induced by the downstream conditions, which in turn depend on the amount of water and sediment distributed by the bifurcation itself. This mutual interaction can lead to different equilibrium states and periodic avulsions of the system, as highlighted by Salter et al. (2018) for the case of a bifurcation in a prograding delta. In this work, we specifically study the morphodynamics of bifurcation and confluence loop, where two symmetric branches diverge and then rejoin after a prescribed distance. We formulate a new nodal point relation for the mobile-bed confluence, based on the momentum balance on two distinct control volumes originally proposed by Shabayek et al. (2002), which allows determining how the bed level adjusts depending on water and sediment fluxes. We then incorporate this confluence relation into the bifurcation model of Bolla Pittaluga et al. (2003), and we analysed equilibrium states and their stability through linear perturbation methods and nonlinear numerical approach. Results reveal that when the connecting channels are relatively short the downstream confluence can significantly affect the stability of the bifurcation, potentially leading to multiple equilibrium states and hysteresis in the response of the system to varying flow conditions.

Session **SP17**

Linking theory, remote sensing and data analysis to understand the bedform dynamics of large natural meandering rivers

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River meanders form as the consequence of opposite outer bank erosion and inner bank accretion processes in natural riverine environments. Such processes give rise to beautiful, sinuous configurations of river planforms that typically exhibit an alternate, oscillating bedform configuration where sediment bars form at the inner banks, while bed scours are usually located at the outer banks, steady with respect to the instantaneous planform configurations.

On the other hand, straight narrow channels display unsteady alternate bedform configurations that migrate downstream the river reach.

The two bedform configurations are typically treated as separate and seldom have migrating bars been observed in river meanders, specifically the laboratory experiments of Kinoshita & Miwa (1974) and those of Whiting & Dietrich 1993. However, the theoretical predictions of Tubino & Seminara (1990), who developed a weakly nonlinear model for free and steady bars in meanders, clearly opened the possibility of coexistence of migrating bars and meanders.

Some field evidence was later ptovided through aerial photos of the Cross River (Nigeria) and the Parnaiba River (Brazil) by Schuurman et al. 2016; however, indivudial pictures cannot provided evidence of proper bar migration.

In the present work, we provide a multitemporal dataset of 24 rivers displaying systematic occurrence of migrating bars in large natural meandering rivers from all over the world.

Furthermore, we provide an innovative procedure that involves theoretical predictions, remote sensing and signal processing in order to better understand such complex and intriguing morphodynamic processes.

Specifically, we estimate hydromorphodynamic parameters such as width-to-depth ratio, relative roughness and shields stress for all the rivers in our dataset through literature research, measurements and hydraulic relations. We also quantify planform characteristics, such as meander wavelengths and curvature ratios, by extracting information through an extensive remote sensing analysis and continuous wavelet transforms on more than 200 Landsat multispectral images.

Such data is employed to feed the weakly nonlinear theoretical model of Tubino & Seminara (1990) in order to investigate the conditions under which alternate bars occur in natural meandering rivers. Through this innovative, interdisciplinary approach we show that alternate bars in natural meandering rivers occur under two conditions: in sand bed meandering rivers, alternate migrating bars may only occur whether the sediment transport capacity is relatively low, while alternate bars in gravel bed meandering rivers may only occur when the meander wavenumber is low enough (high amplitude meanders).

Finally, based on our results, we provide a conceptual model for summarizing the behavior of the bed configuration in natural meandering rivers.

Session **SP17**

Scientific impact of a nine-year doctoral program in river science

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Presenting author: Alyssa Serlet

Research in river science has developed rapidly in recent years combining many disciplinary fields to address emerging interdisciplinary research agendas. The SMART (Science for MAnagement of Rivers and their Tidal systems) EMJD programme was focused on the core areas of the natural and engineering sciences relevant to the sustainable management of river systems from their headwaters to estuaries. A multidisciplinary, multiscale approach was adopted that integrates relevant aspects of the physical, chemical and biological sciences, including relevant theory, monitoring and modelling techniques. By adopting this multi-scale, multidisciplinary approach, the aim was to move the field of river science forward from its current strong emphasis on discipline specific issues, frequently investigated at the reach and smaller scale, and from an emphasis on the flow regime as the driving process, to encompass multiple stressors (e.g. climate, water temperature, water quality), operating at widely varying spatial and temporal scales through complex interactions between physical, chemical and biological environmental components in different river environment settings (Gurnell and Petts, 2010; Gurnell et al., 2016).

This study provides an overview of the scientific advances within river science achieved by the SMART EMJD programme over a time span of 9 years (2011-2019). Thirty-six doctoral theses and 70 scientific publications (and growing) which have already received 831 citations were reviewed for their cutting-edge research contribution within the river science community. Three multidisciplinary research areas were defined to classify and explore these contributions: A) ecosystem resilience to stressors, B) natural functioning and C) rehabilitation of function. A further sub-classification was made in relation to geographical setting, methodological approach, temporal and spatial scale, and sub-disciplinary fields. The results highlight a highly diverse and interdisciplinary scientific contribution and impact from the SMART programme. Key outcomes from the publications and theses have also been used as a basis to identify further challenges in river science and these are evaluated in the context of broader literature sources.

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Session **SP17**

Contribution of large-scale mesocosm experiments in interdisciplinary river science: an overview of the SMART experimental activities

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Presenting author: Maria Cristina Bruno

Assessing the ecological impacts of anthropic alteration of aquatic ecosystems is difficult due to the presence of confounding and interacting factors. Large-scale mesocosms enable experiments with greater complexity, e.g., by including different trophic levels, to be conducted and to separate effects of multiple stressors on whole ecosystems. Thus, results can be extrapolated to natural systems. Within the SMART programme, four PhD projects included interdisciplinary mesocosm experiments. Two different facilities were used: i) a set of five open-air, stream-side flumes, fed by a 2nd order gravel-bed Alpine stream ("Fersina flumes", Trentino, NE Italy); ii) 24 large lake mesocosms (enclosures) reaching into the sediments ("LakeLab", IGB, Lake Stechlin, Germany).

The Fersina flumes were used by three SMART PhD students. The experiments aimed to disentangle the effects on macroinvertebrates and periphyton of: 1) HYDROPEAKING: we simulated daily 5-h hydropeaking events for five consecutive days in spring and autumn, and assessed the effects on periphyton biomass and nutritional quality, and on macroinvertebrates drift. For both biotic targets, we assessed the use of wood as a mitigation measure. 2) artificial light at night (ALAN): we simulated the light conditions of a light-polluted area in spring and autumn, and assessed the effects on periphyton growth by measuring biomass and community composition, and on zoobenthos by measuring density and composition and the induction of drift. The main findings were: 1) Repeated hydropeaking alter primary producers biomass and nutritional quality (fatty acids content), and zoobenthic communities densities and composition by inducing catastrophic drift, and availability of wood substrate may mitigate part of these effects; 2) ALAN alters biomass and composition of periphyton and potentially its nutritional quality in artificially-lit waters, and suppresses macroinvertebrates drift densities resulting in changes in benthic densities and composition.

One SMART PhD student attended a LakeLab experiment within the 'Illuminating Lake Ecosystems' (ILES) project. This project aimed to elucidate the effects of increased levels of diffuse luminance of the night sky due to human presence and activity (i.e., skyglow) on lake ecosystem function. As part of this project, a large scale mesocosm experiment was carried out, simulating three skyglow conditions (no, low and high skyglow). Through the use of a mechanistic mathematical model and a stochastic calibration of model parameters in a Bayesian framework, metabolic rates were calculated: gross primary productivity, ecosystem respiration, and net ecosystem productivity. Interpretation of results will be supported by additional laboratory results still in preparation.

This presentation will demonstrate the importance of mesocosm facilities in interdisciplinary research training and how this led to insights that would not have been possible otherwise.

Session **SP17**

Integrating point and distributed techniques with flow and heat transport modelling for upscaling the identification and quantification of hyporheic processes

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Presenting author: Jaime Gaona

The need to investigate multiple crucial processes for the ecosystem functioning of rivers requires an appropriate identification and quantification of the water exchanges taking place below and alongside rivers, in what is call the hyporheic zone. This region is where groundwater and surface water mix to define hyporheic exchange flows.

Given the inaccessibility to measure the spatiotemporal and in-depth variability of water exchanges from the sediment-water interface (i.e. infiltration and exfiltration), it is necessary to use indirect measurement techniques, such as using temperature as a tracer of flux.

Despite the simplicity of temperature measurement, scalable techniques are necessary to conduct multiple and repetitive measurements of temperature. Distributed temperature sensing techniques such as fiber-optic distributed temperature sensing enable the scaling and continuous monitoring of temperature measurements at multiple scales with high spatial and temporal resolution. Thes capabilities allow identifying the distinct spatiotemporal thermal patterns caused in the sediment-water interface by the components of hyporheic exchange: groundwater discharge, interflow and local downwelling.

Nonetheless, the quantification of the patterns of exchange is limited to the use of point methods, such as temperature profiles or vertical hydraulic gradients of the sediment, which are able to quantify the vertical component of exchange based on temperature / hydraulic gradients. Thus, 1D methods can describe the vertical distribution of exchanges. However, their reliability is challenged under complex conditions differing from their strict assumptions, such as the presence of horizontal component of flow or the concentrated dampening of the gradients. Additionally, point estimates may overlook the spatial variability of exchanges.

Some of these limitations can be avoided by integrating point and distributed information in three-dimensional (3D) numerical modelling of flow and transport of the hyporheic zone. The application of models such as MODFLOW-MT3D shows great potential for overcoming the limitations of 1D methods while enabling accurate and distributed evaluation of hyporheic exchange flows at multiple scales. In addition, 3D models can integrate EMI geophysics data which provide distributed exploration of the sediment heterogeneity. Including this data enhances the reliability of 3D models for reproducing and quantifying flow and thermal patterns of exchanges across scales.

In conclusion, this study illustrates the advantages of adopting a multi-technique approach, using point and distribute techniques to identify and quantify the spatiotemporal distribution of hyporheic exchange flows. Finally, the present study describes the potential of 3D heat and transport models to integrate multi-scale data aiming to upscale hyporheic exchange flows estimates, and the usefulness of modelling for improving our understanding of hyporheic processes.

Session **SP17**

Enhanced Retrieval of Lake Water Quality Parameters from Satellite Imagery by Extraction of Novel Spectral Features

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Remote sensing of water quality parameters in inland lakes can enable remarkable advances in a wide range of aquatic science and management applications. Satellite imagery by providing spatially distributed and temporally repeated information can play a key role in water quality indicators estimation. This improves conservation of aquatic habitats and biodiversity, understanding essential climate variables such as carbon cycle, and management of ecosystem services including urban water supplies. Water-leaving radiance, detected by satellite sensors, is affected by in-water constituents such as chlorophyll-a (Chl-a), total suspended sediment (TSS), and colored dissolved organic matter (CDOM). The variation in concentration of constituents alters the water-leaving spectra at specific portions of the spectrum. The total water-leaving radiance is affected by both the absorption and scattering properties of in-water constituents as well as the pure water ones. Therefore, it is required to extract informative and robust features from the spectral data to enable an accurate estimation of constituents. The empirical models, widely used for remote sensing of in-water constituents, are built upon regressing concentrations of the constituent of interest for several points against their associated spectra-derived features. The existing empirical methods for estimation of water quality parameters mostly rely on simple features derived from the original spectral space of optical imagery (e.g., band ratios). This research examines novel features based on applying direction cosines and transformation of either color space or the coordinate system of the original spectral space. Moreover, the optimal feature combination is determined automatically by performing an exhaustive search among all the possible combinations. The effectiveness of the proposed features is comprehensively examined against standard ones in a wide range of in-water optical conditions using radiative transfer simulations, in-situ measurements, and satellite imagery acquired over lake Constance and Lucerne. In this context, a comparative analysis is also performed on the effectiveness of spectral resolution of recent satellites with the primary focus of the aquatic science community for retrieving in-water constituents including Landsat-8, Sentinel-2, and Sentinel-3. The results suggest the outperformance of the proposed features compared to the standard ones in retrieving the lake water quality parameters.

Session **SP17**

Integrated river basin management in developing countries. Lessons learned from an international intersectoral interdisciplinary effort to better manage the Salado River Basin, Paraguay

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In developing countries, river basins face a series of challenges naturally posed by economic growth like rapidly increasing population, unplanned urbanisation, industrialisation and land use change. The context is usually characterised by insufficient freshwater supply and wastewater treatment infrastructure. Institutional disorder is common, environmental policies, if existent, are lacking, and the enforcement of law and regulations is in general weak. As a result, governments do not normally support scientific research or continuous monitoring programmes of their water resources, except when these become politically relevant. Climate change introduces yet new challenges, linked to changing meteorological patterns that modify hydrologic ones. Major engineering interventions can also alter the hydraulic response of the basin's water bodies, compromising the validity and usefulness of the already limited available datasets.

This is the case of the Salado River Basin, of major importance in landlocked Paraguay, partly because the metropolitan area of Asunción, its capital and most populous city, reaches into it, and partly because it includes its most important lake: Ypacaraí Lake. Not only does this lake support a rich biodiversity and provide a major source of drinking and irrigation water, but it also holds a special place in the hearts of Paraguayans as the country's most iconic lake, attracting a lot of tourism. Mainly due to this high socioeconomic and cultural significance, its current state of pollution and eutrophication, which has already resulted in harmful cyanobacterial blooms, has received a lot of attention in national media, making it a highly sensitive political issue.

So far, actions to halt its environmental degradation have had little success due to many factors. The data base that is available for a proper analysis of the system is insufficient. Knowledge about the dynamics of the Salado River system, which besides the lake includes impacted urban streams and interconnected wetland areas, is very limited. Also weighing in are the lack of a long-term scientific programme that considers all aspects of the problem, an ineffective communication between sectors and the discontinuity of many isolated projects and initiatives proposed over the years.

Here, we present our take on how to move towards an integrated river basin management in the context of a developing country, resulting from a recent coordinated international, intersectoral, interdisciplinary effort we undertook to set a course correction in the case of this basin. By extensively reviewing the history and current scientific understanding of the system, engineering interventions and implemented management strategies, we identified some of the most pressing research needs and started addressing them through several academic theses in international collaboration, bridging the gap between science and management by actively engaging with authorities and practitioners.

Session **SP17**

Promoting creativity and teamwork in science

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Presenting author: Klement Tockner

Innovative research requires intellectually diverse teams of people, and diverse teams often outperform homogeneous groups, even homogeneous groups of high-performing individuals. Hence, leading research institutes go well beyond traditional metrics (e.g. grant money and number of scientific publications) in assessing potential candidates for open positions. Furthermore, crossing thematic, institutional, and geographic borders may facilitate creativity and accelerate innovation; and inter- and transdisciplinary research is required in understanding of and coping with the increasingly complex societal challenges we are facing. At the same time, academic freedom is under continuous pressure; hence, skills in research ethics and research integrity are of pivotal importance for researchers.

Session **SP18**

A cross-continental evaluation of the response patterns of fish assemblages to landscape-scale human stressors in European' and United States' major freshwater habitats

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Presenting author: Rafaela Schinegger

Riverine ecosystems and their related services are threatened by manifold human activities all over the planet. Dominant human stressors differ regionally, with differences pronounced over large spatial extents. Consequently, anthropogenic impacts on fluvial fish habitats and their fish communities vary between regions and sometimes also between continents. Thus, our main objectives are for the freshwater ecoregions and main habitat types of Europe and the United States to (1) understand patterns of human stressors at these large scales, (2) compare the response of fish metrics to stressors and (3) draw general conclusions for future aquatic ecosystem assessment and management world-wide. Based on a comprehensive database to assess rivers in the United States and Europe, an innovative, cross- continental analysis on the response of fish communities to large-scale human stressors, including various land use categories, human population- and road crossing density was conducted. The joint database comprises information on fish assemblage traits collected by single-pass electrofishing of over 30,000 fish sampling sites spread across 55 Freshwater Ecoregions and in 7 Habitat Types. Eight fish metrics based on relative abundance values were available for cross-continental evaluation, i.e. species intolerant to degradation in general as well as lithophilic-, rheophilic, phytophilic-, speleophilic- and potamodromous species. A generalized and replicable methodology was applied for both continents. First, we assessed the comparability of sampling sites and eliminated spatial autocorrelation by the use of Moran's I Eigenvector Based Spatial Filtering, second we controlled for natural variation by the use of boosted regression trees (BRTs) and third, we detected fish assemblage's responses to large-scale stressors. Overall, 528 significant responses of fish assemblages to stressors (in form of threshold values) were detected for 17 fish metrics in 28 ecoregions at both continents. The results show that the investigated stressors at the network catchment scale were more pervasive and caused a more severe impact on fish communities in most ecoregions than at the local catchment scale. Urban land use and human population density combined accounted for 60% of all the identified significant thresholds. As a consequence, especially the impact of urbanized areas has to be a focus for future river basin management.

Session **SP18**

Assessing Condition of Stream Fish Habitats throughout the Mississippi River Basin

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The Mississippi River is the largest in North America, draining approximately 3.26 million km2 of the U.S., as well as portions of two Canadian provinces into the Gulf of Mexico. Many human stressors occur throughout the basin including agriculture, urbanization, nutrient loading, and stream network fragmentation by dams and road/stream crossings, affecting habitats of hundreds of ecologically- and socioeconomically-important stream fishes. Consistent and comprehensive information is essential to support decision making on where and how to conserve stream fish and their habitats when managing for both current stressors and future changes resulting from changes in climate, especially across large regions such as the Mississippi River Basin. To help meet this need, we have conducted a current condition assessment of stream fish habitats based on threshold responses of sensitive fish species to human land use in stream catchments, nutrient loading in catchments, and network fragmentation by dams and road/stream crossings. We have generated three specific indices characterizing the relative condition of stream fish habitats to these discrete disturbance types for all stream reaches in the basin. Spatially-explicit results for these indices may be used together to identify locations with minimal disturbance that could be protected or areas with disturbance from only a single stressor type (e.g. fragmentation by dams, nutrient loading) that could be restored. Additionally, these indices may be combined with other spatial information including locations where air temperature and precipitation patterns may change with changes in climate. Our results can directly inform conservation efforts of stream fishes throughout the Mississippi River basin by providing critical information that supports decision making on where and how to prioritize conservation actions for stream fishes and their habitats.

Session **SP18**

Linking Local to Landscape Metrics to Aquatic Biodiversity to Prioritize Streams in a Diverse Landscape

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Many current efforts to forecast biotic conditions in streams are based on top-down approaches using landscape-level anthropogenic disturbance data. These approaches represent surrogate measures of in-stream habitat and water quality metrics, and are limited in their ability to describe the mechanistic response of streams' physical, chemical, and biological characteristics to landscape alterations. We developed a bottom-up approach for testing local habitat and water quality metrics' effects on stream fish community structure using data collected from wadeable streams in Missouri, USA between 2000 and 2013 in two distinct ecoregions. The Central Plains Ecoregion (242 stream samples) has primarily agriculture land with some large urban centers (e.g., Kansas City, MO). The Ozark Ecoregion (361 stream samples) has primarily forested watersheds with less agriculture than the Plains but still has urban centers. After accounting for natural sources of biological variation (e.g., watershed drainage area, reach gradient), we used boosted regression trees to model the influence of channel morphology, substrate, cover, and water quality, and watershed-level flow modification and fragmentation, urbanization, agriculture, and point-source pollution on stream fish and aquatic macroinvertebrate community characteristics of wadeable streams of Missouri. Reach-level environmental predictors explained between 8% and 46% of the variation in our ten biotic metrics, with channel morphology and water quality metrics consistently accounting for more variation than substrate or cover. Biotic metrics related to stream health (e.g., Ephemeroptera, Plecoptera, Trichoptera richness, native lithophilic fish species richness) increased with bankfull width/depth ratios and dissolved oxygen, and decreased with increasing total chlorophyll. Watershed-level environmental predictors accounted for between 4% and 51% of the variation in biotic metrics, with stream health metrics increased with forest cover, and decreased with increased headwater impoundment density, road crossings, and pasture lands. In general, invertebrate metrics showed higher sensitivity to row-cropping and water quality impairment than did fish metrics, particularly in the Ozarks. We used these results to predict biotic metric values at over 28,000 wadeable stream reaches across Missouri to generate an overall estimate of biological integrity at each site. Some of the high-quality stream were relatively near urban centers, which could provide an opportunity for demonstration projects to raise public awareness on the value of protecting biodiversity in stream systems. Our methods represents a novel approach to characterizing and forecasting stream impairment, and can be used to prioritize streams for protection and restoration of biodiversity.

Session **SP18**

The influence of best management practices on stream biota

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Watershed approaches to management are critical to the conservation and management of aquatic organisms. Land use changes may affect fishes by reducing water quality and by altering substrate heterogeneity, water temperature, physical habitat, and allochthonous energy inputs. Agriculture and urbanization in a watershed may increase sediment, nutrients, and pollution inputs into streams, while also changing the stream temperature and flow patterns, ultimately leading to a degraded biotic community. Most landscape level assessments provide a coarse filter approach to identify these stressors and use metrics like the percent agriculture or urban land in the upstream watershed as surrogates for physical or biotic responses. Our objective was to link biotic response to measures of water quality to predict how biotic communities may respond to Best Management Practices within watersheds.

Best Management Practices (BMPs) are conservation practices aimed at addressing an environmental problem and have become increasingly common over the last few decades. In aquatic systems, BMPs typically focus on issues such as soil erosion and non-point source pollution to improve or maintain water quality. Examples of BMPs include no-till of agricultural lands, planting cover crops, and leaving a vegetated buffer between an agriculture field and a water body. In general the intent of BMPs relative to aquatic systems is to reduce or maintain a set standard of water quality. For example, a compilation of 22 field studies on sediment removal efficiency for vegetated riparian buffers found that riparian buffer widths of at least 30 m removed roughly 85% of the sediment delivered to the stream from the adjacent land (Sweeney and Newbold 2014).

We demonstrate our approach using two watersheds in differing ecoregions where one is in a highly agricultural matrix and the other in a forested matrix. We leveraged a regional dataset of standardized sampling for aquatic taxa and water quality to identify stream species in each ecoregion that were sensitive to total phosphorus, total nitrogen, and total suspended solids. Sensitivity was based on changes in abundance across gradients of each water quality measurement. We developed a baseline model of water quality for all stream segments in the two selected watersheds using a water quality modeling toolset called Soil and Water Assessment Tool (SWAT; http://swat.tamu.edu/). BMPs were categorized by type (e.g. no tillage, grassed waterway) and intent relative to aquatic conditions (e.g. reduce soil erosion, reduce flooding) for this assessment. We then estimated the cumulative impact of BMPs on water quality parameters and predicted the associated fish community under different scenarios of BMP placement and type.

Session **SP18**

The effect of woody riparian buffer strips on river macroinvertebrates: A comparative and complementary study on two large datasets from Central Europe - a focus on general effects in a French dataset

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In temperate regions, most rivers cross or have sections bordered by riparian forest. These riparian buffer strips offer benefits for biodiversity: (i) They improve the quality of water by retaining nutrients, pesticides and fine sediments; (ii) their shadings temper the heating of water by direct radiation and can limit the negative effects of climate change and (iii) the supply of leaves and twigs are food sources for freshwater organisms. While literature highlights the importance of local effects, there is limited knowledge about the effects of upstream woody riparian buffer strips on biodiversity, i.e. at the river network scale. The OSCAR project (Optimising the configuration of woody riparian buffer strips along rivers to enhance biodiversity and ecosystem services) aims at synthesizing and complementing the knowledge on the effects of riparian buffer strips at multiple spatial scales (local and upstream) in two comparative and complementary studies on two large datasets from France and Germany.

In this first study from France, we present and use a structural equation model (developed with the Partial Least Square Path modelling approach) to investigate the general relationships and effects at the different spatial scales by linking variables describing (i) land use at the reach scale and at the watershed scale, (ii) riparian buffer strips at the reach scale and at the watershed scale, (iii) hydromorphological characteristics, (iv) chemical characteristics, and (v) river characteristics. This method quantifies the direct, indirect and total effects of local and upstream riparian buffer strips and their contributions towards other variables. This analysis was based on 1672 macroinvertebrate samples (mainly at genus-level) covering a large geographical area of France with 4 landscape-types (limestone lowlands, non-limestone lowlands, medium limestone mountains and medium non-limestone mountains). We hypothesized that the spatial arrangement of the woody riparian buffer strips determines their multiple functions. For example, upstream woody riparian buffer strips can modify water temperature and the input of CPOM, locally favouring species sensitive to water temperature and shredders. This study enhances a better understanding of the role of buffer strips in the landscape to improve river biodiversity.

Session **SP18**

The effect of woody riparian buffer strips on river macroinvertebrates: A comparative and complementary study on two large datasets from Central Europe - a focus on specific effects in a German dataset

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Woody riparian vegetation benefits stream biodiversity through multiple pathways: (i) intersection of solar radiation, (ii) provisioning of leaf litter plus other forms of CPOM and (iii) buffering nutrient inputs all regulate the food web across multiple trophic levels, whereas (iv) large woody debris, (v) sediment retention and (vi) bank structuring affect habitat conditions. Re-establishing and maintaining trees along rivers are common conservation and restoration measures. While local effects are partly understood, there is limited knowledge on the importance of these mechanisms on river biota at larger spatial scales. The OSCAR project (Optimising the configuration of woody riparian buffer strips along rivers to enhance biodiversity and ecosystem services) aims at synthesizing and disentangling the knowledge on the effects of riparian buffer strips at multiple spatial scales (local and downstream) in two comparative and complementary studies on two large datasets from France and Germany.

In this second study, macroinvertebrate biodiversity was quantified using 8,500 samples, mainly at species-level, from western and central Germany. Since resolution of official national data on land use does not suffice to account for small woody features along watercourses, more than 35,000 high resolution orthophotos were analysed. This allowed identification down to single trees along the river networks, information not previously available in data covering such geographic scale. The local conditions at the sampling sites as well as woody vegetation in 500 m segments, up to 5km upstream (including tributaries and headwaters) and in buffers of three different widths (10 m, 30 m, twelve times wetted width) were considered to account for different spatial scales.

Based on these data, a structural equation model (SEM) was populated to investigate the relationship between woody riparian vegetation at different spatial scales and macroinvertebrate biodiversity through its multiple pathways (i-vi) while considering confounding variables like catchment land use (forest, grass, arable, urban) and hydromorphological alterations to account for multiple pressures in anthropogenically impacted landscapes.

Results of these analyses were used to identify the spatial scale most influential regarding the macroinvertebrate community (taxonomic groups, functional traits, diversity indices, indices of biotic integrity). Results of the SEM were compared to findings of the similar study from France. Its predictor variables found to be most relevant in this approach were applied to address more detailed effects of woody riparian vegetation on macroinvertebrate communities. This results in recommendations towards more efficient conservation and restoration measures by addressing the spatial configuration of woody riparian buffers strips along the upstream river network.

Session **SP18**

European Fish Community Macrohabitat Types - a baseline for river management.

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Presenting author: Kamila Belka

This paper presents a map of the Fish Community Macro Habitat Types (FCMacHT), which support a specific reference structure of the fish fauna at the European scale. This typology is based on a selected physio-geographic factors determining habitat conditions for Expected Fish Communities (EFC) - a quantitative structure of fish community in a given habitat based on the 11 macro habitat use and tolerance guilds of the selected non-disturbed sites.

The European Intercalibration database containing electrofishing data from 19 countries as well as Catchment Characterisation and Modelling River and Catchment Database, , European Soil Database, International Hydrogeological Map of Europe 1:1,500,000, and the Environmental Stratification of Europe dataset are used to establish the relationship between the catchment level physical setting and the expected, reference fish community structure.

The proportional composition of the guilds found in the reference sites, together with described environmental attributes of those sites such as size of catchment, Strahler stream order, slope of a river segment, mean altitude of a river segment, geological type and environmental zone determined the macrohabitat typology of the waterbodies.

Two step cluster and discriminant analysis was applied for the statistical analysis of 1099 undisturbed fishing sites First we clustered only environmental attributes, then we clustered relative fish abundances together with environmental classes. This offered a robust and accurate model (R=0.98, p<0.001) of 15 FCMacHT classes. Subsequently a Classification and Regression Trees (CART) model has been applied to develop classification trees presenting the relationship between the macro scale environmental attributes and FCMacHT class. This allowed to predict those classes to all riverine waterbodies in Europe. The model offered 86% of correct classification.

This template model of Expected Fish Community habitat is established on catchment scale attributes, which are not sensitive to human induced alterations. It allows therefore to define Europe-wide benchmark for impact assessment and defining restoration goals such as environmental flows or ecological potential. This work is a deliverable of EC funded AMBER project.

Session **SP18**

All kinds of inland navigation significantly add to multiple pressures on fish in large rivers

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Presenting author: Petr Zajicek

Beside the multiple human influences cumulating in large rivers, the latter have been further modified to waterways. Ecological impacts of vessel operation on fish are well described; however, they have rarely been studied in interaction with other stressors. Therefore, a unique dataset has been assembled and analyzed consisting of 250 fish samplings at 77 sites in eight large rivers, with all sites characterized by ten categorized human induced stressors as well as quantitative information on load and frequency of different vessel types. Corresponding to our initial hypotheses cargo vessel traffic appeared as significant impact on river fishes and functional guilds even in multi-pressure environments. The frequency of passing cargo vessels had the second highest average relative influence (16%) among 110 pressure-response combinations after increased flow velocity (39%) and before the loss of floodplains (11%). The impact of cargo vessel frequency on fish densities was even higher (23%) resulting in significant declines of lithophilic, phytophilic and psammophilic fish. Going further into detail for different modes of navigation, cruising vessels and sport boats had likewise significant impacts on fish densities that were further distinctive form those of cargo vessels. Both touristic vessel types' operation resulted not only in significant declines of lithophilic and rheophilic fish, but also of the rather generalistic, eurytopic fishes. This indicates that the specific impacts from cruising and pleasure boats more generally affect the early live stages of all species and guilds. Among the two touristic modes of inland navigation, sport boats appeared substantially more detrimental than river cruisers impacting fish already at a frequency of ten passing boats per day. In sum, inland navigation significantly contributes to the decline of river fish assemblages on top of hydromorphological degradation, diffuse source pollution and other stressors in large rivers. Furthermore, all kinds of motorized vessel operation have distinct, significant impacts on river fishes and sensitive functional guilds. The latter is in particular relevant, because touristic navigation is the fastest growing sector of inland navigation. Further improvement of the touristic utilization of waterways will compromise ecological improvements if not specifically addressed in river rehabilitation efforts. This finding has tremendous consequences for initiatives such as The Blue Belt ("Das Blaue Band") in Germany aiming at increasing the ecological quality of waterways while fostering recreational sport boat activities at the same time.

Session **SP18**

AQUATAG - Preferences, dynamics and ecological consequences of water-bound recreational activities

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Popular recreational activities associated with rivers and lakes, such as swimming, angling, jogging, boating, paddling or walking can, in addition to providing a range of positive effects for human well-being, have negative impacts on aquatic ecosystems and biodiversity. Direct recreational-induced consequences include the introduction of pollutants e.g. nutrients, detergents or pathogens and physical stress caused by boat waves, damage to vegetation, and other disturbances from visitors or engines. These issues can cause a change in the behaviour of wild animals and alter habitat structure and function, collectively affecting species communities. We assume that short-term and locally extremely high use densities and frequencies, as they occur at popular locations on summer weekends, are of disproportionate importance for the functioning of aquatic ecosystems and biodiversity. However, comprehensive spatially explicit approaches measuring these extreme events of water-based recreation are rare. Relatedly, the functional relationships between use dynamics, their effects on aquatic biodiversity and their significance for recreational quality are still only partially understood. We aim to (i) quantify the frequency, user preferences and ecological effects of various water-based recreational activities to (ii) derive socio-ecological carrying capacities and to (iii) develop management recommendations that contribute to achieving social and ecological management objectives. Here we present the results of a literature study on ecological effects associated with water-based recreational activities. In addition, we quantified the use dynamics of freshwater ecosystem-related recreation in Germany derived from geotagged data of the social network Twitter. We analysed about 3.3 million tweets posted during the years 2012-2015 and transformed these into an utilisation model for Germany via boosted regression trees and Bayesian networks. Use dynamics of water-based recreation was found to be depending on weather, land use and distance to the water body. Moreover, spatial patterns indicated a strong shift in recreational use from urban areas to suburban recreational areas on hot summer days and during weekends. When such use dynamics coincide with sensitive periods in the life-cycle of certain taxa (e.g., breeding birds in spring), important long-term consequences for freshwater biodiversity could occur, which is an open question to be addressed in the future.

Session **SP18**

Challenges in restoring aquatic biodiversity in the Yangtze River Basin under multiple human landscape stressors

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Presenting author: Yushun Chen

The Yangtze River Basin (YRB) is a global hotspot for fisheries and biodiversity conservation. It plays extremely important economic, social, cultural, and ecological roles in China. However, few studies have holistically considered the landscape-aquatic linkages for aquatic biodiversity conservation in the YRB.

In this study, we identified major human landscape stressors to fish assemblages from the headwater region to the estuary of the YRB. We found that riparian erosion was one of the key stressors in the headwater region; cascade dams and hydrological modifications were key stressors in the upper reach; sand mining, navigation, overfishing, agriculture and urban development were key stressors in the middle and lower reaches; and upstream pollution was dominant in the estuary. Temporal trend analysis of related landscape stressors showed continued human impacts in the YRB, especially navigation, urban development, and dams, and the expansion of landscape stressors remains the biggest challenge in restoring aquatic biodiversity in the YRB. We discuss recommendations including large scale restorations and monitoring, and we also describe specific management activities including seasonal closures of fishing, restoration of selected tributaries, ecological flow management, and fish stocking to conserve biodiversity of the YRB.

Session **SP18**

Assessing the importance of riverine fisheries as metacoupled human and natural systems

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Riverine fisheries are ecologically and socioeconomically important worldwide. Although we know these fisheries involve interactions among biota, habitats, and humans, systematic assessment of the nature and importance of their social-ecological couplings is relatively scarce and difficult to measure. However, new approaches to study coupled human and natural systems (CHANS) offer insights for informing and advancing riverine fisheries research, management, and governance. The recently developed telecoupling and metacoupling frameworks are systematic approaches for studying and managing the myriad number of social-ecological linkages (i.e., telecouplings, metacouplings) associated with riverine fisheries and ultimately to ecosystem health and societal well-being. For instance, Michigan salmonid stream fisheries for brook charr (Salvelinus fontinalis), brown trout (Salmo trutta), and rainbow trout (Oncorhynchus mykiss) encompass complex telecoupled and metacoupled processes of fish production, migration, financial exchange, and information transfer between sending and receiving systems. Moreover, environmental changes to these riverine systems has resulted from changes in the land and waterscapes particularly as related to urbanization and climate change. We found that these stressors have the potential to significantly alter stream temperatures which will result in historically valuable coldwater streams becoming less suitable for salmonid growth and survival. This talk describes how the telecoupling and metacoupling frameworks promote flow-based riverine fisheries governance - the management of interconnected relationships among sending, receiving, and spillover systems to better understand, conserve, and enhance riverine fisheries systems and their value to society in an ever-connected globalized world.

Session **SP18**

Assessing the contribution of protected landscapes for conserving river fishes across the United States

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To evaluate species protection, spatial characterizations of species' distributions and protected landscapes can be combined to identify the degree to which a given species' range is sufficiently protected and ideally, to highlight species that may need additional protection. For river fishes, such an evaluation should occur throughout river networks in which species occur in order to provide a comprehensive assessment of species status. Our project helps to meet that need by developing species distributions models (SDMs) for 150 common river fish species found across the United States identified as priorities by natural resource managers. SDMs were developed using boosted regression trees from a database of fish presence/absence records from more than 40,000 river reaches throughout the country, along with a set of 14 natural and anthropogenic landscape variables summarized in river catchments. Model results were constrained by ecoregion to help account for natural landscape influences on distributions of river fishes and to most effectively characterize the full suite of suitable habitat available across the country. Our results highlight differential sensitivities of river fish species to anthropogenic stressors as well as strong associations between distributions of some fish species and climatic factors. Additionally, we couple our results with spatial locations of landscapes protected under two different scenarios, lands strictly managed for biodiversity (e.g., highly restricted use) and lands that are less stringently protected (e.g., multiple use; including grazing, resource extraction such as logging and mining, and off-road vehicle use). Drawing from previous work, we consider threshold responses of fish species to catchment urban and agricultural land uses to identify levels beyond which increases in urban and agricultural land use would result in dramatic decreases in numbers of a given species. We then use these protection target levels" or PTLs to assess the amount of catchment required for protection of species in each ecoregion. Results show that fewer than 2% of river catchments in the conterminous United States meet the proposed PTLs under the restricted use scenario, while only 16% of catchments meet PTLs based on the multiple use scenario, with most protected lands concentrated in the western U.S. Our results indicate that in the conterminous United States, protected landscapes may be severely limited for many river fishes, and that managers may need to consider alternative actions to conserve river fishes from both current and future threats."

Session **SP19**

Riparian vegetation dynamics of the multi-thread river system in Slovak Carpathians

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Presenting author: Anna Kidová

Riparian vegetation represents migration between land and water ecosystems with surface and underground hydrological interconnection with the floodplain. From the geomorphology point of view, the riparian vegetation in the study high-energy braided-wandering Belá River is important mainly for its stability function during flood discharges. The significance of riparian vegetation is mainly related to the evolution of its multi-thread river pattern. Its influence on fluvial processes is manifested mainly by the reduction of the channel width, the braided and wandering indexes, thus also affecting the flow dynamics and the cohesion of the river bed and banks. On the whole river length (23.6 km) we analysed relation between vegetation structure (type and density) and fluvial forms based on vegetation patches on gravel bars with different succession phases. Changes on vegetation patches area were analysed in seven time spans since 1949 to 2009 where we distinguished four types of vegetation cover - without vegetation (up to 10% herb vegetation cover), sparse vegetation (up to 50 % herb and shrub vegetation cover), dense vegetation (over 50 % herb and shrub vegetation cover), island (more than 90 % tree vegetation cover). Area size and structure/ type of vegetation cover dynamically reacts as a positive feedback on the flow rate changes and directly influences the local variability of sedimentation rate and fluvial forms formation. The declining type of vegetation area up to 10% and 50% of central bars and the greater spread of small areas with a vegetation cover more than 50% have a negative impact on the Belá River in terms of degradation of the braided and wandering river pattern. On the larger scale, on the selected unmanaged river reach of the Belá River, we compared bio-geomorphologic changes between 2012 and 2018. Aims of the presented study was to i) identify the vegetation species which are responsible for stabilization of the in-channel landforms and banks and ii) determine the geomorphic feedback between in-channel processes and vegetation succession. Phytocoenological registrations according to Zürrych-Montpellier school (Braun-Blanquet, 1964) were realized in the study river reach. The grain size and vegetation homogeneous 4x4m square area were selected on every in-channel form (bar, island) and floodplain on cross-section width. Plant representation was evaluated by a nine-step Braun-Blanquet scale of abundance and dominance. During study time span (2012-2018) the discharges overstepped the 5-years discharge only in 2014 and 10-years discharge only in 2018 what was sufficient for in-channel riparian vegetation reduction as well as rejuvenation.

Session **SP19**

Do boundaries of Flood Hazard Maps reflect vegetation characteristics?

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Floodplains provide a variety of habitats for plants and animals, among them some endangered species. However, floodplain dynamics are disturbed in all Central European rivers due to human interactions and morphological floodplain boundaries do not correspond to active floodplains anymore. As consequence, typical floodplain habitats are classified as endangered.

In Germany, the statistical occurrence of once in 100 year-floods (HQ100) was applied to define active floodplain borders. With the EU-Floods Directive a EU wide approach was implemented to map more frequent floods that statistically occur once in five to 50, mostly once in ten years (HQ10). This frequency might serve as a better basis regarding floodplain functionality than HQ100-borders. However it has not been tested whether these boundaries actually correspond to functional floodplain habitats and their typical vegetation, and can thus serve as a new definition of active floodplains. The research question of this project is: How do floodplain borders differ regarding the consideration of different flood frequencies? How are these borders reflected by vegetation?

Flood hazard maps were obtained from the Federal States of Germany. Additionally, for several Federal Water Ways results of the Software FLYS were obtained from the German Federal Institute of Hydrology (BfG) for modelled borders of more frequent floods (HQ1 and HQ5). Vegetation relevés from various projects along Federal Waterways were standardized and intersected with these maps to obtain the respective statistical inundation frequency for each relevé (HQ1, HQ5, HQ10 or HQ20, HQ100). We looked for typical floodplain species and most frequent species. Ellenberg's moisture indicator values (MIV) are selected as tool to compare the respective values between characteristic species of several Natura 2000 floodplain habitats with the available dataset. Therefore the datasets are grouped according to different HQ-areas and floodplain typical habitats such as grassland and river banks. For further comparisons an unbiased classification of vegetation types is obtained by a cluster analysis.

The first results indicate that there is little difference in the vegetation of each habitat between HQ10 and HQ20 and HQ100 areas. All habitats within these HQ-areas show a shifted range of MIV towards less moist conditions compared to the MIV of the Natura 2000-floodplain habitats.

From our analysis we see the pattern described by many authors that on the species level typical floodplain species can hardly be identified because many floodplain species are ubiquitous (e.g. Urtica diocia or Elymus repens). Therefore the cluster analysis will help to identify similar groups of vegetation within the different areas to look for other driving parameters than soil moisture alone as MIV does. However, it still remains unclear how long the effect of high floods lasts in our floodplains where inundation dynamics are far from natural.

Session **SP19**

COST Action CONVERGES : A network approach of riparian vegetation assessement at European scale

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Riparian ecosystems belong to the ecosystems most modified by human pressures. They provide essential hydrological and ecological functions and their vegetation represents one of the main components of river functioning. Riparian vegetation interacts with fluvial processes, plays a significant role in flood prone areas and provides multiple ecosystem services. However, riparian vegetation remains marginal in EU normative assets (e.g. the Water Framework Directive) and vegetation-mediated processes are globally neglected in water policy debates. Thus, despite the advances in research and EU policies requirements in terms of biodiversity, water resources and flood-risk management, to date, no pan-european agrrement exists in the characterization and assessment of riparian vegetation, and no continental scale synthesis of riparian vegetation status and pressures has been done for Europe. To adress these issues, a european network (named « CONVERGES ») has been launched through a COST Action for the period 2017-2021. The goals of CONVERGES are i) to establish a baseline in the state of knowledge regarding riparian vegetation; ii) to coordinate and share research efforts among countries ; iii) to contribute to knowledge conversion from science to practitioners ; and iv) to promote common research interests between practitioners and the scientific community. We present how this network is tackling the issues of characterization and assessment of status and pressures of riparian vegetation at European scale. Notably we present works developed about phytosociological approaches, european assessment protocols, analysis of the relationships between pressures and status, and synthesis of ecosystem services provided by riparian vegetation

Session **SP19**

Biogeomorphology from space: Using optical satellite imagery time series for analyzing the dynamic interaction of vegetation and hydromorphology along the Naryn River, Kyrgyzstan

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The structure and development of riparian vegetation is controlled by an interplay of hydrological, geomorphological and ecological processes. Over the past decade, the concept of biogeomorphology has become more and more relevant in river science to describe and analyze these manifold interactions. Meanwhile, a large number of studies exist within the emerging field of biogeomorphology. However, the majority of this work focuses either on conceptual development or on local investigations on the plot or reach scale. Only very few studies enlarge the spatial scale to the river corridor or network scale despite the fact that recent conceptual models emphasize this scale to be relevant for river research and management. For instance, LiDAR or high resolution satellite imagery has been used to characterize riparian vegetation and its linkage to hydromorphological processes at the network scale. Due to the high costs of such data sets, analysis is constrained to single date or maximum inter-annual time steps. This is a potential shortfall in riverine ecosystems being characterized by high hydrological and morphological dynamics. In addition, for many developing countries such data sets do not exist at all. In terrestrial ecology, the use of time series of optical satellite imagery has recently become popular to analyze vegetation development over time including trends and disturbances. However, to our knowledge such approach has not yet been applied to the assessment of biogeomorphology of river systems. In this study, we present an analysis of biogeomorphological interactions for the Naryn River in Kyrgyzstan based on field mapping and an analysis of Landsat and Sentinel-2 time series. This river is still in a natural state on an entire flow length of more than 600 km without dams or embankments. Along the central part of the catchment, the Naryn is a highly dynamic braided river system shaped by the annual summer floods of a glacial discharge regime. This makes the Naryn River ideal to study large scale biogeomorphological dynamics. In our study, we follow the concept of biogeomorphological succession suggested by Dov Corenblit and discriminate four phases: A biogeomorphological phase, a pioneer phase, a biogeomorphological phase and an ecological phase. We mapped these phases in the field and used the results to train algorithms for the classification of the satellite imagery. The results show that a classification surface phenology (i.e. the temporal trajectory of the spectral indices within one year) is critical for the accuracy of the classification. In addition, we use statistical time series analysis to assess trends and breakpoints of spectral indices. The results show that dense time series of optical satellite imagery are suitable indicators for biogeomorphological dynamics of rivers on a large spatial scale. Especially the Sentinel-2 imagery will provide useful information about the dynamics of riparian ecosystems.

Session **SP19**

Coexisting with cottonwood: a flood-dependent species in a flood-intolerant world

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Worldwide, many rivers have been trained to occupy straight and static channels in order to reduce flooding and to increase the amount of land available for agriculture and development. Floodplains and the unique forests that occupy them can become casualties of this practice. In the dry Okanagan region of British Columbia, black cottonwood forests and the species they support are at risk of becoming extirpated. In order to understand how river training has affected forest stand structure in this area, we surveyed cottonwood stands at 43 sites across 6 rivers that were either affected by diking, channelization, both, or neither. We measured tree size, recruitment rates, topography, and substrate. We found that diking alone had little impact on stand structure compared to reference sites. In contrast, stem density of new recruits at sites that were both diked and channelized could either be well above or well below reference sites depending on whether or not trees were permitted to grow on dikes. The lateral extent of cottonwood forests along channelized rivers without dikes was severely constrained, due to encroachment of developed land and high streambank gradients that limited root access to water. Channelized streams were also the most densely occupied by competing non-native and upland tree species. To ascertain whether or not cottonwood forest restoration is possible given the current hydrological milieu, we planted young trees at a range of different elevations and positions relative to the water in the Okanagan and Similkameen valleys and measured their growth and survival along with a selection of environmental variables. In keeping with what is already known about this species, we found that root access to water was paramount for the survival of cuttings and seedlings. Diked planting sites tended to be located at higher elevations relative to the water table, and were associated with higher mortality rates compared to un-diked sites. Survival and growth rates were positively related to cutting size, with date and temperature being more critical factors for seedling survival. In areas where dikes had been set back several years before in an attempt to restore floodplain habitat, natural recruitment rates were poor, and mature trees tended to exhibit high rates of water stress and herbivory. Adaptive management at one of these sites in the form of floodplain excavation and a mass planting event are expected to improve outcomes for cottonwood. Overall, this work highlights the primacy of water in the challenges faced by an important riparian tree species along engineered rivers, both in conservation and restoration contexts.

Session **SP19**

Short-term temporal and spatial dynamics of herbaceous vegetation and their drivers in a highly regulated floodplain system.

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Floodplains are biodiversity hotspots and provide numerous ecosystem services. However due to heavy anthropogenic impacts floodplain systems were dramatically altered. This is also true for the floodplain system of the Weiße Elster near the city of Leipzig, Germany, where anthropogenic regulations were intensified in the 20th century. Nevertheless, a relatively high proportion of the former floodplain hardwood forest remained in a near-natural state. But as a direct consequence of the regulations and missing dynamics, we already see a change in species composition. For a long-term conservation of the characteristic floodplain biodiversity there is the need for revitalization measures. To be able to predict and evaluate improvements of the ecological state resulting from revitalization measures, a long-term monitoring was set up including 60 permanent plots (0.25ha each). These plots were inventoried for woody and herbaceous vegetation and different environmental variables including light, soil and groundwater over a period of five subsequent years (2013-2017). We analyzed the short-term temporal and spatial dynamics (beta-diversity) of the herbaceous vegetation and identified the drivers of community assembly.

We found a significant homogenization of species composition throughout the 5 subsequent years. Temporal variation of the herbaceous vegetation significantly increased with temporal variation of the groundwater availability especially at sites with a high groundwater availability throughout the vegetation period. The higher the abundance of allelopathic Allium ursinum the smaller was the richness and the temporal turnover of co-occurring species.

We aim to use the findings about the recent temporal and spatial vegetation dynamics in the system to predict changes of vegetation composition and dynamics under future changes like changes in groundwater availability due to climate change or river revitalization measures and thus, to provide knowledge for decision-making processes for revitalization and conservation projects in floodplains.

Session **SP19**

A spatially and temporally dynamic riverine vegetation model to inform environmental flow management

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Presenting author: Tanya Doody

Globally, riverine systems and their associated biota have, and continue, to be in decline. Australia's Murray-Darling Basin is a 'working' river basin and the 'food bowl' of the nation. As a result, the aquatic ecosystems within the Basin are considerably altered. One of the key indicators of hydrologic change in the Basin, are the long-lived flood dependent native riparian and floodplain woody vegetation. Under a natural flow regime, these trees require both wet and dry periods. Over the last two decades however, prolonged drought and increasing abstraction have significantly reduced the flood return interval, resulting in extensive tree decline and death. To ameliorate tree stress and prevent further negative biodiversity outcomes, environmental flows are delivered under the Murray-Darling Basin Plan to 'patches' across the Basin with few tools available to inform decision making and identification of priority areas in need of water for vegetation maintenance and also restoration. A broad scale remote sensing decision support tool has been developed to monitor vegetation water status, using field data to validate model results. The model provides an indication of vegetation evapotranspiration (ET) every 8-days from 2001 to current, where high consistent ET indicates good ecosystem condition. The model provides a fine-scale temporal time series over which to understand antecedent and current vegetation hydrological dynamics and determine thresholds of ET, which once exceeded will trigger a management intervention involving prioritisation of environmental flow delivery. Areas of high value biodiversity are often targeted for restoration and efforts to restore are monitored using the spatial model to ensure ecosystem condition continues to improve and allows for adaptive management to ensure positive riverine biodiversity and ecosystem outcomes.

Session **SP19**

From the leaf scale to the floodplain: Effects of herbaceous vegetation structure on sediment retention

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Flood events transport huge amounts of sediment downstream. Under natural conditions, fluctuating water levels and floods ensure that the transported sediment reach the floodplain. In that case, the floodplain acts as sink for sediments and nutrients bound to these sediments. However, anthropogenic interventions, such as river straightening and embankment isolate streams from their floodplains and disrupt the connectivity between the terrestrial and the aquatic system. Additionally, due to intensive conventional agriculture more and more soil and nutrients erode and are washed into streams. To enhance the ecosystem service of retention capacity on floodplains and to increase the success of stream restoration projects, it is crucial to understand the mechanisms by which vegetation can filter the sediment from floodwater while inundated. For coarse sediment, the floodplain morphology is a major factor; however for fine sediment also the vegetation can play a relevant role. In a first study, we investigated on single plant leaves of 30 herbaceous species multiple functional traits related to leaf surfaces characteristics to understand their capacity to capture sediment. The results show that the leaf area negative influences sedimentation, while sedimentation increase with a high density of adaxial hairs. Furthermore, we found an interaction effect between leaf area and hair density, as sedimentation decreased much more strongly with leaf area on species with no or few hairs than on species with many hairs. In a second study, we conducted an experiment in a flume and investigate the influence of two structural characteristics of whole plant patches, namely their height and density on the capacity to capture sediment on and in between plants. To be able to transfer the experimental results to floodplain conditions, we additionally performed an observational study with sediment traps to investigate links between vegetation structures of floodplain meadows with sedimentation after a flood.

Session **SP19**

Application of hydrogen peroxide indicator to evaluate the habitat preference of plant species in the riparian zone

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As the riparian vegetation is constantly prone to the fluctuations in the water level changes along the elevation. The fluctuating water level can cause high or low soil moisture stress on plants which exist within the fluctuation level. When plants are subjected to environmental stresses, reactive oxygen species (ROS) are generated in the organelles of cells based on the intensity of the stresses. ROS are generated in different organelles of plants depending on the type of stressors, regardless of the organelle ROS leading to oxidative stress, and damaging proteins, etc. The most common ROS in plants is hydrogen peroxide (H_2O_2), and the H_2O_2 concentration in plant tissues has a potential to be used as an indicator to monitor the instantaneous environmental stress intensity to evaluate the current condition and habitat preferences of the plants under fluctuating environmental conditions. Current study examined the colonization preference of the riparian vegetation communities by quantifying environmental stress using foliar hydrogen peroxide concentration. Observation was conducted in the riparian zones of sandy channel, the Hii River and gravelly channel, the Arakawa River, for several woody and herbaceous species common in Japanese rivers (Salix species, Robinia pseudoacacia, Ailanthus altissima, and Juglans madshurica for tree species, Phragmites australis, Miscanthus sacchariflorus, etc. for herbs).

Plant leaves were sampled species-wise under both light exposed and shaded condition, at different elevation in transects. The foliar H_2O_2 concentration, antioxidant activities, and chlorophyll concentrations were quantified. At the sampling time, solar radiation was measured at each site, and soil samples were collected to analyze nutrients and moisture availability. Then, the number of trees of each species was counted in quadrats, and herb biomass was collected.

The comparison between light exposed and dark-adapted samples indicated that solar radiation did not become a stress for any of the species. H_2O_2 concentration did not exhibit the proportional change with nutrient availability. Thus, soil moisture is identified as the most important stress factor in the riparian zone. H_2O_2 concentration of tree species increased with increasing moisture content, except for Salix spp. Thus H_2O_2 concentration decreased until 4m from the normal water level, indicating the preference condition at the height. It agreed with the species distribution concerning the elevation. In contrast, H_2O_2 concentration of herbaceous species decreased with increasing soil moisture content, except for terrestrial species. Thus, near shoreline can be considered as preferable for herbs only, not for tree species.

Session **SP19**

How do riparian buffer zones affect nutrient emissions and loads in river systems? A new modelling approach applied in two German catchments

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Presenting author: Andreas Gericke

Despite all the efforts in the past, the eutrophication and poor ecological status of lakes and rivers are still of general concern. Riparian buffer zones (RBZ) are common practice to attenuate the diffuse pollution of surface water, corresponding to the rich literature dedicated to the local efficiency of RBZ to retain substances from upslope areas. Only a few studies have addressed the regional effects of RBZ.

In our study, we integrated a grid-based approach into the nutrient model MONERIS to assess impact of RBZ on nutrient emissions and loads in the catchments of rivers Nahe (4000 km²) and Stever (900 km²). Both study areas are located in the Rhine basin in western Germany. The emissions of phosphorus (P) and nitrogen (N) via soil erosion and surface runoff were modelled for sub-catchments and spatially disaggregated using ATKIS land-use data. We used a flow accumulation approach with flow efficiency to derive the net emission into surface waters. To determine the relative flow efficiency for each grid cell, we identified the water bodies and the riparian vegetation from airborne imagery using object-based image analyses. Based on a broad literature review, we derived rules how RBZ width, RBZ vegetation, nutrient type (particulate P, total P, dissolved P and N) as well as preferential flow affect RBZ retention and estimated the flow efficiency of RBZ cells for the different nutrient forms. The nutrient loads were calculated from the cumulated adjusted emissions and the in-stream retention as implemented in MONERIS.

Based on the current spatial distribution of RBZ and the contribution of soil erosion and surface runoff to the emissions and loads, we will discuss the potential of management options with an outlook to the regional climate change until the mid-century.

Session **SP19**

Global overview of ecosystem services in riparian vegetation

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Riparian vegetation has the capacity to deliver a high amount of ecosystem services relative to their extent in the landscape due to their ecotone characteristics and linear configuration. Consequently, natural riparian vegetation plays a central role in the structure, diversity and functioning of riparian corridors. However, natural riparian vegetation is under increasing pressure from a range of anthropogenic activities such as dam construction, pollution, grazing, land-use change, water diversion, mining, and deforestation. In Europe, it has been estimated that 80% of natural riparian habitats have disappeared during the past 200 years. Riparian zones and their vegetation have been investigated from a range of perspectives covering multiple scientific and applied disciplines such as hydrology, biology, geography, management and restoration. Thus, the knowledge on structure and function of riparian vegetation is distributed among a wide range of fields and disciplines. Several studies have documented how riparian vegetation is important for specific ecosystem services but few have attempted to document the full range of ecosystem services. Here we will present an overview of ecosystem services provided by riparian vegetation. More specifically, we adopt a structured approach to identify the range of ecosystem services, describe their characteristics and rank the importance of each service. We evaluate this within four main riparian vegetation types and take a global perspective to derive the evidence. Based on the structured approach we introduce a guided framework for use in riparian vegetation management. We also seek to identify key knowledge gaps and conclude by evaluating the opportunities an ecosystem services approach offers to riparian vegetation management and restoration.

Session **SP20**

First analysis of a large panel of restoration operations on riverbanks with bioengineering techniques in France

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Riverbanks form edges between aquatic and terrestrial habitats. They fulfil numerous important ecological functions and services. Natural riparian habitats are known for their great biodiversity, which is extremely high in comparison with their relative area. However, land pressure and building constructions are often built close to the water. Riverbank protection works with bioengineering techniques can be a compromise both for protecting human issues and preserving some riparian biodiversity and ecological services. But the lack of knowledge and experience collection is one of the main obstacles to bioengineering techniques development.

Therefore, the building of a database about bioengineering for riverbank protection could offer an experience collection for both practitioners and scientists. River managers will have the possibility to know what bank protections already exist in their neighbourhood. In this way, they can use this knowledge and feedback to develop new riverbank protection works. For research, it would allow scientists to improve their knowledge through a large set of data including temporal evolution and mechanical resistance of bioengineering techniques.

Information is assembled in six groups: about the work itself (e.g. localisation, riverbank features), the watercourse (about the section in front of the bioengineering work), the soil bioengineering techniques, the origin of the data (which institute, which project), the plant species and a description of the different visits (including the present condition of the techniques).

The database is accessible to everybody on internet on the website https://genibiodiv.irstea.fr/en/database-of-french-constructions/.

After the delivery of the prototype, field work is being done to complete the database. About a hundred verified operations are expected in the database for the end of 2019. Analyses began this year with a first overview of the situation of bioengineering techniques in France. We mainly work on the different techniques employed, the date of the realisation of the operations, the slope gradient of the river and the area of the catchment, looking for correlations between the bioengineering technique and the last three factors. But the database offers a lot of others direction for the future analyses.

Session **SP20**

Spatial variation and seasonal differences of ground beetle assemblages in a mountain river subjected to restoration

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Although numerous river restoration projects have been recently conducted in Europe, little is known about the effects of passive restoration on terrestrial invertebrates in the riparian ecosystem. In the 20th century the Raba River draining the Polish Carpathians was heavily channelized and incised deeply in its mountain course. Abandonment of maintenance of bank reinforcements and the passage of two moderately large floods in 2010 and 2014 enabled a river recovery in two reaches. This gave us an opportunity to identify environmental variables of microhabitats determining the distribution of ground beetles in the restored river and to verify the impact of seasonal differences in species occurrence on conclusion about restoration success. Six unmanaged cross-sections and six cross-sections from adjacent channelized reaches, each with 12 sampling sites of 1 m2, were sampled and characterized by distance from and height above the nearest low-flow channel, surface slope, presence/absence of actively eroded cutbank, sediment size class and degree of plant cover. The environmental variables were determined only once as no flood occurred between sampling campaigns of ground beetles. Ground beetles were sampled three times during low-flow conditions: in spring (mid-May), summer (turn of June and July) and autumn (turn of September and October) of 2015 to avoid missing those species which are periodically absent because of their phenology and/or breeding type. Altogether, 3997 individuals representing 78 species were collected. The abundance of beetles was negatively affected by the distance from and the height above the nearest low-flow channel and positively by the substrate grain size, degree of plant cover and presence of actively eroded cutbank. Species richness decreased with increasing height above the nearest low-flow channel and increased with increasing plant coverage. The change in composition of beetle assemblages in different seasons substantially affected the results of comparison between unmanaged and channelized cross-sections. In spring, beetle abundance and richness were higher in the unmanaged than channelized cross-sections and differences in Shannon-Wiener and Berger-Parker indices were found. In summer none of the metrics describing beetle assemblages differed between the two cross-section types, whereas in autumn the only difference was found for abundance. The study showed that the site height above the nearest low-flow channel is predominantly responsible for the differences in beetle abundance, species richness and diversity among the study sites. Moreover, only surveys encompassing the whole period of beetle activity provide a sufficiently complete picture of differences between channelized and restored river cross-sections. Sampling beetles only once by exposing traps for a week in summer, as it was done in many previous studies, may substantially affect conclusions about the effectiveness of river restoration activities.

Session **SP20**

Impact of surface runoff and temperature on the radial increment of Populus euphratica in arid region, China

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Tarim River is the longest inland river in China. It is also characterized by abundant natural resource and weak environment condition, the contradiction of the regional water resource is most prominent in China and even in the entire world. Populus euphratica plays a dominant role in maintaining desert ecosystem function of the Tarim River. The degrading sequences of species were related to their physiological and ecological characteristics, especially their sensitivity to changes of water condition and temperature. To illuminate the variations in growth conditions of the P. euphratica following the different water condition and temperature from temporal and spatial scale, this paper studied the relationships between radial increment and surface runoff and local temperature. We found that the radial increment of P. euphratica responds significantly to surface runoff variations in upper and middle reaches of the Tarim River during the entire study period. While it showed less dramatically respond in the lower reaches of the Tarim River before ecological water conveyance in 2000. The surface runoff during January and February is a key factor that restricts P. euphratica in upper and middle reaches of the Tarim River. The radial increment of P. euphratica has a high inverse correlation with the surface runoff in the lower reaches of the Tarim River during the first two months of a year. In the water limited desert ecosystem, the response of P. euphratica growth to temperature is sensitive. P. euphratica may benefit from the summer temperatures and showed a maximum growth from June to September during the previous year. The response of P. euphratica showed a delayed response to the fluctuating temperatures.

Session **SP20**

Characterizing inundation regimes in space and time to inform floodplain forest management in the Upper Mississippi River System, USA

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Inundation regimes drive the form and function of floodplain forest ecosystems in the Upper Mississippi River System (UMRS). Despite their importance, inundation regimes have not been systemically characterized in spatially-explicit ways that would advance understanding of ecological processes or inform management actions in the UMRS. We developed a geospatial model of floodplain inundation using topo-bathymetric terrains and 40 years of daily water surface elevations. We applied the model across 2.6 million acres of the UMRS and summarized long-term patterns of surface water dynamics in terrestrial areas including inundation event frequency, duration, depth, and timing. We found that distributions of these inundation regime attributes varied within and among multiple levels of river organization, including navigational pools and geomorphic reaches. Non-linear relationships among inundation regime attributes and their geospatial distributions likely reflect complex interactions among topographic, hydrologic, and anthropogenic constraints on flooding dynamics. We also present examples of how we have applied the model to understand the role of flooding in forest succession, to identify hydrologically sensitive areas, and to develop eco-hydro-geomorphic classifications. We conclude by discussing how this work is used by the management community for informing decisions and developing restoration designs in the UMRS. These hydro-geographic analyses demonstrate the utility of spatially-explicit flood quantifications at various spatial scales to help develop robust, process-based relationships that inform floodplain forest ecology and management.

Session **SP20**

Status and needs on genetic resources conservation across European riparian ecosystems

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Riparian vegetation is a major element of the landscape, structuring and modulating ecological functions yet widespread river degradation across Europe is compromising role as a key ecosystem services provider. CONVERGES COST Action intends to identify research and management needs, including how riparian vegetation has been managed, and to translate scientific evidence that may be relevant to update EU policies. The assessment of riparian genetic resources across Europe can assist policy and decision making to contribute to the conservation of species and habitats, to mitigate biodiversity decline and to improve ecological status of riparian ecosystems. One working group within CONVERGES (GC-WG2) is devoted to mapping who, where and what has been done in terms of riparian genetic resources conservation across Europe. The main goal of the GC-WG2 is to review the state of art in genetic conservation of riparian ecosystems/species at the European level and to identify knowledge gaps, conservation barriers and future research and management needs. For this purpose, the GC-WG2 is working on a two stage process. The first step is the identification of relevant experts in the field of genetic resources conservation of riparian ecosystems from all CONVERGES participating countries. This has been performed through the distribution of a short questionnaire, collecting information on geographical distribution of experts; research to date on the topic (literature review), target riparian species (for conservation, ecosystem functions, economics, etc) across countries, and a list of important projects at the European scale. The second stage includes the development of a structured interview addressing the identified experts with the aim of making a collection of brief country reports on genetic conservation in riparian ecosystems on the country level, to provide an assessment of the strategies implemented so far, the major barriers, the current needs and the potential solutions for improving the conservation of genetic resources across European riparian ecosystems. Preliminary results show great disparity of research efforts among species (only a few well studied taxa such as Populus nigra) and the need of conservation programmes to incorporate riparian provenances and their genetic resources if we are to preserve biodiversity of riparian vegetation and associated communities in increasingly uncertain environments.

Session **SP20**

Analysing socio-ecological responses to riparian vegetation degradation across Europe through the CONVERGES COST Action Network

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Vegetation is a central component of riparian landscapes, modulating biological and physical processes and providing multiple ecosystem services yet subject to intense use and pressures that have resulted in widespread degradation. Such degradation has motivated several types of responses such as research and restoration efforts. However, riparian status across Europe remains poor because vegetation-mediated processes are seldom considered within their socio-ecological context and the lack of adequate knowledge conversion among scientific disciplines, between scientists and managers, and among geographic areas. This has stalled scientific progress and implementation of new management methods. CONVERGES Cost Action is a network program (CA 16208, approved in June 2017) that pursues coordinating research and training efforts across Europe, to improve knowledge conversion from science to practitioners and to integrate practitioner's experiences and interests in the scientific community. The network is structured in four working groups with one (WG2) explicitly focused on mapping current knowledge of the socio-ecological responses to riparian vegetation degradation across Europe. The approach developed by this working group includes the elaboration of a common grid to analyse three types of responses: production of knowledge, management practices and tools and social response. For the last one, the focus is on policy/legislative awareness at the different scales of responsibility for water and nature management (EU, national and regional). For each type, a knowledge synthesis is built to present which response resides where (e.g. country, institutions, people) and to identify patterns of knowledge flow (source, medium, target). Each synthesis is based on literature synthesis and consultation, seminars with local/national managers involved in the Action and regional/national legislation reviews. Among the types of responses to be addressed with more detail are the evolution of main research topics, creation of scientific networks, development of remote sensing methods, implementation of restoration measures, genetic conservation, policies and legislation.

Session **SP21**

Learning about rivers - examples, approaches and experiences of education-research-cooperations from pre-school to high school

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Teaching is an important task of many freshwater research institutes, ranging from university and postgraduate training programs at an international level to pedagogic in- and outdoor activities for school students of all ages on a regional level. School cooperation activities bear specific challenges as they require a special design and a lot of preparation to achieve various educational, and sometimes also scientific, goals. Research – education cooperation projects focussing on rivers should not only lead to an increased understanding of the ecosystem river and its functioning, they should also raise scientific literacy by giving insights into the research process and latest research results. Additionally, all activities with school groups should sustainably promote environmental-friendly behavior among the young population group. Education represents a starting point in order to bridge the existing gap between knowledge and action ("value - action gap"). In this way, innovative educational concepts can contribute to achieve a transformation in the environmental behavior of our society.

We present selected research - education cooperation projects, their aims, major findings, and experiences we made with different approaches. The overall objective of all our projects is to give young people an understanding of the sensitivity of stream ecosystems and the complex interaction between humans and the environment. We want to actively involve the young participants through hands-on workshops that combine outdoor and indoor experiments. Older students try to answer their own research questions about ecological interrelations via in-situ surveys of the stream and experiments in the lab (explorative learning). We are also using the Citizen Science (CS) approach within our school cooperation projects and will present the limitations and benefits we identified for both, the science and the school, sides.

Session **SP21**

Formal education about rivers and its significance for sustainable river management

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Despite the legal requirements by EU member states to improve ecogical status of rivers, restoration efforts do not seem to be gaining momentum in Poland. On the contrary, recent plans to construct extensive waterways that would further alter river hydromorphological conditions seem to be accepted by many and spark little protest. Similarly, studies of public perception of rivers show that conventional approach to river management is widely accepted, while public recognition of its negative effects is scarce, in spite of the overwhelming evidence from scientific research. In this paper we investigate how formal education on pre-academic level may be contributing to the current perception of rivers in Poland.

In Poland, most information on the geography, geomorphology, function and social significance of rivers and their interaction with people would be traditionally provided in the geography lessons, while the content of the core curriculum is decided on the national level and is mandatory to most schools. A limtited number of textbooks adjusted to the current curriculum is formally approved for use in class across the coutry. In this analysis we focus on (1) the content of the previous and recently introduced geography curricula to identify information about and contexts in which rivers are presented, (2) accuracy and consistency of the messages about rivers delivered in the course of pre-academic geography education, (3) illustrative and lingustic presentation of rivers in geography textbooks at pre-academic level.

The analysis revealed a distorted and inconsistent image of rivers, focused mostly on river use and human-altered riverscapes. Modification of rivers is shown rather as a result of development while recognition of morphological degradation of rivers and ideas of restoration are non-extistent. In this homogenized view of mostly heavily impacted rivers, diversity of river form and regional variability of river dynamics and its consequences (such as in mountain regions) seems to be largely lost. Importantly, ubiased information on natural river dynamics and its links to river ecology is lacking or discussed in the context of natural distasters and damage to infrastructure and property. This shows that although geography education is intended to enhance pro-environmental attitudes, it is yet unlikely to have that effect in relation to rivers and riverscape perception as the information and the image of rivers are largely outdated and non-representative of the actual role they play in the natural environment. We postulate that more focus is needed on the formal education system as it comprehensively and simultaneously delivers information to the largest group of young people. Involvement of the scientifc communtity to improve translation of current knowledge into pre-academic education and teacher training seem vital to secure future public support for sustainable river management.

Session **SP21**

Danube as a Symbol of Europe. Perception of the River from Varied Spatial Perspectives

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Presenting author: Tomasz Padło

The Danube is promoted as a pan-European river, what can be justified for instance by the vast range of its drainage basin, covering 19 countries on both sides of the historical border dividing Eastern and Western Europe. Differentiation of perceptions of Danube course from the perspective of 7 European cities (Balti, Bern, Cork, Cracow, Porto, Nis, Uppsala), based on research covering 1480 respondents, students from secondary schools in years 2005-2007 and again 2016-2018, has been presented in the paper. Maps presenting the generalized perception of river course in two periods have been generated for each city using kernel analysis. It has been proved that in spite of substantial political, economical and symbolical importance of this river for big part of Europe, the course of Danube remains unknown for inhabitants of its Western part, in parallel to more correct recognition of the river by students from Eastern Europe and perception has not changed even decade after enlarging European Union.

Session **SP21**

A collaborative game to enhance sustainable river basin management in Indonesia

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Presenting author: Jan Fliervoet

Facilitating collaboration and shared learning has become an area of interest in sustainable river basin management. Novel approaches, such as game-based learning, for enhancing collaboration and interactions are demanded to ensure that stakeholders and governments are able to develop a shared vision that supports sustainable river basin management (Jean et al., 2018). Game-based learning has shown great potential for allowing stakeholders to understand the complexity of the problem, improve relationships and think about possible ways forward. In Indonesia as well as many countries in Asia, the drive to promote stakeholder participation in river basin management has gained growing support in recent years. Therefore, we developed a collaborative serious game that support stakeholders to develop a jointly formulated master plan for the Citarum River Basin in Indonesia. Secondly, the goal of the Citarum game is to promote social learning and awareness about sustainable river basin management among students and professionals. The research question is: what is the impact of the Citarum game as a learning tool for students and professionals regarding sustainable river basin management and future collaboration? The impact of the Citarum game is evaluated on three aspects: the stakeholder's perceived problem definition, evaluation of the decision-making process and usefulness of the collaborative game for developing a river basin master plan.

The Citarum game is a collaborative, board-based simulation game developed by Deltares, Province of West Java, ITB and Radboud University. The game is developed based on the "Ports of the Future" game (Schipper et al. 2017) and by making use of the triadic game design (Harteveld et al., 2010). The Citarum game was tested with students and professionals in the Netherlands and Indonesia. In the end, four game simulations events were organized with environmental engineering students from ITB and ITENAS and with professionals in Indonesia. Participants were divided into teams of 2-3 members to play one of the four stakeholder roles (government, industry, farmers, environmental NGO) and were surveyed during the game by a pre- and postquestionnaire. In total 44 participants were involved in the simulation events.

The analysis shows that serious game simulations provide a change in the perceived problems with regard to sustainable management of the Citarum basin. The problem definition of the players shifted from mainly technical issues towards a more inclusive problem definition by including social-economic issues, such as the lack of financial resources and the sectoral interests of stakeholders. According to the participants, the Citarum game invited the players to get actively involved in the decision-making process. Finally, the Citarum game can be used as an educational resource, but also as an intervention platform for improving stakeholder participation to ultimately develop shared decisions and policies.

Session **SP21**

Building a framework for the River-based ImmersiVe Education & Research Field Studies Network

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Presenting author: James Vonesh

Field studies combine active learning practices in an immersive environmental context to create experiences that inspire students and catalyze their transition from student to scientist. Despite this formative role, field study opportunities in undergraduate biology education are declining due to real and perceived student, faculty, and institutional barriers. Our project, using river ecosystems as the immersive context, will identify and overcome these barriers by establishing the "River-based ImmersiVe Education & Research (RIVER) Field Studies Network." This network focuses on undergraduate education in and around rivers for three reasons. (1) Rivers are natural classrooms for interdisciplinary STEM learning; their processes integrate across biology, hydrology, geology, and coupled human and natural systems. (2) Rivers offer unique logistical solutions for many barriers to immersive field studies. (3) Rivers provide essential services to society but are among the most imperiled ecosystems. Addressing current and emerging challenges facing river ecosystems requires scientists and professionals trained to work across disciplines, technologies, and landscapes. Creating capacity within undergraduate biology education for immersive field studies in these critical ecosystems will advance STEM training and inspire future problem-solvers to address the challenges facing river ecosystems in the twenty-first century.

The RIVER Field Studies Network Incubator project will build human and institutional capacity for active learning pedagogy and comparative river biology. It will enhance the quality and capacity of current programs by supporting communication and coordination of educational and research activities across disciplinary, institutional, and geographic boundaries to advance undergraduate biology education at multiple scales. It will work to overcome barriers of entry for underrepresented populations and students with differing abilities while developing tools to support the creation of river field studies at new institutions. It will leverage the resources of individual academic programs and professional partners to begin building the foundation for transformative network-scale capacity for active learning in river field studies. Examples of transformative network-scale capacity include: establishing cooperative agreements for student exchange across the network; creating a national comparative river field studies curriculum; and developing a plan to transition the network into a self-sustaining national organization supporting interdisciplinary river field studies. As we begin the process of creating the vision for the RIVER Field Studies Network we are interested in cross-pollinating with the ISRS about this society's interest in developing an international education program in river science.

Session **SP22**

Functional Change in a Large River Ecosystem - the Anthropocene Through a Resilience Lens

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Presenting author: Jason DeBoer

Many of the world's large river ecosystems are subject to a host of anthropogenic stressors including climate change, land-use modification, flow regulation, and disconnection of the main river channel from its adjacent floodplain. Viewed through a resilience lens, these ecosystems are now potentially in a new basin of attraction, exhibiting a different structure, function, and set of interactions - they are Anthropocene River Systems. Food webs developed for different periods are used to investigate the functional response of the Illinois River (Illinois, USA) to a range of anthropogenic stressors, including system-wide attempts to improve water quality along the length of the river. Four lines of evidence are presented - stable isotope ratios, community niche space, basal resource contribution to higher levels in the food web, and mean trophic position of fish functional feeding guilds and food chain length - to show the loss of resilience of this large-river ecosystem over a 150-year period. Major changes in trophic status and food web character of the Illinois River among four distinct periods reveal a sustained shift in ecosystem function, and movement to a new basin of attraction. Changes in trophic status and food web character also vary spatially, further highlighting a complex functional response to multiple anthropogenic stressors along the Illinois River. These complex changes, which led to a shift to a new basin of attraction, have implications for the future management and restoration of the Illinois River, particularly given the challenges facing large river management in the Anthropocene.

Session **SP22**

Geomorphology and river resilience: a wheel reinvented?

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Presenting author: Ian Fuller

How does resilience apply to river geomorphology? Is there such a thing as resilient river geomorphology and if so what would a geomorphologically resilient river look like? Resilience as a concept relates to the way a system responds to disturbance. When disturbed, systems both resist and recover from that disruption. A resilient river may have a high degree of resistance and / or a high rate of recovery, so that disruption is minimised. In geomorphology, the concept of resilience thinking (how does a system respond to disturbance?) is implicit in equilibrium theory and the role of intrinsic and extrinsic thresholds, which govern landform behaviour and form. When a geomorphic system is disturbed a period of time (relaxation time) elapses during which the system returns to a relative state of balance. However the nature of river systems is such that they are characterised by repeated adjustment to change (disturbance) in flow and sediment regime with repeated floods and erosion / sediment transport events. A resilient river can be construed as being a messy river, with capacity to absorb, respond to, and recover from flood disturbance. Equilibrium forms in river geomorphology can be recognised in these rivers. Engineered rivers are, superficially, resilient, in that they are engineered to resist disturbance and change, as long as the disturbance does not exceed design capacity. Failure of engineering schemes can be spectacular, revealing a far from resilient system. We argue that while engineered rivers may strongly resist change, their capacity to recover once disturbance exceeds design is impoverished. A truly resilient river is one in which natural processes are allowed to function; the river floods, banks can erode, bars can form and re-form, channels can migrate, backwaters form, floodplains accrete. In such a condition, the river readily absorbs or recovers from disturbance without change in state. This ought to be the goal of river management in the Anthropocene. While the concept of resilience is arguably a wheel reinvented to define well-established concepts in the science of river geomorphology, geomorphologists should be willing to embrace this reinvention if this is what it takes for these concepts to be recognised and applied by river managers today.

Session **SP22**

Conceptual model of river ecosystem functioning in backwater fluctuation zone of dam reservoir

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Presenting author: Maciej Liro

Despite about 59000 dams functioning worldwide, very little is known on biophysical functioning of rivers in the so called backwater fluctuation zone (BFZ) - a river section upstream of a dam reservoir, that is inundated during reservoir stages higher than the normal or average. This inundation may be deeper and longer lasting than those produced by the natural flow regime of river, which may disturb both abiotic (flow, sediment, morphology) and biotic (vegetation, animals, human) components of fluvial ecosystem. I present a conceptual model, which provides a guidance for further research of rivers in BFZ. Based on the sequence of occurrence and the temporal and spatial extent, backwater fluctuation influences were divided into: (i) first-order influences on river hydrodynamics, (ii) second-order influences on river sedimentology, morphology, vegetation, animal habitats and land management and, (iii) backwater-induced feedbacks triggered by first- and second-order influences of backwater fluctuation, which may operate independently from direct influences of backwater fluctuation. First-order changes in river hydrodynamics occur in a whole BFZ and last from seconds to months. Second-order changes take from few hours for changes in bed sediments to few days or decades for changes in river morphology, vegetation, animal habitats and human management, and they cover smaller areas (e.g., limited elevations or morphological forms such as channel bar, island, floodplain backswamp, oxbow lake, river terrace). The smallest spatial scale and the longest temporal scale (from decades to centuries) of occurrence is typical of backwater-induced feedbacks (e.g., sediment characteristic changes resulting from animal habitat transitions, river flow modification around new morphological forms, etc.). A similar distinction between first and second-order influences was previously applied by other researchers to physical and biological adjustments of rivers downstream from dams. The presented model in its general form is a template for further research design and may allow for formulation of general hypotheses for different types of alluvial channels.

Session **SP22**

Resilience, social-ecological systems and risk: the ineffectiveness of water management in the Murray Darling Basin, Australia

Author(s): Martin Thoms; Melissa Parsons & Paul Martin

Affiliation(s): University of New England, Armidale, NSW, Australia

Presenting author: Martin Thoms

Resilience thinking advocates an approach in which landscapes, ecosystems, economies and societies are implicitly linked as social-ecological systems. Thus, viewing rivers as social-ecological systems requires consideration of how ecological and social properties such as ecosystem services, environmental impacts, fast and slow variables, human actors, institutional responses, social impacts and external drivers interact to influence the landscape of these highly coupled systems. A key component of the governance of social-ecological systems is identifying and managing risks from policies that have significant economic, environmental, social or other impacts, estimating the potential losses associated with future events, and where there is risk - the potential for a future event to cause a significant loss of value. With this background, we consider water management in the Murray Darling Basin, Australia, through a resilience lens that incorporates concepts of risk management. A step wise process is outlined that includes identifying; 1). The range of stakeholder values, associated with water and rivers that may be at risk; 2). Contingencies that adversely affect these, from nature, from other stakeholders and from government; 3). The range of possible risk management strategies, with a particular emphasis on the vulnerable interests that have not been accommodated within the current legislation. Water and river management requires a greater focus on comprehensive risk management strategies in order to reduce the potential of tipping into alternate regimes that are commonly associated with a significant loss of productivity.

Session **SP22**

Resilience as a basis for river management in the Anthropocene - a geomorphic and river science perspective

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Presenting author: David Gilvear

This paper will examine the geomorphic resilience of rivers from the perspective of a UK based fluvial geomorphologist and river scientist and assess the implications of resilience for river management and restoration in the 21st century. In natural settings, rivers are dynamic disturbance-driven resilient environments that can alter their channel geometry, sedimentology and location within the river corridor whilst still retaining a complex suite of geomorphic units and fluvial processes that form the foundations of lotic ecosystems. River channels, unconstrained by bank and bed protection, subject to disturbances both natural and human, remain resilient by adapting their drainage density, planform, channel size, shape and potentially their type in response to the change. Rivers subject to direct and increasingly severe human interventions progressively lose geomorphic resilience to disturbance events above a threshold value compromising their nature conservation value. Moreover, the suite of ecosystem services provided by resilient rivers are progressively constrained and lost as resilience is reduced. As such protection and promotion of geomorphologically resilient river reaches sustains ecosystem service delivery in rivers.

Session **SP22**

Living Deltas

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Presenting author: Andy Large

River deltas comprise only one per cent of global landscapes, yet support over half a billion people. Today, deltas are being altered at a greater rate than at any time in history, facing existential threats from over-exploitation of natural resources, climate change and predicted sea level rise, combined with sediment scarcity and sinking land. South and Southeast Asian deltas are among the world's most vulnerable social-ecological systems: imprudent resource use, agri-food system change, urbanisation and the wider pressure for development continually threaten to compromise the dynamism of natural processes at this delicate interface between land and water. The problems facing deltas reflect 'siloed' single-discipline thinking, and will remain intractable unless this changes. Hydrologists, engineers and water managers are rarely taught about the wider consequences of their projects for delta SESs, or the significance of natural-cultural heritage. Nor are ecologists trained to think about the critical role of water in delta society. Economists, developers and politicians seldom project far enough into the future to fully account for potential costs of shorter-term plans, nor do they acknowledge the value of community knowledge for sustainable development. The needs of deltaic systems and the needs of society for water must be addressed collectively if ecological integrity is to be maintained or restored. Enacting these transformations requires a new scale of river research investment and activity.

The Global Challenges Research Fund (GCRF) is a £1.5 billion fund which supports cutting-edge research and innovation to address issues faced by developing countries. The 12 Research Hubs are among the most ambitious investment the UK has to date made in international development research. They provide a framework for the wider GCRF portfolio, position the UK as a leader in development research and promote the dignity and prosperity of some of the most disadvantaged and hardest to reach people on our planet. Working in the Red River and Mekong River deltas in Vietnam and the world's largest delta, the Ganges-Brahmaputra-Meghna delta in Bangladesh and India, the five-year, £17m UKRI GCRF Living Deltas Research Hub (2019-24) will directly address the UK-Aid requirement for sustainable livelihoods supported by strong foundations for inclusive economic growth and innovation and resilience and action on short-term environmental shocks and long-term environmental change. We outline here how, as wide-ranging trans-national societal impacts on deltas increase, the need for locally-rooted sustainable development strategies, underpinned by traditional knowledge bases and protected heritage becomes ever greater. Living Deltas will operate using this model to achieve more resilient communities with the SDGs addressed by co-creating transdisciplinary, natural-cultural-heritage-based understandings.

Session **SP22**

Monitoring and assessing for river resilience: opportunities and challenges for river science

Author(s): Melissa Parsons & Martin Thoms

Affiliation(s): University of New England, Armidale, Australia

Presenting author: Melissa Parsons

River assessment is the evaluation of river condition using surveys and other direct measures to determine the effects that human activities have on the structure and function of river ecosystems. River bio-assessment has developed into a discipline in its own right, endeavouring to empirically identify river ecosystem deterioration or improvement through the use of sophisticated sampling methods, statistical analyses and reporting tools. River science is an area in which the adoption of resilience is increasing. The concept of resilience acknowledges the ability of people, communities, societies and cultures to live and develop with dynamic environments. Classically, resilience is defined as the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime – essentially retaining the same function, structure and feedbacks. However, it is unclear whether established river bio-assessment approaches can be used to assess river resilience. Assessment and monitoring under a resilience approach requires a slightly different emphasis – that of being able to detect, with some confidence, whether rivers are maintaining their resilience, and their capacity to supply ecosystem services to society. In this presentation we explore what is needed to undertake resilience-based monitoring and assessment of rivers. We investigate the social, economic and ecological variables that could be used to assess river resilience, the measurement models underlying assessment of river resilience and the governance systems needed to support resilience-based river management decisions. We show that these requirements differ from, but may be supported by, established bio-assessment routines. A framework is then proposed to establish the components of a best practice framework for assessing and monitoring the resilience of river ecosystems.

Session **SP22**

Socio-ecological approach of agricultural practices modification in riparian areas, the example of Brittany, France

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Presenting author: Simon Dufour

For several decades, entire regions of Europe have experienced a significant change in land use, with the abandonment of certain agricultural practices leading to the development of spontaneous afforestation. The objective of this presentation is to present the results of an analysis of the effect of changes in land use on the socio-ecological functioning of riparian zones conducted in the Brittany region (France). What is the scale, spatialization and temporality of the afforestation process at the regional level? In what context does wasteland appear? What are the functional consequences for aquatic environments? A spatial analysis of the phenomenon by remote sensing at regional scale shows a significant increase in spontaneous afforestation over the past 30 years, with a higher increase in wetlands than in the rest of the landscape. However, the process is not spatially or temporally homogeneous and this heterogeneity is largely explained by socio-economic, demographic and agricultural specificities. Interviews with local stakeholders make it possible to trace the socio-economic trajectories and diversity of uses in riparian areas, which explain the different landscape mosaic configurations that exist today. In addition, an analysis of the bibliography shows that the process of wasteland does not appear to be generally unfavourable for the functioning of aquatic environments and therefore raises questions about the choice criteria to focus on in environmental management strategies.

Session **SP22**

Who talks to whom in lake basin management in the Columbia River system: relating communication network dynamics with indicators of water quality and fisheries

Author(s): Karen I. Trebitz

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Presenting author: Karen Trebitz

The Columbia River Basin is a complex social-ecological system, spanning political, legal, socio-economic, geographic and biophysical boundaries. Water resource managers in individual lake basins within the Columbia River system are faced with a multi-jurisdictional structure, as well as challenges in meeting the interrelated place-based needs of water users, with sustainable plans that are resilient to change in social and environmental conditions. Reaching out to others in social networks is fundamental to developing the communications needed if collaborations in adaptive management are to be sustainable and responsive to change. Such networks should focus on enhancing the cooperation between parties with diverging roles, interests, and goals for managing these complex systems.

Social network analysis has been a valuable tool for identifying and describing communication patterns among actors in various water resource management scenarios. Few direct comparisons have been made across multiple communities, however, so little can currently be said about whether consistent patterns exist between individual basins within a developed river system. Likewise, few studies have examined linkages of communication networks for water management and biophysical indicators of the system. Developing metrics for outcome success is challenging, as they should consider values, and positions of the actors in the systems as well as management circumstances.

This research examines the patterns in communication networks among water resource managers in five Columbia River headwaters lake basins in the northwestern U.S. and Canada (from west to east): Chelan and Roosevelt in Washington, Pend Oreille in Idaho, Koocanusa in Montana and British Columbia, and člq̓etkʷ (Flathead) in Montana. Survey respondents are water resource professionals working for Tribe/First Nations, federal, state, or provincial department in water quality or fisheries, or one of many people who engage in the network on behalf of area businesses, regional government offices, public services, non-profit organizations, research and educational institutions, and other entities. The surveys, administered April through June 2019, identify relationships among actors in the communication networks in each basin for water resource management. Input is gathered about process in network collaborations, such as whose voice is heard, and the ability to plan and implement binding management actions in the basin. The survey additionally asks respondents to identify biophysical indicators in measuring lake health of their particular basin. The data is used to construct models of regional communication networks, which are evaluated relative to perceived social processes within the networks and outcomes on ecological indicators of lake conditions. This research can help water resource managers strengthen the effectiveness of their communications networks to achieve desired management outcomes more efficient

Session **SP22**

The circular economy: a useful perspective for sustainable river management?

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Presenting author: Jeroen Rijke

The concept of the circular economy is rapidly gaining popularity in a variety of domains such as consumer goods, construction and logistics. The Ellen Macarthur Foundation (2015) has developed three principles for the circular economy as a basis for sustainable development: 1) design out waste and pollution; 2) keep products and materials in use; 3) regenerate natural systems. Drawing from cases in the Vietnam (VN), Indonesia (IN) and the Netherlands (NL), this study explores how the circular economy can be applied to support sustainable river management.

For each of the cases, interviews and workshops with practitioners are conducted to determine: 1) the viability of 'circular' management approaches for plastic in river systems (all cases), sediment (IN and NL) and biomass (VN and NL); and 2) requirements for successful implementation; and 3) challenges for wide uptake. Subsequently, these findings are used to put forward a vision and research agenda for applying the principles of the circular economy to river management.

With regards to principle 1 and 2, all cases show that material flows that are generally considered waste can be turned into valuable resources for e.g. construction (e.g. plastic floaters, go-engineered flood defences, ropes), soil improvement, paper, accessories and energy. This provides opportunities for enhancing livelihoods of riverine communities, and for achieving 'self-supporting river systems' in which management costs are (partly) covered by new revenue streams. The benefits of this approach can only be yielded if supplies are sufficient and stable enough to support the existence of new value chains, transportation distances are relatively small, and the cost of supporting infrastructure (e.g. plastic catchers, soil banks and equipment, composting depots) is relatively low.

With regards principle 3, the cases of IN and NL (both sediment) illustrate a need for systems thinking to reduce excess or deficit material (sediment) flows through the system. Again, value chain thinking is in this respect vital to sustain appropriate management practices (e.g. agroforestry as a means for erosion control). In NL, it was shown that biomass production in floodplains for paper or soil improvement is not a viable option, due to limitations of the related value chains.

Applying the principles of the circular economy to river management adds a perspective of business viability with a long term outlook to dominant river management approaches, incl. holistic catchment management, integrated and adaptive planning and governance. It requires thorough understanding of material flows throughout the river system and the functioning of value chains that are dependent on these flows. Accordingly, the circular economy invokes a myriad of research questions related to efficient resource management, value chain development, new forms of governance, and the technology that is required to support these.

Session **SP22**

Mapping stressors to watershed functions using the Index of Watershed Integrity

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Watersheds are spatially explicit landscape units that contain a range of interacting physical, ecological and social attributes. They are social-ecological systems that provide a range of ecosystem services valued by society. Their ability to provide these services depends, in part, on the degree that they are impaired by human-related activity. Our objective has been to develop a more comprehensive definition of watershed 'integrity', operationalize that definition, and field test and iteratively improve the approach through applications in multiple geographic settings globally.

Definitions of 'integrity' have been developed for river ecosystems, but mainly at the reach or site scale and usually for specific biotic communities, such as fish or macroinvertebrates. These scales are inappropriate for defining integrity at the watershed scale. In addition, current assessments of endpoints do not indicate the source of impairment. The Index of Watershed Integrity (IWI) is an aggregate index ranging from zero (low integrity) to one (high integrity) based on first-order approximations of relationships between stressors and six key watershed functions: hydrologic regulation, regulation of water chemistry, sediment regulation, hydrologic connectivity, temperature regulation, and habitat provision. It is a cumulative index in which all conditions upstream influence the score downstream. That is, impairment of a watershed can accumulate (or be cumulatively buffered) downstream, reflecting the reality of watershed-scale processes. A related Index of Catchment Integrity based on local drainages indicates local impairment independently of upstream impairment. A key feature of the index is that it can be deconstructed to identify factors influencing index scores, thereby directly supporting the adaptive management of components that contribute to watershed integrity. Deconstruction also facilitates the examination of individual watershed functions, such as hydrologic regulation. The approach can be iteratively improved as new data and information become available.

The IWI has been applied to the conterminous United States (CONUS), the Western Balkans, and the Matanuska-Susitna Basin in Alaska. The Western Balkans application demonstrated how datasets different than those applied in the CONUS can be substituted. The Alaska application demonstrates the Index can be applied to a single watershed to respond to specific questions, and with consideration of cold-climate hydrology. Index performance in multiple watersheds and their strong relationship with site level responses provides weight-of-evidence support for their use in state, local and regionally-focused applications. IWI output can be used in conjunction with other 'big-data' to explore spatial and temporal trade-offs, and thus support decision making. Input coverage values can also be varied to explore the effects of increased or reduced stressors on IWI/ICI scores, or of independent functions. Future

Session **SP23**

Future coastal river deltas are critical social-ecological systems for achieving global Sustainable Development Goals

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Coastal river deltas support complex social-ecological systems that are central to achieving the 17 global Sustainable Development Goals (SDGs) laid out by the United Nations in their Agenda 2030. These systems are often densely populated, highly important for food security, and support rich biodiversity and ecosystem services. However, they are also set precariously between rising seas and catchment and land use pressures, making them particularly vulnerable to loss and damage caused by climate change and creating unique adaptation challenges. Thus, deltas are model riverine landscapes for exploring the sustainability of social-ecological systems.

In this study, we analyse the consequences of global change drivers in 46 coastal river deltas for achieving the SDGs. We quantitatively compare pathways to the SDGs between deltas and non-delta areas using three plausible future development scenarios until 2050. The scenarios represent three Shared Socio-economic Pathways (SSPs): SSP1--sustainable development with low challenges for climate change mitigation and adaptation; SSP2--a 'middle of the road' scenario with intermediate challenges; and SSP3--a future with high mitigation and adaptation challenges due to rapid population growth, slow technological change, high inequalities, and weak institutions. We use the Integrated Assessment Model IMAGE to project global gridded outputs related to key SDG indicators in deltas for each scenario.

The challenges faced in delta areas will be significant under all three scenarios. Balancing trade-offs between urban development, food production, groundwater extraction, hydropower, and ecosystem services in deltas will be paramount for achieving the SDGs. Climate change adaptation strategies will vary among deltas of the world, and scenario analyses can help researchers and policymakers hone in on important interactions and potential conflict between social and environmental goals in deltas. We conclude that greater attention should be paid in research and governance for the SDGs to the biophysical and geomorphological setting of social-ecological systems, particularly deltas and other riverine landscapes, and discuss different development pathways under different scenarios in deltas of the world.

Session **SP23**

Evaluation of ecosystem services in the course of hydro-morphological floodplain restoration measures along a large alpine river east of Vienna, Austria

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Presenting author: Martin Tschikof

River floodplains are highly endangered ecosystems, hotspots of productivity and biodiversity and recognised to fulfil vital ecosystem functions and services (ES). Restoration measures of the decoupled Danube floodplains east of Vienna aim to ensure navigation, preserve unique habitats and re-establish natural processes through reconnection of side arms, removal of embankments and groins and the addition of bed-load to counter riverbed incision. The impact of three hydro-morphological restoration scenarios (current state, no implementation and full implementation of proposed measures until the year 2050) on selected ecosystem services was assessed. Therefore, regulative services and habitat provisioning were predicted using multivariate regression models and the potential of cultural ES was assessed based on mapping activities.

Regulative services included nutrient retention and greenhouse gas (N_2O) regulation. Mass balances for nitrogen and phosphorus species were modelled using significant hydro-morphological and seasonal indicators (connectivity, discharge, morphology, etc.) for a wide range of hydrographs. The probability of occurrence for protected species (including fish, birds and amphibians), being indicative for biodiversity was modelled using binary logistic regressions with presence/absence data and abiotic parameters in terrestrial and aquatic sections. Potential cultural ES included recreational activities, intellectual and spiritual interactions with biota, ecosystems and landscapes as well as their aesthetic value. The ES were evaluated and mapped by already available indicators (infrastructural facilities, monuments, water quality, etc.).

Data have been available from research and scientific monitoring of past projects for approximately two decades. Indicators for the respective ES were defined and results together with parameters for navigation compiled in a multi-criteria analysis (MCDA) to evaluate the implementation scenarios in an interdisciplinary ES-framework to support decision making for future restoration projects. Significant indicators for the respective ecosystem services can be further used to refine monitoring strategies and investigated parameters.

Key words: River-floodplain-system, river restoration, ecosystem services, nutrient retention, greenhouse gas regulation, red list species, recreation, multi-criteria decision analysis

Session **SP23**

The importance of heterogeneous shoreline habitats and reconnection of side- arms for ecosystem functions in regulated rivers

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Nutrient cycles are highly dependent on the physical habitat heterogeneity and retention capacity within the riverine landscape. Functioning rivers need bioactive zones available at all water levels for long-term ecological stability. While during high water levels water bodies in the floodplains are important retention zones, shoreline structures within the main channel are considered as key sites during low water situations. Hence, riparian habitats and shoreline structures are defined as bioactive zones in regulated rivers, so called „hot spots", for nutrient cycling.

In order to quantify the ecological effects of hydro-morphological restoration measures, we investigated the effect of several side arm and shoreline structure restoration measures in the River Danube within the Danube Floodplain national park in Austria. The aim was to analyze how the extent of side-arm reconnection and shoreline restructuring and thus changing hydrological connectivity controls nutrient retention and planktonic processes. First results indicate that nutrient concentrations follow closely the extent of connectivity, while plankton communities and their processes show responses that are more complex. Planktonic processes respond to small connectivity changes, shifting between external and internal drivers.

An understanding of the relationship between the function and design of reconnected river side-arms and artificial shoreline habitats are required for ecologically orientated planning and management of highly modified large rivers.

Session **SP23**

Longitudinal training dams - river training of the 21st century

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Presenting author: Frank Collas

Humans have used rivers for several functions, for instance as a freshwater source or as a transport corridor. Additionally, rivers have been modified to accommodate the aforementioned functions and to reduce the risk of floods. Human usage of rivers often results in a reduced ecological value clearly showing the conflicting interests in rivers. In order to facilitate several of the aforementioned functions river training should focus on an integrative approach. Recently such an approach was applied in the dutch part of the river Rhine in the form of the removal of existing groynes and the placement of novel Longitudinal Training Dams (LTDs). These dams are placed parallel to the river axis, separating the river into a main channel and a bank-connected side channel with upstream sill. Three LTDs were built over a 10 km stretch in the inner bend of the lowland river Waal, the largest distributary of the river Rhine in the Netherlands. The average width of the side channel is 80 m and the main channel has a width of 230 m. The division into two separate channels allows to separate conflicting functions. The LTDs are expected to 1) increase and maintain the minimum water depth for navigation during drought; 2) increase the discharge capacity for improved flood safety; 3) facilitate the safe discharge of ice; 4) reduce fairway maintenance costs; 5) increase ground water levels; 6) decrease salt water intrusion and 7) increase habitat diversity and stability through the sheltered side channels.

Within the monitoring programme 'WaalSamen' and the research programme 'RiverCare' it is studied whether the expected effects are achieved. These programmes focus on the hydraulic, morphological, ecological and societal effects of LTDs and on the integration of research outcomes into numerical models. Here we focus on the development of the side channels from a hydromorphological and an ecological perspective (fish and macroinvertebrates), including exchange with the main channel.

Within the present study, Acoustic Doppler Current Profiler (ADCP) measurements, Multi-Beam Echo-Soundings (MBES) and several ecological measurements and samplings were carried out over the course of the project. This includes a single-day measurement campaign to obtain a rich data set consisting of contemporaneous hydraulic, morphological and ecological data. Additionally, a physical scale model and a hydraulic conceptual model were used.

Adapting the upstream sill height and geometry allows for steering the discharge division at the side channel entrance and the amount of deposited sediment in the side channel. During period of low water levels the LTDs increases the water level thereby increasing the water depth for navigation. Compared to groynes, the LTDs increase the discharge capacity during floods. The ecological effects clearly show that LTDs block the effect of commercial navigation and create a sheltered side channel were fish and macroinvertebrates thrive.

Session **SP23**

The Big Muddy - hydrophone recordings to capture invisible feature of rivers

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Presenting author: Christina Gruber

"The Big Muddy" tries to capture invisible features of Large Rivers. The project emerges from extensive artistic research on the Mississippi and the people living on and off the river. The foundation for this research was built during a residency in New Orleans from March to May 2017 and a consecutive journey down the Danube River until the Black Sea. During this period I met people with strong ties to the river; from fishermen to sedimentologists. It became clear that wetlands are one of the most productive areas within the United States - ecologically as well as economically. From an ecological point of view, wetlands are constantly dissolving and growing. From an economic point of view, there is a lot of agriculture and petro-industrial production.

Many different types of data have already been collected in this neverending process. The one thing that stood out to as a missing link from this data pool is sound in relation to land loss. "The Big Muddy" captures it through sound recordings. Using a hydrophone, the sound produced by the sediment that passes through the river was recorded and transmitted online. Sound is one of the waves that travel very well in water and that can also be transmitted digitally. The recordings uncover another layer of what is happening underneath the surface. Something usually invisible due to high turbidity (muddy appearance). The recordings act as documents in an alternative archive of a natural object; the Mississippi River. They can help to understand the complex processes going on in the river and show its transformative nature. In addition, hydrophones were permanently installed in the Mississippi and the Danube river to constantly stream their sounds online and enable to link the two rivers. Furthermore, the data acts as detectors for specific fish species and sources of noise pollution. The recordings can be streamed online and were, so far, simultaneously broadcasted in an old gas station in Upper Austria, at a forest in Lower Austria and in the city square of New Orleans.

Session **SP25**

Nature bsed solutions crucial to manage an estuary in times of global change

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Presenting author: Patrick Meire

Estuaries are very dynamic habitats impacted both by changes in the catchment on one end and sea level rise on the other end, next to many human impacts such as river deepening and embankments. Along the Schelde estuary a restoration plan was developed and consists of a variety of measures, from hard engineering near major cities to complete managed retreat at other places. In this presentation we will describe how we derived the restoration goals and the role of ecosystem based solutions. As several projects are already realised we will be able to give an overall evaluation and guidance for future approaches.

Session **SP25**

How to integrate different governance levels for NBS? - the example of a River Basin Organization in Costa Rica

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Presenting author: Barbara Schröter

Nature-based Solutions (NBS) are a promising approach to support more sustainable development of river landscapes for people and nature. The revitalization of river floodplains, for instance, can alleviate societal risks of flooding of downstream communities and provide multiple co-benefits for recreation and biodiversity.

Successfully governing the establishment and management of NBS in river landscapes is however challenges by issues of scale. Governance must thereby consider both institutions (the rules of the game) and actors (the players of the game) involved in regulating the development and management of water resources and provisions of water services at different levels of society.

For the governance of NBS on the one hand small local initiatives can be found that undertake actions like the reforestation of river banks. On the other hand there are also initiatives for changing rules at the national policy level. But how can the local and the national level be integrated? How can integrative governance be ascertained and how can NBS be planned and implemented considering all scales?

We investigate these questions based on the example of a River Basin Organization in Costa Rica, the Comisión de Gestión Integral de la Cuenca del Río Grande de Tárcoles (CGICRGT). The aim is to explore the RBO as a governance model and describe its institutional design regarding different rule types (authority rules, aggregation rules, boundary rules, information rules and pay-off rules). Based on document analysis and indepth interviews with experts and members of the Commission we expect to classify the RBO according to these rule types. We also discuss the strengths and weaknesses of the RBO regarding its performance to see if it is a suitable governance model for the integration of the local and national scale. We conclude with some recommendations for further research and practical experimentation for other RBOs.

Session **SP25**

Nature-based solutions of different spatial scales to improve the urban water cycle

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Presenting author: Jochen Hack

The urban water cycle has traditionally been designed by engineering concepts of recollection, conveyance and centralized treatment of storm and waste waters. These concepts of a drained" city have led to an optimization of urban space for housing and vehicle transport but at the cost of urban ecology and rivers due to high degrees of surface sealing, piping and channelization of (natural) water flow paths. With the implementation of Nature-based solutions in form of Green Infrastructures at three spatial scales (1 in-situ as source control of surface runoff, 2 at decentralized undeveloped urban free spaces and 3 along urban streams), the inter- and transdisciplinary research group SEE-URBAN-WATER challenges this traditional approach. The implementation of these Green Infrastructures is characterized by a process of Co-Design with local residents and other stakeholders in order to achieve a high degree of multi-functionality. This multi-functionality includes a technically sound design to reduce surface runoff and treat waste water, social-acceptance through including functionalities of direct benefit to the local residents and improvements of the ecological status of urban spaces and streams. In this manner, the implementation of Green Infrastructures addresses societal challenges more effectively and adaptively than merely technical solutions, while simultaneously providing human well-being and biodiversity benefits. In this contribution, the transdisciplinary process of site selection, design and implementation of pilot measures of Green Infrastructure in the district of Llorente in Costa Rica is presented. Different design alternatives and how they have been co-designed are discussed. Additionally, a concept is introduced of how the multi-functionality of the three spatial scales of Green Infrastructures and the differences of ecological and social functions of them relate to each other. Finally, difficulties and important steps of this process are addressed as well as recommendations for replication of similar processes at other sites are highlighted."

Session **SP25**

The uptake of nature-based solutions in German flood risk management plans: Comparing institutional structures and plan outcomes within three different governance regimes

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Presenting author: Mario Brillinger

Nature-based solutions (NBS), defined as actions that fulfil the criteria of challenge-orientation, ecosystem process utilization and practical viability, are advocated as a promising strategy for flood risk management. The EU Flood Directive and its instruments can leverage the idea of NBS for water management practice by integrating individual actions, such as restoring floodplains, into flood risk management plans (FRMPs). However, the way how the FRMPs are designed as institutions for identifying and evaluating appropriate risk reduction measures shapes plan outcomes and, consequently, also the uptake of NBS. There are hardly studies exploring the institutional dimension of designing management plans. Furthermore, it remains unclear which measures can be regarded as NBS and to what extent they are actually considered in decision-making and planning practice.

The present study aims to provide a current status of different NBS types being proposed in selected FRMPs in Germany und explain this actual uptake with a comparative analysis of the institutional structures used and the outcomes produced in these plans. Hence, the following research questions are addressed:

1. How are the selected FRMPs structured in terms of scope, problem definition as well as valuation and decision rules?

2. To what extend NBS types are proposed in the selected FRMPs, compared to the other measure types for flood risk reduction?

3. How is the uptake of measures explained by (a) the performance measures regarding flood impact, costs and benefits, (b) the determined flood risk level for a river basin district or (c) the level of stream order under consideration?

Three federal states were chosen as case studies: State of Hesse, State of Lower Saxony and State of Saxony. Each case represents a different organizational mode of water management and published FRMPs for the first implementation cycle (2012-2015) on state level. The contents of nineteen FRMPs were analysed by a method of qualitative content analysis. A catalogue of different types of natural water retention measures (www.nwrm.eu) served as benchmark to be able to classify the measures found in the FRMPs as 'Nature-based Measures'.

The results show that each case applied different valuation and decision rules for planning measures in its FRMPs and proposed different types of 'Nature-based Measures to varying extents. Whereas mostly bank and floodplain restoration measures were found for the case of Hesse, the state of Saxony often proposed the removal or ecological reconstruction of weirs. However, in all three cases the uptake of 'Nature-Based Measures' was very low, compared to other structural measures such the construction of dikes and mobile walls. The comparative study indicates that NBS are increasingly considered in FRMPs when FRMPs take into account small rivers, low risk levels and cost-benefit relations instead of only relating to implementation costs to damage reduction potentials."

Session **SP25**

Social-ecological assessment of tropical urban rivers and restoration opportunities: blue-green infrastructure for Jarabacoa, Dominican Republic

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Presenting author: Gonzalo Pradilla

River restoration and blue-green infrastructure are being increasingly recognized as successful strategies to reestablish ecosystem services partially or totally lost due to unsustainable urban development. Both strategies can be subsumed in the overarching framework of nature-based solutions, which comprises all actions and projects that aim to protect, restore, create, design, manage, and use ecosystems and semi-natural systems to address societal challenges in a sustainable manner through multifunctionality. In Latin America and the Caribbean, river restoration initiatives appear to be increasing, but only a very small fraction of them has been subject of systematic research, and thus, the applicability of concepts and measures developed for high-income, temperate contexts, is still not well understood. In the Dominican Republic, multi-stakeholder restoration plans for the Yaque del Norte River and some of its tributaries are being developed. This study aimed to contribute to the restoration efforts in the city of Jarabacoa, by assessing the hydromorphological and urban quality of three watercourses within the urban area, along with a citizens survey on the perception and uses of green spaces, rivers, and nature-based solutions for the city. The assessment was carried out through a standardized on-site visual scoring of 28 hydromorphological and 5 urban quality parameters. The survey was applied to 108 respondents using a 37 points questionnaire. The river assessment revealed significant differences between three watercourses: the Yaque del Norte river displays a heterogeneous array of hydromorphological and urban conditions, varying from little to strongly altered floodplain corridors and river banks, and bad to good urban quality, highly dependent on urbanization densities. Two tributaries share strong to total transformation levels of the river banks, floodplain corridors, and river beds, together with bad to very bad urban quality, making these watercourses almost completely unsuitable for contemplation and recreational purposes. The survey showed that rivers are key elements of Jarabacoa's blue-green infrastructure, and despite their ongoing degradation and the lack of adequate public spaces, they are consistently used for recreational, contemplation, and experiential purposes. Priority areas and potential nature-based solutions are proposed and discussed. Community involvement and citizen willingness to support restoration initiatives are two of the most important strengths to be consolidated in the coming years, while institutional weakness is the biggest challenge of upcoming restoration efforts.

Session **SP25**

Nature-based Restoration of a Small Urban Stream in Blacksburg, VA, USA

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Presenting author: W. Cully Hession

In the United States, numerous public agencies are expending considerable funds and effort to restore riparian forests and to control streambank erosion as a means of reducing sediment and nutrient loads. Yet, there is little quantitative information regarding the cost and environmental effectiveness of various stream restoration practices. In 1996, Stroubles Creek in Blacksburg, Virginia, USA was listed as having an impaired benthic macroinvertebrate community. Subsequent studies identified sediment from streambank erosion as the primary stressor and recommended cattle exclusion, stream restoration, and the establishment of forested riparian buffers to improve the ecological integrity of the stream. In 2010, we restored 1.5 km of Stroubles Creek using three different restoration techniques: 1) livestock exclusion; 2) livestock exclusion with bank reshaping and replanting; and 3) livestock exclusion with creation of inset floodplains and replanting. Project impacts have been evaluated using pre- and post-project topographic surveys to evaluate changes in channel morphology, channel stability, and possible sediment trapping within the restored research. Results indicate that natural restoration techniques (without expensive, highly-engineered in-stream structures) are effective even in a highly urbanized catchment. The restoration site has become the Virginia Tech Stream Research, Education, and Management (StREAM) Lab. The StREAM Lab is utilized by over 15 faculty members from seven departments across five colleges at Virginia Tech for research, education (16 classes), and outreach activities.

Session **SP25**

Costa Rica's readiness in the implementation of Nature-Based-Solutions: A methodology of policy assessment

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Presenting author: Veronica Alejandra Neumann

Nature-Based-Solutions (NBS) are a combination of economic, social, and environmental goals and benefits that requires an adaptable policy framework for its implementation. They have emerged as a major approach when discussing about the sustainable future of urban areas suffering from rapid urbanization and stormwater problems. However, NBS have fallen behind in reaching to the political and legal framework, and with this, to a policy mix for urban sustainability. When looking closer at NBS, it becomes more than obvious that they are loaded with many challenges, including institutional, political ones, and what is more, to the urban areas social context. These challenges are also deepened by the lack of policy guidelines for its implementation. In addition, the European Commission stated that the NBS definition is still at the concept phase and in need to increase awareness through case studies and living labs for its proper implementation, while the Economic and Social Research Council (ESRC) consider living labs as urban experiments for policy making. For this reason, this paper proposes a Policy Feedback Cycle (PFC) of an urban experiment for successive policies suggestions that promote NBS. The PFC assesses the policies in a cyclical manner, from policy creation to its maintenance, to enhance the design of subsequent policy outcomes. Combined with the criteria of urban experiments to promote sustainable innovations and new policies initiatives, this paper elaborates a PFC from the New York City (NYC) Green Infrastructure (GI) Plan as it can work as an evidence-based policy making for future projects. Finally, this PFC will be compared against the current policy framework of the province of Heredia in Costa Rica. Results indicate that sustainability policies for NBS at the municipal level should incorporate not only economic and public policies, but also; (i) community involvement and communication; (ii) transdisciplinary knowledge transfer between specialists and relevant stakeholders and (iii) constant communication and community?s feedback.

Session **AJWI**

Austrian Joint Water Initiative – the situation of aquatic ecosystem management in Austria and future visions

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Presenting author: Thomas Hein

Water is a key natural resource in Austria, available in sufficient amounts and in high quality for different uses. Major achievements in the past to improve the water quality of aquatic ecosystems supported the societal perception about the high quality of aquatic ecosystems although the improvements mainly addressed water quality. The last two EU-WFD river basin management cycles showed a contrasting picture: major deficits in hydromorphology for running water systems and an urgent need to implement restoration measures to improve the conditions of the ecosystems. Specifically the number of dams and in consequence disruption of continuity are seen as one of the main deficits affecting biota, like migratory fish but also abiotic dynamics in the ecosystems like sediment transport and balance. Thus, major efforts are needed to improve also the quality of water ecosystems, which requires a more concerted cooperation between different sectors, including water users, the business sector and research institutions, as well as a better alignment of main policies targeting aquatic ecosystem management. Furthermore, as Austria is mainly sharing the Danube River Basin, the transboundary collaboration in water management is of key importance to achieve major improvements in future. Therefore, in this presentation we aim to present an overview on the Austrian status of aquatic ecosystems, transboundary aspects and current developments in aquatic ecosystem management. Following the current situation, we will present the Austrian Joint Water Initiative, and how this initiative will support improvements in aquatic ecosystem management at the national scale and foster more targeted cooperation

Session **AJWI**

Biotic monitoring for the management of gravel column waters along the March/Thaya- alluvial zones from Rabensburg to Marchegg - Biological baseline survey including chemical and isotope water analysis and an additional eDNA approach

Author(s): Robert Konecny et al.

Affiliation(s): Environment Agency Austria

Presenting author: Robert Konecny

The aim of the project was to investigate the effects of this gravel column water management measure on selected bio indicators and protected goods, taking into accountthe nature conservation requirements along the March and Thaya rivers from Rabensburg to Marchegg. The selection of suitable indicator species was based on the requirements of these nature conservation projects.

The central object of the investigations were all waters on the land side of the flood protection dam along the March and Thaya rivers that are within the conceivablesphere of influence of a potential "gravel column water management". In consultation with the experts, this area of influence was carefully restricted to a buffer zone 200 m wide on the landside of the dam. Modelling of lowering funnels shows that this bufferarea has been very generously demarcated. All bodies of water - both temporary (astatic) and permanent - lying in or reaching into this buffer band were included in the survey area, regardless of whether measures were planned or gravel columns were laid. Includedwas also the proof of origin of pool-water ("Sutten") by means of isotope- and wastewater indicator analysis. In addition to this project eDNA samples were analyzed to broaden the range of detection for the cryptic and rare indicator fish species "misgurnusfossilis".

The project was commissioned by via donau and has been running since 2013 until 2017/18. It covers a four-year observation period.

Session **AJWI**

IRIS - Integrated River Solutions in Austria

Author(s): Yvonne Spira

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Presenting author: Yvonne Spira

IRIS is a project funded by the EU within the LIFE 2014-2020 programme. The project deals with integrative river basin management, which considers different disciplinesin planning and implementation. The technical basis for this work is the overarching planning instrument "River Development and Risk Management Concept (GE-RM)". Based on the planning results, concrete measures with synergies between ecology - environment - flood protection will be implemented at regional and local level on seven selected rivers in order to achieve the mandatory improvements in the affected waters. A comprehensive monitoring programme will examine the effects of concrete river engineering measureswith regard to ecology, flood protection and ecosystem services.

LIFE IP IRIS Austria is the first integrated LIFE project in Austria.

The project runs from 01.12.2018 to 31.12.2027. The Federal Environment Agency acts as a project partner.

Session **AJWI**

The next step in wastewater treatment - Removal of toxicological effects by wastewater treatment plants

Author(s): Norbert Kreuzinger

Affiliation(s): Technische Universität Wien

Presenting author: Norbert Kreuzinger

Traditionally, wastewater treatment plants are designed and operated for the removal of macronutrients as C, N and P. The regulation of these substances has a long traditionand contributed to significantly improved surface water qualities. Since several years, organic micropollutants as endocrine disruptors, pharmaceuticals or household chemicals are in the focus of research. Due to the large number of different substances, anenvironmental assessment based on single substance considerations has reached its limits and new effect based biotests with a multitude of endpoints are applied to access potential environmental effects of the wastewater released. In this presentation, anoverview on the performance of wastewater treatment plants in regard to the decrease of ecotoxicological endpoints as estogenicity, androgynicity, mutagenicity and others is presented as well as the potential of further treatment steps as ozonation and activatedcarbon filtration. Results are derived from an interdisciplinary Austrian study operating an advanced wastewater treatment plant accompanied with a toxicological long term monitoring over more than one year.

Abstracts – poster presentations

Session **GS01**

Effects of drought length on the hyporheic microbial processes of intermittent streams

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Presenting author: Laura Coulson

Intermittency in streams is expected to become more common as the climate changes. Previous work on intermittency has largely focused on Mediterranean streams. This research project aims to evaluate how drought affects the microbial processes in the hyporheic zone of temperate streams. We use experimental hyporheic flumes (5 m long, 0.5 m wide, 1.2 m deep) to examine how drought duration affects the state and activity of hyporheic biofilms.

Initial tests were completed in fall 2018 with dry periods ranging from five to 48 days. During the dry period, the flumes were allowed to fall dry in the upper sediment layers (0-60 cm depth) while retaining subsurface flow in the deepest layer (60-80 cm depth). The flumes were then rewetted. Preliminary results show that in dry periods below 41 days, effects on extracellular enzyme activities were negligible or low with recoveries within 24 hours of rewetting. Only the flume that had the longest dry period (48 days) showed an effect on enzyme activities and a slow recovery upon rewetting. Possible explanations include high moisture contents at the end of the dry periods in most flumes and water temperatures below 10°C which generally restricted microbial activities.

To further explore these questions, a follow up experiment is planned for Spring 2019 which will include extended dry periods.

Session **GS02**

The effects of a forested channel section on the phosphorus buffering capacity of fine sediments in an agricultural stream, Thayatal National Park region, Austria

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Presenting author: Elmira Akbari

Agricultural streams are exposed to inputs of phosphorus-loaded soil particles from the catchment, which impair water and sediment quality and may lead to habitat degradation. Forested channel sections have a beneficial role in delivery of ecosystem services such as phosphorus (P) buffering. They protect streams from lateral inputs, and thus may have positive effects on the P buffer mechanism, further depending on the hydrology. The transport of P-rich sediments is highly influenced by precipitation and flood events. We investigated the effects of a forested channel section and the role of flood events on the P buffering capacity of fine sediments in the lower reach of a medium-sized agricultural stream (Fugnitz), located in the Thayatal National Park (NP) region, Austria.

We sampled fine bed sediments at five locations within the NP and at an upstream (reference) site outside the NP during base-flow conditions before and after a flood event. P adsorption and re-suspension experiments were applied to determine the equilibrium P concentrations (EPCo) of bed sediments and P exchange rates between water and sediments. Additionally, we analyzed P-forms, organic matter (OM) content and clay/silt proportions in the sediments.

EPCo decreased from 180 to 41 µg L-1 between the upstream and downstream sites in the NP in the pre-flood period. Upstream sediments showed a high potential for P release, with EPCo greater than soluble reactive P (SRP) concentrations in the stream water, reflecting the influence of upland agricultural influence. In contrast, downstream sediments had lower EPCo than SRP concentrations, indicating a potential of sediments to act as P sinks. Flooding increased both stream water SRP concentrations and EPCo, and induced a switch from potential sink to source function in the upstream part of the NP. In contrast, EPCo did not differ significantly at the agricultural site outside the NP. These results indicate the input or re-mobilization of P-rich sediments from upstream channel sections or from the catchment.

Our results show the function of ecosystem services (i.e. P-buffering) in national parks and natural streams that help to improve downstream water quality. Flood dynamics, however, may influence P loads in national parks through the transport of P-rich sediments from upstream agricultural areas.

Keywords

Equilibrium phosphorus concentration, Thayatal National Park, flood dynamics, agriculturally derived sediments

Session **GS02**

The effects of different DOM sources on stream bacterial activity

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Dissolved Organic Matter (DOM) influences streams functions in a variety of biological, chemical, and physical processes. Agricultural land use has shown to shift both DOM quantity and quality in streams, thereby affecting microbial activity, an environmental issue that still demands in-depth analysis. The current study focuses on the effects of DOM composition from three sources (leaves, maize and dung) on benthic microbial processes within a laboratory flume experiment. Furthermore, we tested whether benthic algae have a positive effect on bacterial DOM degradation. The experiment consists of 22 laboratory flumes, 11 of which were exposed to a 14/10 hours dark/light cycle and 11 were kept under dark conditions. The flumes were filled with pre-cleaned sand and glass slides as substrates for biofilm growth, and fed with nutrient-enriched groundwater in circulating flow mode. After 4 weeks colonization, DOM leachate were added in a single pulse, 6 per source and 4 controls. Samples were taken before and after additions in increasing intervals over 7 days. DOM degradation was analyzed through benthic respiration and primary production experiments, DOC and nutrient uptake rates, extracellular enzymatic activity, as well as DOM quality analysis through absorbance characteristics and fluorescence Excitation - Emission - Matrices. Preliminary results display DOC degradation being always higher in the flumes under dark/light conditions than in the dark flumes. Maize leachate was degraded fastest (26-35% during the first 20 hours in dark/light flumes), followed by leaves (19-24%) and dung (10-11%). Leachate addition led to an SRP increase by 17-38 µg/L in the dark flumes after 4 h, which remained stable during the experiment. In contrast, in the light flumes, no SRP was detectable 4 h after the additions.

Session **GS07**

Anthropogenically altered flow affects compositional variance of dissolved organic matter.

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Studying the effects of altered flow regimens on the riverine carbon cycle is paramount to update the role of rivers in the transport and transformation of organic matter. However, the effects of flow dynamics - natural or anthropogenic - are so far largely not understood. Dissolved organic matter (DOM) is the largest active carbon reservoir in rivers and its chemically diverse composition and reactivity are determinants for heterotrophic ecosystem functioning. At any one location in a river network, dynamic flow implies temporal variance of DOM composition due to changes in relative input rates among DOM fractions, affected transport rates through upstream portions of the river network, and altered transformation rates during upstream riverine passage. Here, we look into the compositional variance of DOM in rivers whose flow regimes are affected by hydropower production and irrigation. DOM was sampled in 20 streams in the North of Spain at 6 occasions spanning the hydrological conditions of one year (2018). The set of streams covered two different hydrological classes with streams of each experiencing 2 different types of anthropogenic alteration of flow. We chemically characterize the composition of DOM and its temporal variance by means of optical methods (absorbance and fluorescence) and ultrahigh-resolution mass spectrometry. We expect season-specific compositional changes across all streams, while changes in the hydrology due to anthropogenic alterations will mainly drive the temporal variance of composition.

Session **GS07**

Effects of Desiccation on Benthic and Hyporheic Microbial Activities in Temperate Streams

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Presenting author: Manuela Waberer

Climate change and water abstraction change the flow regime of rivers and brooks and cause the reduction of summer flows in the process. These environmental conditions promote flow intermittency in formerly perennial streams. Shortened flow periods affect autotrophic as well as heterotrophic organisms living in and on sediments. Currently there is little knowledge about stream intermittency in temperate climate regions. This project assesses the effects of flow intermittency in temperate streams in southern Austria. Both perennial and intermittent streams were sampled during different flow conditions. The following parameters are used to determine stress responses in autotrophic and heterotrophic organisms: activity of biofilms, bacterial abundances, chlorophyll-a, EPS, extracellular enzyme activity, microbial respiration, and photosynthetic light curves. Preliminary results show that heterotrophic microbial activities do not show significant immediate or long-term differences between flow and non-flow periods in benthic or hyporheic zones due to a relatively high moisture content of 10-15% even after long no-flow periods.

Session **GS08**

Environmental Impact Assessment along Somesul Mic River (Transylvanian Depression, Romania) from an historical perspective

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Presenting author: Ioana, Perșoiu

Recent investigations on historical river behavior (ca. 150 yrs) in Romania highlight the main role played by climate variability on the identified general trends of channel planform and vertical evolution, while human influence has a strong but still subordinated role. However, in the absence of a systematic evaluation of human impact on riverine ecosystems, the amplitude and aggressiveness of these interventions are expected to have a dramatic impact on their functionality and connectivity, as many field evidences and monitoring programs support.

We report here a first attempt to use the historical background of channel dynamics along a medium size river from Romania, i.e. Somesul Mic River, in order to place the existing ecological monitoring data along it in a spatial and temporal geomorphological context.

Somesul Mic River is a 175 km long river located in northwest Romania, passing Cluj Napoca city and draining a surface of 3733 km2. During the last 50 years, the river and its floodplain were affected by intense anthropic interventions, from dam constructions to bank stabilization, artificial meander cutoffs, dykes, or intensive gravel mining. In the medium and lower part of it, the present day channel configuration is highly dependent on this human intervention history. By contrast, the natural state of the river is characterized by a complex alternation of channel types (sinuous – meandering – anabranching). We identified 42 distinct channel reaches for which were estimated the natural dynamics of the river and the amplitude of disturbances induced by human interventions. For the purpose of this study, the 42 reaches were regrouped in 9 longer ones, reflecting the succession of areas where the river is completely disturbed from its previous patterns, with the ones where the interventions are more local and some reaches partly preserve their natural forms.

For each of the nine reaches we performed the Environmental Impact Assessment, by using an adaptation of the Battelle Environment Evaluation System (EES). Both aquatic and riparian habitats were considered in the evaluation, and the original parameters on ecology, aesthetics, environmental pollution and human interest/social were adapted to meet the specific requirements of the Somesul Mic river system. According to the Battelle EES, each parameter has assigned an importance weight (PIU - Parameter Importance Unit). An Environmental Quality-scale value (EQ) was designated for every parameter considered in the analysis, based on field observations, water quality data, ecological status or expert judgements. The EQ values were multiplied by the PIUs and aggregated to obtain the Environmental Impact Unit (EIU) score for all the investigated river reaches. The EIU score was then used to compare the nine river segments, in order to highlight the present day status of the riverine ecosystems and to discuss the amplitude of disturbances from a natural status, as defined at historical scale.

Session **GS09/10/15**

Use of fish passes in a highly regulated Mediterranean river: experience of LIFE+ Segura-Riverlink

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Presenting author: Ana Sanchez-Perez

Mediterranean river systems suffer a strong human alteration due to the scarcity of water resources. Infrastructures such as dams and weirs built to take advantage of this resource imply a high impact on fluvial connectivity. Some projects are carried out to restore longitudinal connectivity and improve fish habitat; however, few of them are developed in Mediterranean watersheds. The Segura-Riverlink is a LIFE+ project that aims to promote and validate a Green Infrastructure as a tool to river restoration in the context of the Segura River Basin (SE Spain), which is one of the most regulated from the Iberian Peninsula. Since September 2015, different fish passes have been implemented along 54 km in the main Segura River as a tool to recover the longitudinal connectivity and re-establish the fish movement. Two main fish-based monitoring programmes have been developed to evaluate the effectiveness of implemented fish passes. The first programme was focused on the use of fish passes by the species that inhabit in the study area. The second was a specific mark-recapture programme of four target species which normally show seasonal movements (Luciobarbus sclateri, Gobio lozanoi, Pseudochondrostoma polylepis and Albunus alburnus) in order to obtain information about fish movement. During two migration periods (2016 and 2017) regular samplings were carried out in five fish passes: two nature-like type (bypass) and three technical type (pool and weir). A total of 26 samplings per fish pass were conducted during the study period and we captured inside the fish passes a total of 12745 individuals belonging to 10 fish species: only one native (L. Sclateri) and nine invasive species. Four target species added 89.6% of the total of captures. The most abundant species was A. alburnus (57.7%), followed by G. lozanoi (32.2%), P. polylepis (4.7%) and L. sclateri (3.8%). Target species used all fish passes, however showed different temporal patterns probably related to differences in their biology. Invasive species with ichthyophagous character were only found in technical fish passes. The mark-recapture programme has confirmed the repeated use of fish passes and down-stream and up-stream movements. These results show that the development of systematic monitoring programmes is necessary to evaluate the effectiveness of fish passes. The knowledge of biological needs for each species is essential to design new fish pass structures. For this reason, engineers and biologist should work together as multidisciplinary teams to achieve successful solutions. This work received funds from the project LIFE12 ENV/ES/001140.

Session **GS09/10/15**

Improving habitat quality through restoration: a key for the protection of aquatic biodiversity and its related ecosystem services

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Presenting author: Cybill Staentzel

Aquatic environments are some of the richest and most productive natural spaces in the world. However, human activities greatly altered the physical quality of these environments. These changes resulted in the destruction of habitats essential to the life cycle of aquatic organisms, thus altering the natural package of ecosystem services rendered by the biodiversity of rivers. Ecological restoration actions are currently considered as tools to restore or improve the quality of stream habitats, thus promoting aquatic biodiversity and its associated ecosystem services. An INTERREG-ECOSERV cross-border (France - Germany) research program has recently started to develop instruments within strategies to significantly improve the quality of ecosystem services in a protected area. As part of this program, we carried out a biological monitoring on the Northern Vosges-Pfälzerwald cross-border biosphere reserve where restoration works consisted of the installation of natural ice jams, i.e. dead wood deflectors, and removal of dam structures. We analyzed the aquatic biodiversity in eighteen sections of rivers, each one reflecting a river condition: (i) positive control sections where the restoration was not required, (ii) negative control sections where the restoration is needed, and (iii) restored sections, on which a restoration took place recently or formerly. On all sections, a fine mapping of the river bottom was performed and was analyzed with transdisciplinary tools. Meanwhile, the macroinvertebrate communities were examined to assess the taxonomic and functional pattern of each section according to their condition for comparison. Bio-indicator species were used to evaluate the quality of aquatic environments. Our approach showed a far-reaching impact of the fine-scale habitat, better demonstrating the interdependence between macroinvertebrate communities and the bottom patchy habitat mosaic. Such results would provide not only keys for the protection and conservation of aquatic biodiversity but also for its related ecosystem services.

Session **GS13/14**

High-throughput sequencing reveals dynamics of a river plankton bloom in response to a strong nitrogen pulse

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Presenting author: Christiane Zarfl

Eutrophication and climate change will increase the number and severity of phytoplankton blooms on a global scale. In contrast to lakes, there is a lack of studies focusing on phytoplankton blooms in rivers and the effects of eutrophication and especially nitrogen (N) and phosphorus (P) loading on riverine plankton communities. Here we studied the effects of an unintentional release of a large amount of ammonium nitrate in a eutrophic temperate river ecosystem in September 2015 that elevated nitrate-N concentrations from 3.1 mg/L to 10-55 mg/L. An intense phytoplankton bloom increased chlorophyll concentrations from <10 to >140 µg/L and followed the N plume downstream. We used high-throughput sequencing to reveal the dynamics of the bacterial (16S rRNA gene) and eukaryotic (18S rRNA gene) community throughout the event, demonstrating the suitability of this technique for freshwater monitoring. Bacterial and eukaryotic community richness was reduced and community composition changed significantly during the bloom. Few eukaryote taxa (e.g. Cyclotella meneghiniana, Chlamydomonas) dominated the bloom and replaced the rich summer phytoplankton community. Long-term data (2008-2016) from the same river showed that seasonal shifts in phytoplankton community composition were linked to physical parameters and nutrient availability, with P-limitation observed in spring but not in summer. The N pulse-related changes in community composition and the phytoplankton bloom may have been caused directly by the release from N-limitation and indirectly by a massive fish kill upstream. Strong N-pulses can thus have significant effects on plankton communities in rivers even under eutrophic conditions.

Session **GS16**

Modelling Of River Water Level Using Artificial Neural Network Algorithm and WA-SVR Model

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Presenting author: Shishir Gaur

Water level forecasting is of significant importance for water management and precise water level prediction assists in practical and optimal usage of water resources. This paper describes Artificial Neural Network (ANN) optimization technique and Wavelet Support Vector Machine (WA-SVR) model of predicting river water level in given terrain. ANN is a widely used modeling technique, which can approximate a non-linear relationship between input and output data sets without considering physical processes and the corresponding equations of the system. As a result, ANN models are much faster than physically based models. In this study two models, i.e. Feed Forward Neural Network (FFNN) and support vector regression (SVR) have been used for comparative analysis. The performance of the models was evaluated using correlation coefficient (R) and Nash-Sutcliffe Efficiency Index ( ). After improving the model accuracy using different types of network architectures and training algorithms, it was observed that FFNN trained with Gradient descent with momentum backpropagation and with adaptive learning rate backpropagation performed fairly well to others. The results indicated that the ANN technique are well suited for forecasting river water levels. The present research conclusively showed the capability of ANN to provide good estimation accuracy and valuable sensitivity analyses. Overall, it was observed from the results that the ANN model have simulated and predicted the water levels in the river with fair accuracy whereas WA-SVR model's results were more accurate. Study concludes that wavelet decomposition based SVR is found to be superior in comparison to ANN model.

Session **GS16**

From drone flight to numerical model: Comparison of the application of two photogrammetric softwarepackages

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Presenting author: Felix Dacheneder

Development of stream bathymetry is a critical parameter in the setup and validation of hydraulic models. For large river systems, bathymetric airborne LiDAR, sonar or acoustic Doppler current profiler are well-established instruments to either survey the bathymetry. In streams with less than 1 m water depth, it is challenging to map a detailed underwater topography or execute velocimetric assessments. Drone-based remote sensing technics such as Structure-from-Motion bathymetry provides a fast and cost-efficient methodology to create high-resolution bathymetry.

The research area, the sandy creek "Holtwicker Bach", is located in North-Rhine Westphalia, Germany. The field of measurements is an in the year 2018 performed river restoration of approximately 0.4 km length with an average water depth of 0.4 m. The creek partly runs dry during summer months.

The bathymetry for the hydraulic model is created by drone-based Structure-from-Motion photogrammetry using Pix4D and Agisoft Metashape. Aerial images with a certain front and side overlap, taken in a flight altitude of 20 and 30 m, are converted to a high-resolution digital elevation model. During the flights, water levels varied from almost dry up to 50 cm. A refraction correction by connecting CloudCompare with an adjusted Python script (Dietrich, 2016) is applied to bathymetries created from surveys with water tables.

To verify the results of the bathymetry, three cross-sections and a longitudinal terrain profile along the investigated area are used. The water level is estimated by a polygon of the captured water surface within the georeferenced aerial images and RTK-GNSS surveyed water edges. Two-dimensional hydraulic simulations are done by HEC-RAS (version 5.0.7). Different constant discharges are tested to show the effects of the developed and changed bathymetry on the hydraulic patterns since the restoration was performed.

The poster will present the employed processes to record a pack of aerial images, how to produce a bathymetry from it up to the generation of a hydraulic model. In the connection of these processes, the publication distinguishes possible sources of error, which should be considered in future investigations.

Session **SP01**

Changes in fluvial processes induced by the restoration of an incised mountain stream

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Presenting author: Bartłomiej Wyżga

Construction of a high check dam on mountain Krzczonówka Stream, Polish Carpathians, in the mid-20th century caused numerous detrimental changes to the downstream reach. They comprised deep channel incision and transformation of the alluvial channel into a bedrock-alluvial or bedrock channel, increase in unit stream power and bed shear stress at given flood discharges, considerable reduction in floodwater retention in floodplain area and degradation of hydromorphological quality of the stream. Before a lowering of the check dam aimed to make the structure passable for river biota, boulder ramps were constructed in the deeply incised channel below the dam to facilitate entrapment of sediment released from the lowered check dam. When the check-dam lowering was underway, a major flood occurred on the stream, flushing out from the dam a considerable amount of sediment that was efficiently trapped by the boulder ramps in the downstream reach. To determine how the environmental problems caused by the long-term sediment starvation of the stream were mitigated by the restoration works, stream surveys were done before the restoration activities (2012), after the installation of the boulder ramps (2013) and during (2014) and after the check-dam lowering (2015). Moreover, one-dimensional hydraulic modelling of flood flows was performed for pre- and post-flood conditions. During the flood of 2014 about 1700 m3 of bed material were retained in the stream, resulting in re-establishment of alluvial channel bed and an average increase in bed elevation by 0.44 m. Bed aggradation reduced flow capacity of the channel and increased water stages attained at given flood discharges. This significantly decreased unit stream power and bed shear stress in the channel zone, markedly reducing entrainable grain size t given flood discharges. The proportion of the total flow conveyed over the floodplain and retention potential of the floodplain increased, but the scale of these effects was largely dependent on the amount of bed aggradation in the study cross-sections. Hydromorphological quality of the stream improved, with 3/5 of the evaluated cross-sections being upgraded from moderate to good quality class. The study demonstrated effectiveness of boulder ramps in mitigating problems in the physical functioning of an incised mountain stream.

Session **SP01**

In-stream substrate and invertebrates assemblages: the importance of microhabitat mosaic in defining the Ecological Potential in heavily modified rivers

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Presenting author: Stefania Erba

Mitigation measures in river environment are acknowledged to exert positive effects on in-stream habitat conditions and the benthic community. However, to ascertain the relationship between mitigation measures, habitat heterogeneity and the response of biota is a complex task, in particular in altered streams. Only few studies document the response of aquatic invertebrates to mitigation measures and habitat mosaic changes in heavily modified rivers. We explored the benthic community structure of leveed lowland rivers in Northern Italy, located in an agricultural landscape. Investigated sites display different levels of mitigation measures implementation and we expected that microhabitat mosaic, here intended as the combination of substrate microhabitats given by their presence/absence and relative share, reflect such different levels. We proposed a simple approach based on Bayesian statistics to quantify similarity of microhabitat mosaic between sites. We then tested the response of benthic metrics and habitat features to the level of implementation of mitigation measures. As last objective, we examined the relationships between microhabitat mosaics, mitigation measures, benthic community alpha and beta diversity and classification of ecological potential. The microhabitat structure observed at sites where measures were fully implemented was different from those of other sites. Investigated sites showed a gradient in number, diversity and mosaic of in-stream microhabitats that mirrored morphological alteration and the level of implementation of mitigation measures. Benthic community assemblages and ecological potential metrics were strongly related to such features. Together with morphological alteration, microhabitat diversity and mosaic were the main factors influencing benthic community structure. Benthic beta diversity was closely related to microhabitat number and diversity, while alpha diversity and ecological status metrics reproduced the microhabitat mosaic gradient. Microhabitat characteristics and most benthic metrics significantly changed according to measures implementation and showed a gradual shift in classes of ecological potential. We established the relevance of in-stream substrate microhabitats as a medium between mitigation measures and the benthic community. In perspective, microhabitat mosaic should be evaluated to better understand biological responses, in particular when ecological classification is considered. The vast amount of data available worldwide on substrate microhabitat composition could support a simple yet effective use of river mosaic information for river management.

Session **SP01**

Wilde Mulde Restoration Project: Looking at the Effects of Floodplain Reconnection on Nutrient Retention

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Presenting author: Thomas Wippick

Floodplains have the capacity to influence many biological, chemical and hydrological processes in the riverine environment and thus, are of high importance for riverine nutrient dynamics. The majority of floodplain reaches, although high in ecological value, have been completely converted or hydrologically decoupled. Recently, river restoration projects have highlighted the importance of reconnecting hydromorphologically altered rivers with their former floodplains. This study aims to investigate the changes in nutrient retention capacity when former floodplain habitats are reconnected to the main river channel. The study site includes recently reconnected floodplain habitats (side-arm, riparian sites and inundation areas) along a section of the River Mulde, a lowland river and tributary to the Elbe near Dessau, Germany. Research objectives include identifying which factors affecting nutrient retention have changed due to the hydromorphological restoration measures, as well as whether the newly reconnected side arm is acting as a source or sink of nutrients. Additionally, this study attempts to describe the driving forces of nitrogen retention in this system. This will be accomplished through sampling of areas with and without restoration measures, and comparison with measurements from before the implementation. Changes in floodplain hydromorphology will be identified. Sediment and water samples will be analyzed for phosphorus and nitrogen fractions, furthermore assessing denitrification processes and uptake rates.

Session **SP03**

The River Network Toolkit - a software for freshwater ecology

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Presenting author: Gonçalo Duarte

Rivers are organized as dendritic networks, and river flow is the ruling force driving multiple functions and components of freshwater systems, meaning that the longitudinal dimension of connectivity is the most pertinent for the ecological processes involving fish species. For diadromous fish species and their life-cycle migratory requirements, this is even more noticeable. In this work, we aim to assess the functional connectivity impairment occurring in Europe, from dam construction along the twentieth century, using the historical distribution of 14 diadromous fish species and one species complex. Historical data was obtained by consulting and combining multiple European databases and sources. Afterwards, the historical data was used in a framework that allows managing the disparity of geographical extent and distinct scales of sources and databases, providing a consistent output dataset of historical occurrence at the segment scale. Information about European large dams was obtained via the GranD database and integrated into the Catchment Characterisation and Modelling- River and Catchment database v2.1 (CCM2). Results show that, historically, longitudinal connectivity impairment increased severely in the second half of the 20th century, and by the beginning of the 21st-century functional connectivity impairment existed for all species analysed. Over 47% of large basins showed potential distribution losses and in some cases, a given species may have had more than 60% of their river length distribution impaired. The construction of mainstem dams tends to be paired with the decline of several diadromous fish species stocks and occurrence, indicating that large dams may have contributed decisively to the European decline of diadromous fish species.

Session **SP04**

Sustainability assessment of agricultural water use as part of a remote sensing management and monitoring tool

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Presenting author: Felix Neuendorf

Managing the allocation of freshwater resources for humans and the environment is a major challenge. In particular, high water withdrawals for agriculture can impair water-related ecosystems and their services as well as increase the competition for water among different users. Knowledge about water use and its sustainability is therefore crucial for management of freshwater resources and for any actor who influences the use and distribution of water.

The transdisciplinary research project Virtual Water Values (ViWA) aims to address these challenges in developing a global, remote sensing based management and monitoring system for the efficiency and sustainability of water use in competing sectors. Part of this project is the development of a method to assess the sustainability of agricultural water uses. The water related 'Sustainable Development Goals' (SDGs) of the United Nations serve as the main reference for this method, focusing on agricultural water use and its' impacts on ecosystems. The method is mainly based on existing concepts like the water footprint with the focus on distinct criteria for adaptation purposes. First, the scale of the assessment has to meet requirements on national and catchment area level but should also fulfil the ability to be downscaled to meet regional level requirements to address the different sectors in questions of water distribution. Additionally, the evaluation criteria are classified according to their degree of legitimacy on global level. This allows building a graded approach that can be adapted to evaluate different levels of sustainability. A spatially explicit biodiversity component is added using GIS based neighborhood analysis and environmental flow requirements to enhance understanding of expected impacts on water dependent habitats and river flows given the observed agricultural practices. Using data that is provided by project partners, amended with globally available data we are able to identify hot spots of unsustainable water use and cold spots of sustainable water use, starting with the Danube basin as a first case study. Assessment results can give incentives for change of water use in areas where unsustainable water uses have been identified and will further be used to evaluate flows of virtual water by amending economical models with sustainability information.

Session **SP04**

Impact of hydromorphological alteration on environmental flow assessment for macroinvertebrates

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Presenting author: Ewelina Szałkiewicz

Environmental flows (EF), which ensure water for environment, has been permanently inscribed in the water policy around the world. During environmental flows assessment (EFA) considering ecological response of water organism is necessary. However, it is usually time and cost-consuming, thus measures aimed at optimization cost and accuracy are needed. One of those measures are general habitat suitability criteria, which represent averaged preferences of the organisms relative to environmental conditions. Those are usually based on large sample of data and used to EFA for variety rivers. Although possibility of transferability of general habitat criteria was already assessed in a relatively large scale (e.g. between regulated and natural rivers), assessment in smaller spatial scale is still needed, especially in case of variety types of river modification. One of the widespread cause of hydromorphological alterations of rivers in agricultural landscapes are technical maintenance measures, which consist of channelization, riverbed dredging, macrophytes cutting or banks modifications. These alterations have significant impact on biota, hydraulic parameters and sediment transport processes. Subsequently, EFA estimated on the basis of general habitat criteria may be not suitable for modified reaches, if more accurate degree of modification is considered.

Main aim of this study was to estimate the impact of alteration caused by technical maintenance measures on EFA for macroinvertebrates. Our basic hypotheses were: (1) EF will differ between reaches with different degree of modification; (2) smaller values of EF will be needed to provide habitats for macroinvertebrates in the semi-natural reach, and (3) transferability of habitat criteria are limited if the degree of modification is defined. To verify hypotheses, two reaches of the Flinta River (Western Poland) were investigated. First reach, semi-natural, was located in the downstream part of the river, in the Natura 2000 area. The reach had variety types of mesohabitats including planes, riffles and pools. Second one, strongly modified, was located in the middle run of the stream and it was plane with small slope. Additionally, at the modified reach technical maintenance measures are systematically carried out. EF were estimated for both reaches using hydrodynamic habitat models, where hydraulic parameters were calculated using 2D modelling. Results confirmed our three hypotheses, showing differences between EF estimated for modified and semi-natural reaches.

Session **SP05**

Effects of macrophytes on nutrient cycling in a groundwater-fed lowland river

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Presenting author: Philipp Mayer

The input of nutrients to downstream river stretches is crucial for their trophic state. The quality and quantity of this input are determined by catchment conditions, hydrology and in-stream processes. Macrophytes can mediate by direct and indirect effects the nutrient dynamics and influence nutrient uptake and release processes in rivers.

The combination of nutrient uptake through assimilation in the roots and shoots, the temporary storage directly by macrophytes and the retention of fine sediments that contain nutrients due to the velocity reducing effect of dense macrophyte patches shows their essential role in nutrient dynamics of rivers.

Our study focus on the immediate direct uptake of nutrients in river stretches and assess the role of macrophytes by applying the nutrient addition approach based on the concept of nutrient spiraling and complement it with ecosystem metabolism measurements and the determination of sediment characteristics and sediment nutrient concentrations.

We investigate two different sections of the groundwater-fed, oligotrophic lowland river Fischa in Lower Austria. One section is characterized by a high biomass and coverage of macrophytes, in the other section no macrophytes are established. The sampling and measurements will take place from March to October 2019 to study the nutrient uptake in relation to the seasonally changing biomass of macrophytes.

The main hypothesis of our work, is that there is a strong correlation between nutrient uptake and the biomass of macrophytes, resulting in a seasonal changing effect, highest at peak macrophyte biomass. First results will be presented.

Session **SP05**

Effects of Macrophytes on nutrient cycling and metabolism in lowland rivers of lower Austria

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Presenting author: Stefan Lötsch

Macrophytes in streams cause changes to water quality and modify the aquatic environment through their physical resistance against flow. Some of the changes are consequences of direct effects, such as assimilation and leaching. Whereas further potential routes of nutrient retention may be accredited to indirect effects, involving sedimentation, adsorption, burial and processes of nitrogen transformation.

We investigated seven river-reaches in different varying landscapes of Lower Austria and subsequently defined an upstream-downstream approach to determine nutrient retention. To gather knowledge and to describe our different reaches we additional took samples of macrophytes, sediment and measured discharge and metabolism.

We hypothesized (1) that macrophytes will be the primary driver of stream metabolism due to their rapid growth rates and prolific biomass, (2) and that the impact of macropyhtes on nutrient retention will clearly correlate with high standing stocks and therefore a high biota-water contact time and there will be a higher effect in nutrient-rich streams because nutrient uptake is not only limited by root uptake.

Preliminary results demonstrated limnochemical similarities within the investigated reaches, which enabled us to categorize them in to three river groups: oligotrophic/groundwaterfed -, oligotrophic/siliceous- and eutrophic rivers in agricultural landscape. Metabolism measurements for all river groups indicated that macrophyte biomass drives ecosystem metabolism. Nevertheless, no clear relationship between nutrient retention and macropyhtes biomass over a season was found. Macrophyte can be either a sink or source of nutrients for the system.

Session **SP06**

An integrated modeling framework to track the impact of agricultural activities on riverine ecosystems

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Presenting author: Damiano Baldan

Agricultural activities are supposed to intensify in the future to meet the demands of an increasing population and dietary transformations. Thus, the pressures on riverine ecosystems are increasing as well. For example, land use change, nutrients pollution and increase of water use are some of the pressures that are ultimately threatening aquatic biodiversity. Based on a literature review, current integrated modelling frameworks focus on agricultural activities or river biota, but the linkages and tradeoffs as the core aspect between agricultural activities and riverine ecosystem responses are scarcely investigated. In addition, the uncertainty related to the chosen models for each aspect can vary largely.

Thus, we propose an integrated modeling framework (IMF) t hat links socio-economic factors involved in agricultural practices, nutrient transport and the riverine ecosystem status to track the impact of agricultural activities on habitat quality and river biota. The IMF includes the socio-economic models CropRota and PASMA [grid], the Erosion-Productivity Impact Calculator (EPIC), the eco-hydrological Soil and Water Assessment Tool (SWAT), the hydraulic model Hec-RAS and a set of species distribution models (SDMs). A general scheme highlighting the input databases, the most important state variables and processes simulated, the main outputs, the interfaces between the models discussed for each linkage and common modeling issues (e.g. calibration and sensitivity analysis) is presented and discussed.

SWAT plays a pivotal role in the proposed IMF because it allows to simulate spatially explicit, catchment scale hydrological and nutrient response to climatic and land use pressures, as well as the impact of agricultural management practices. SDMs are increasingly applied to assess river biota spatial distribution as resulting from pressures acting at different spatial scales and can provide a powerful tool to summarize different models outputs. The PASMA [grid] outputs are re-scaled to SWAT computational spatial units: the hydrological response units (HRU), slices of landscape that share similar elevation, slope, land use, and soil type. For the SWAT and species distribution models, the interfaces are common parameters, for example, nutrient (e.g. N and P) transport. Local hydraulics can be simulated with Hec-RAS, using SWAT outputted water flows.

The proposed IMF aims to provide a comprehensive tool to support interdisciplinary research. For example the impacts of agro-environmental policies and management practices on riverine biota can be assessed this way with a transparent modeling sequence As an example for the feasibility of the IMF, we present the setup of SWAT for different agricultural catchments in Austria (e.g. lower Mur catchment, Melk catchment and Danube-Marchfeld catchment) by using the outputs of an existing PASMA [grid] model and discuss how to use ecohydrological outputs to setup SDMs in the study sites.

Session **SP06**

Assessing the necessary complexity and effort to quantify nutrient uptake processes in river systems using different modelling approaches

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Presenting author: Matthias Pucher

Due to the fact, that the cycling of nutrients is critical for river ecosystems, the determination of the degradation of nutrients along a stream is of high importance. In the last decades, various approaches were developed for the quantification of the nutrient degradation, but the complexity of processes in the interstitial and other storage zones is still challenging. The developed approaches range from very simplified conceptual models (e.g. nutrient spiral length) up to process-based models using complex differential equations (e.g. reactive transport modelling). On the one hand, models that are more complex deliver more detailed results, but on the other hand additional data are required and more expertise is needed to use them. However, there are limitations in gathering these data in the field (e.g. the extent of storage zones cannot be measured directly). In this study different concepts and models for the assessment of nutrient uptake are compared and supplemented by a hydrodynamic-numerical model.

The case study site is at an agriculturally influenced brook in Lower Austria were ten plateau additions with five different leachates were performed for the investigation of the dissolved organic matter (DOM) uptake. In-between the addition and during the plateau, we took water samples at 11 sites along the 220 m long stream reach. After water sampling, we took sediment samples at each site. Dissolved organic carbon (DOC), dissolved organic matter (DOM), nutrients (P, N), as well as extra-cellular enzymes and bacterial abundance were analysed in both, water and sediment samples. Due to the limited available measuring devices, the hydraulic conductivity of the conservative tracer was only measured on 3 to 6 points per leaching experiment. In addition, a hydrodynamic-numerical model was developed for the study area in order to calculate various parameters (e.g. wetted area, hydraulic radius, diffuse transport of the tracer) and thus supplement the missing data. This model is based on measuring river bathymetry in 47 cross sections, distributed along the brook and a high-resolution DEM (1x1 m) of the floodplain.

Using the calculated data from the hydrodynamic-numerical model for the other approaches might lead to better results for the assessment of the degradation of nutrients along a river. However, further field measurements of the river geometry and the sediment layer is required, so this expenditure of time is in contrast to the calculation time of the computer models, which estimates certain model parameters by means of iteration approaches. We use this case study to compare different insights into nutrient uptake using different levels of model complexity, data acquisition efforts and data analysis efforts.

Session **SP06**

Integrative framework for communicating pluvial flood risks

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Presenting author: Lena Simperler

In the past years pluvial flood damage and the number of reports from such events has been increasing in Austria. As legal requirements and protection targets currently do not exist in regards to pluvial flooding in Austria, approaches to risk management vary greatly. Research has shown that more integrative approaches are beneficial for flood risk management. The implementation of mitigation measures, however, has been focusing mainly on a local level and emphasizing on building precautions.

For an integrative approach it is necessary to involve not only scientists and decision makers, but all relevant target groups that can contribute to flood risk adaptation and mitigation. While scientists have a main focus on understanding the processes of pluvial flooding and the impact of changing framework conditions for example through modelling, decision makers and stakeholders have local knowledge about previous floods, specific local conditions and challenges in implementing mitigation measures. When it comes to risk reduction also the involvement of the organized and broad public is crucial to raise awareness for pluvial flood risks and to stimulate self-provisioning measures where necessary.

By connecting the knowledge and fostering collaboration of those groups, an integrated approach for risk management can be achieved. Depending on the target groups, different means of communication are needed. Therefore, we want to develop a methodological approach for communicating pluvial flood risks engaging scientists with a) decision makers and stakeholders and b) the organized and broad public. In both groups responsibilities regarding pluvial flooding, potential mitigation measures and risk awareness are relevant topics to be addressed for developing an integrative view of pluvial flood risks.

The developed approach is based on two case studies, where different groups have been involved with reference to pluvial flooding.

One case study is the Pielachtal located in Lower Austria. Here modelling results of pluvial flooding for the whole region (20 communities) were used as the basis to discuss measures, responsibilities and challenges in pluvial flood mitigation in two workshops with decision makers and stakeholders from different institutions at regional and local level. The setting involved a general presentation of the modelling approach, a gallery session with plans of the modelling results and world cafes to discuss adaptation and mitigation measures in different sectors.

The second case study in Styria focused on the scientific supervision of an education program from the Styrian civil defense organization, which aims to raise awareness of the general public related to flood risks. For this, people from 8 communities in Styria, who attended the talk of the education program, were interviewed, the results were analyzed and used along with scientific studies as a basis for suggested improvements.

Session **SP06**

Integrative water resource management on the example of freshwater fish aquaculture - An overview of methods and parameters used in studies on production potentials

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Presenting author: Melanie Haslauer

Fisheries policy in Europe and other industrialized countries focus on an increase of freshwater fish production for human consumption. The underlying reasons usually are low levels of self-sufficiency rates (e.g. 24% in Europe in 2016), high global sector specific growth rates and limits in expanding wild fishery harvests. To assist growth strategies several countries conducted studies on production potentials with different scopes and spatial scales to gain knowledge about suitable sites or production limits in certain regions. Environmental impacts of prospective fish production are considered with varying degrees of detail.

The aim of the conference contribution is therefore to give an overview of national studies, applied methods and considered parameters. Furthermore, different levels of detail and complexity are shown. Selected case studies are emphasised reaching from simple GIS-mapping of parameters to complex modelling approaches demonstrating integrative water resource management for sustainable freshwater use and aquaculture production. Since freshwater aquaculture is a cross-sectional discipline, which calls for a multisectoral planning, it is outlined, if and how relevant stakeholders are involved during analysis. A further task is to gain information about challenges (e.g. data scarcity). It will be shown to what extent different production systems are considered (eg carp pond culture, trout flow systems, recirculation systems).

The Food and Agriculture Organization of the United Nations (FAO) provide a framework that serves as a basis for present conference contribution. The so-called ecosystem approach to aquaculture (EAA) takes a holistic view on the developments in the sector, which is mainly applied for marine aquaculture. As a conceptual approach, it integrates the activity within the wider ecosystem in a way that it accelerates sustainable development and resilience of interlinked ecological and social systems. Major component of EAA is the carrying capacity (coming from the concept of ecosystem-based management). EEA is a four-category approach based on physical (primary site identification), production, ecological and social carrying capacity and it assits to set upper limits of aquaculture production given by the environment and the society. The results of the conference contribution are prepared in accordance with the EEA.

Session **SP07**

Project CERES, Forest and riparian landscape connectivity at Southern Europe - SUDOE - space

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European landscapes have been shaped by past and present human activities with the consequent loss of biodiversity and fragmentation of natural ecosystems. At the SUDOE space, landscapes have become dominated by intensive forest and agricultural production systems, sparsely interconnected by residual areas of natural and semi-natural habitats, such as mature forests and riparian remnants. The CERES (Connectivity of forest and riparian ecosystems of the SUDOE space) project objective is to develop actions to maintain and improve the connectivity between terrestrial and riparian forests in order to enhance biodiversity and ecological functions of the natural Ecosystems.

The project includes analysis at multiple spatial scales (regional and local) and at distinct SUDOE matrices (vegetation types/ecoregions) where environmental and biological data will be collected in situ and remotely. A common method to characterize the structural and functional connectivity will be harmonized between partners. Ecological Relevant Units (ERU) will be defined as key vegetation elements able to maintain and enhance the structural and functional connectivity across the SUDOE space. ERUs will be characterized based on a set of attributes: a) typology (linear vs non-linear), b) location (riparian and non-riparian), c) vegetation structure (woody and non-woody) and d) shape configuration (area/perimeter). A combination of accessible land-use and land-cover data refined by visual classification of World Imagery Layer (50cm of spatial resolution) will be used to map ERUs in several case studies.

Several biodiversity and ecosystem services indicators will be derived from field surveys focusing on chiropterans, ants and dummy caterpillars. These groups provide not only biodiversity measures (richness and abundance) and ecosystem services (pest predation and seed dispersal and soil enrichment), but may also respond to different scales of analysis. An empirical modelling approach using generalised linear mixed models will be used to link ERU attributes (e.g., size, spatial configurations) with biological data in order to predict biodiversity measures and/or ecosystem services at all distinct SUDOE matrices. The connectivity analysis will rely on a graph theory approach and may provide insights for management actions concerning riparian systems.

The consortium includes an international and multidisciplinary team composed of three countries (France, Spain and Portugal) and distinct partners (public institutes, forest production associations, university schools and research institutes).

Session **SP07**

Project Optimus Prime - Optimal greening of irrigated farmland to achieve a prime environment

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Agricultural intensification is currently considered as a major driver of worldwide biodiversity loss. EU-agro-environment policies were introduced to reduce biodiversity loss by subsidizing farmers that promote agricultural practices that are beneficial for climate and environment, by committing a percentage of productive farmland to Ecological Focal Areas (EFA). Nevertheless, studies are missed to assess the effectiveness of EFA schemes to improve biodiversity conservation

This project aims to establish predictive relationships between biodiversity indicators, ecosystem services and the EFAs, considering their typology and landscape configuration. The study area enclosure two irrigated floodplain areas surrounding Mediterranean rivers located in mainland Portugal. The project will also determine the importance of distinct EFA types (linear, non-linear, riparian, non-riparian) and their spatial location in the structural and functional connectivity of these highly modified agricultural landscapes. Several biodiversity indicators and ecosystem services will be collected, using distinct sampling techniques (e.g., acoustic sampling and identification for birds and bats, pitfall traps for invertebrates, dummy caterpillar for predation assessment). EFAs will be mapped using high-resolution airborne images (RGB, 50cm of spatial resolution) while its habitat suitability for target animal groups will be addressed using a field protocol adapted from the French Biodiversity Potential Index (BPI). In addition, simulations of water and habitat delivery of biodiversity services for different climate change scenarios and agriculture storylines in the future will be performed, while economic costs and agro-policy environmental trade-offs will be analysed.

Session **SP07**

Modelling the risk of water pollution impacts on ecosystem services in the Ramganga Basin, India

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Presenting author: Miriam Glendell

River Ganga - meaning Mother and Goddess, is critically important for the livelihood and wellbeing ~10% of global and 43% of India's population. In addition to its economic importance, the river is also a religious symbol of utmost spiritual significance. Declared as National River of India in 2008, the water quality and quantity are severely compromised, due to rapid industrialisation, urban and peri-urban development, poor sanitation and agricultural inputs. Being a pathway of sewerage disposal of much of northern India, the river is among the most polluted mega-rivers in the world (Mukherjee et al., 2018), leading to contamination of both surface and ground water supplies, impacting health and suppressing development. River flow depletion related to excessive groundwater abstraction has direct impact on food production (Mukherjee et al., 2018), while increased sedimentation exacerbates the adverse effects of flooding with corresponding damage to crops and basic infrastructure.

Identification of point and non-point pollution sources is essential for successful development of water quality mitigation strategies, however it is hampered by the scarcity of water quality and water quantity data in the public domain (Sapkota et al., 2013; Khan et al., 2017). This project tests the development of a risk-based Decision Support Tool, based on Bayesian Belief Networks, to simulate the likely impacts of pollution on human livelihoods, based on publicly-available data. Our model couples the spatial distribution of likely water pollution source areas (hazard) with vulnerability to pollution derived from the spatial mapping of the five sustainable livelihoods framework capitals (social, human and financial, physical and natural capital) to simulate impacts on crop yields, fisheries and human health within a probabilistic framework. We derived sustainable livelihoods capitals and information on population density, sewage treatment and irrigation from the 2011 census (and the corresponding 2015 SRS Statistical Report) and linked it to further spatial GIS data on the catchment land use, fertiliser applications and industry. Pollutants of interest include heavy metals, nitrogen, phosphorus and faecal indicator organisms. The conditional probability tables, linking pollutants to impacts and risks were populated based on available literature and expert opinion. Further model validation through sensitivity analysis and stakeholder consultation is envisaged to produce a tool for understanding hotspots, where specific pollution impacts may coincide with the most vulnerable communities and therefore with the highest risk to human livelihoods.

Khan et al. 2017 Environ. Earth Sci. 76(5): 1-13.

Mukherjee et al. 2018 Sci. Rep. 8(1)

Sapkota et al. 2013 Hydrological Processes 27: 2197-2208

Session **SP09**

Implementation of genomic tools in water quality biomonitoring: comparison between the French and the English model.

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Presenting author: Estelle Lefrancois

The French-Swiss program SYNAQUA (INTERREG France-Switzerland 2017-2019) focused on the development and validation of a genomic tool for biomonitoring, based on diatoms and oligochaetes. One of the four work-packages of the program aimed to raise stakeholders' and citizens' awareness of the readiness, the advantages and the limitations of this novel tool. Three participative seminars were organized in Lyon and Paris during the first trimester of 2019. These seminars aimed to build an ideal but realistic scenario for implementation of the genomic tools in France. As England is the only country where a genomic tool has already been implemented for biomonitoring, questions about English experiences were often raised during the seminars. This presentation focuses on preliminary feedback from stakeholders on the implementation of genomic tools for water quality biomonitoring in England. We also present organization and stakeholders' interactions both in France and England. We try to highlight the main differences between the two countries and to understand what could be implemented in France and, in contrast, could or should not be implemented. The English experience, along with our analysis of this, could fuel reflection in France and other European countries where the EU Water Framework Directive applies.

Session **SP10**

Thermotolerance: a GAM-DLNM Approach to Navigate Between Natural and Dammed Sites in Different Climatic Conditions.

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Presenting author: Matteo Redana

Human-managed flow downstreamof dams impacts water temperature regime, both in temperate and tropical areas, by decreasing, or rapidly varying, thermal diel regime and seasonal patterns. The underlying mechanisms between organism's thermal tolerance (CTmax) and water temperature are ofimportance to determine, in order to minimize disturbances. To quantify how and how much different water temperature regimes affect benthic larvae CTmax at different time intervals, I used a dataset of water temperatures and mayfly (Ephemeroptera) larval CTmax from eight sampling sites in Scotland and Malaysia. Thesamplings differ for river typology (artificial vs natural), location (upstream vs downstream), and larval stage. The statistical method of Distributed Lag Nonlinear Models (DLNM) and Generalized Additive Models (GAM) was used to build the function CTmax -water temperature – lag, where lag indicates the time since a particular temperature was experienced. This is important to model because acclimation processes can take up to one week, thus significant, plastic changes in thermal tolerance of freshwater organismsare not predicted to occur instantaneously in response to temperature exposure. The study aims to dynamically understand how both (1) the degree of absolute water temperature change and (2) the time scale at which substantive changes or extremes in water temperature occur, affect changes in larval CTmax. Results show similar shape of the CTmax - water temperature – lag curves, with nonlinear relations between the three terms. Heat tolerance is negatively affected by low and high temperature values, with maximum impact of temperatures occurring 40-60 hours beforesampling time. Heat tolerance is improved following experience of ambient (close to the mean) temperature values, and the effect of ambient temperatures to improve tolerance does not show a lagged effect. In downstream site of artificial reservoir this relation is different and, given the low variability in temperature trend of the site, shows an increasing of CTmax connected with highest values of water temperature. Further researches are need to confirm theserelations.

Session **SP11**

Wastewater treatment plant effluents change microbial communities in river bed sediments

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The European water framework directive aims for a good ecological status for all surface waters. The biological components to evaluate this 'good ecological status' are orientated along the presence and community composition of macroorganisms and algae in a specific habitat, for which clear standards have been defined. The neglected domain of bacteria, however, is also very abundant in aquatic systems and plays important roles in biogeochemical transformations. Bacteria are sensitive to short-term perturbations which may not be visible on higher trophic levels. Moreover, microorganisms in the sediment may mirror long-term developments. Thus, we propose that bacteria and other microorganisms can be a valuable indicator for the ecological status of a river system.

The ecological quality of a river is impacted considerably by anthropogenic pollutants. While non-point sources of pollutants, such as run-off from agricultural fields or urban areas, are difficult to characterize, wastewater treatment plant effluents represent point-sources with a clear upstream-downstream situation. In this study, we sampled sediment cores in a spatial gradient between the spring and the outlet of three small rivers in southern Germany. While two of the rivers receive the effluent of one or more wastewater treatment plants, a third river is situated in a nature protection zone and served as reference location. We characterized the river bed sediment microbial community along the three rivers and hypothesized that the wastewater treatment plants would have a major effect on the microbial community composition.

Bacterial communities were characterized using cost and time efficient genetic fingerprinting (ARISA). The pore water of the cores was analysed for ions, dissolved organic carbon and total carbon. We compared these data to a long-term dataset (2009-2016) of chemical and physical parameters of the three rivers. The bacterial community composition showed a strong shift with a reduction in diversity directly and further downstream of the wastewater treatment plants. The communities did not return to the original composition along the river down to the mouth. In contrast, the reference stream in the nature protection zone did not show a significant shift in the bacterial community composition. The wastewater treatment plant effluents increased conductivity, nitrate, sodium, calcium, organic carbon, chloride and potassium in the river water and in the pore water. The bacterial community shift may be caused by the physical and chemical conditions changing through the wastewater treatment plant effluents as well as by the direct inflow of bacterial taxa from the effluents. The study shows that bacterial communities in river bed sediments are a sensitive indicator for changes in chemical and physical river parameters and anthropogenic impacts. After standardization of techniques, they may thus serve as indicator for water quality.

Session **SP11**

The PARISTREAMs Project

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Suburban streams have often remained outside of the scope of research programmes dedicated to Nature in the city and are often considered as our least restorable ecosystems. The possibilities for ecological recovery remain hypothetical because the potential they offer, the relationship between hydrosedimentary dynamics and biodiversity dynamics remains poorly understood. Moreover, they constitute a major part of the hydrographic network and crucial environmental infrastructures in the perspective of future urban development. Thus, the project considers them as fragments of socio-nature and proposes a holistic approach of river management and restoration to develop socio-ecological knowledge. It is based on an interdisciplinary approach combining social sciences, hydrogeomorphological, biological, palaeoenvironmental and historical investigations which integrate different temporal and spatial scales (comparative approach between 5 streams) in the Paris urban area.

Task1 combines paleoenvironmental and historical research to define the legacy by reconstructing the trajectories of hydrosystems. Indeed, situating current restoration operations in a trajectory seems essential to understand the role of legacies, open the discussion on baseline states and operations, and anticipate tipping points in a context of climate and metropolitan changes. The time-window considered is the last 2 millennia corresponding to their transformation through the repercussions of the anthropisation of watersheds, hydraulic management and the consequences of the industrial revolution and urban sprawl on their hydro-ecology

Task2 is focused on environmental dynamics and on social practices and associated representations to determine the contemporary dynamics. The suburban streams are probably the hydrosystems most difficult to restore but they are also paradoxically the most appropriate to link the ecological project with people because ecological projects in urban areas are in general multidimensional including social aims such as the enhancement of the recreational potential. Thus, analysing and comparing stakeholders' practices and representations is necessary to promote socio-ecological restoration.

Task3 compares the situation in the Paris urban area with other cities in the Western world within other regulatory contexts and socio-cultural determinants. To cross-fertilize knowledge, we believe that the bibliographical approach is not sufficient and that only the sharing of experience can allow us to take a sufficient step back and put the Parisian case into perspective.

Task4 promotes the co-construction of socio-environmental projects in collaboration with managers to achieve the full potential of suburban streams according to their biophysical realities, the expectations of the local populations and territorial projects. The confrontation of academic research with river managers and local people is planned by developing field visits and local workshops.

Session **SP12**

Migratory fish habitat mapping in Mura River in Slovenia

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The Slovenian pat of the Mura River has always been an important waterway, with the first regualtions already implemented in the 16th century to provide space for exploding agricultural production still confining the river today. The loss of habitat diversity affected the biodiversity which started decreasing and many fish species became rare or locally extinct. Each migratory fish species has a particular and complex habitat requirement and shifts to different habitats during its life time (larval, juvenile and 0+ stage). These characteristic makes them suitable indicators of habitat connectivity or fragmentation. Historically, the most common long migratory fish species in Slovenian part of the Mura River was sterlet (Acipenser ruthenus), but the last confirmed record of its occurance dates back to 1976. The track record of other migratory fish in the Mura River such as Danube salmon or nase shows similar declining trends.

Therefore, the MEASURES project in Slovenia aims to determine the wintering, spawning and nursey habitats of migratory fish species in the Mura River by field sampling and survey among the local fishermen. The first sampling campaign has been implemented in the autumn of 2019. We used visual inspection of the river coupled with sonar tracking from a boat to determine the most promising locations of suitable habitats which will be sampled for presence of fish during the next nursery and wintering period. The 3D sonar track was then coupled with GIS data to develop a first habitat map to be used in the following campaigns in which the habitat suitability for different species will be confirmed or rejected based on the presence of fish.

In addition, a stakeholder cooperation campaign was launched to collect historical records of migratory fish presence in the Mura River to couple these data to the field results obtained. An interactive workshop revealed gaps and opportunities for improved management of migratory fish species in Slovenia, including the need for capacity building, data availability and sharing as well as a lack of appropriate policy documents.

Session **SP13**

Newly emerging effects in riverine ecosystems: combined effects of climate change and malacosporean infections on brown trout

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Proliferative kidney disease (PKD) is a widespread disease of salmonid fish worldwide caused by the malacosporean parasite Tetracapsuloides bryosalmonae (myxozoa: malacosporea). In Switzerland, PKD is considered to be a main reason for declining brown trout populations (Salmo trutta). The lifecycle of the parasite consists of moss animals as main hosts and salmonid fish as intermediate hosts. In fish, an infection leads to enlargement of kidney and spleen, anaemic gills, skin darkening and distension of the abdomen. The clinical signs of disease become more serious with higher water temperatures. Infected bryozoan colonies excrete more spores during warm water periods. Therefore, stream warming due to climate change might contribute to an aggravation of PKD symptoms in infected brown trout and in further consequence threaten wild brown trout populations.

The aim of the ClimateTrout project is to investigate the interaction of thermal regimes and the emergence of proliferative kidney disease (PKD) in brown trout populations of four Austrian rivers in relation to climate change.

In the case study river Wulka, 92 % of all examined fish were PKD infected and many of them showed signs of disease. An analysis of the population structure revealed a massive decrease of the brown trout abundance since 2010. Furthermore, analysis of the mean summer water temperatures between 2000 and 2018 showed an increase by 3°C. In conclusion, it can be said that the brown trout population of river Wulka is close to extinction since the numbers of remaining fish are too low for a re-colonization.

The risk for PKD outbreaks was modelled according to the recorded stream temperatures in different sites all over Austria for the present, near and far future (RCP8.5). Results show that thresholds for PKD-related mortality are already being exceeded in some rivers. In the near future even more water stretches will have PKD permissive temperature regimes and in the far future brown trout will be endangered in all main rivers.

Session **SP14**

LUNKERS-type structures as potential hydropeaking flow-refuges for Iberian barbel (Luciobarbus bocagei) in experimental conditions

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Presenting author: Miguel Moreira

Storage hydropower plants causes artificial sub-daily flow fluctuations in the receiving waters - hydropeaking, which leads to quickly rising and falling river flows, potentially causing serious ecological impacts, particularly on fish. Thus, it is necessary to establish effective mitigation measures in peaking rivers. Indirect measures, such as the introduction of flow-refuging structures, intend to mitigate those impacts by enhancing fish habitat quality and variability. In this study we aimed to assess the potential of an overhead cover type of refuge - named LUNKERS - as a hydropeaking mitigation structure, by conducting indoor flume experiments for the cyprinid species Iberian barbel (Luciobarbus bocagei). We designed a lab-scale LUNKERS structure and built it with wood, creating an opaque shelter, and acrylic, a totally transparent refuge. With this contrast we had the goal of testing the different structures visual and hydraulic attraction potential for distinct base-flow (7 L/s) and peaking (60 L/s) events. At the same time, the levels of blood glucose and lactate were assessed to find physiological changes as potential responses to hydropeaking as a stressor and evaluate LUNKERS influence. We defined and assessed metrics of usage inside and in the vicinity of the structures, and analyzed the individual and schooling behavioral differences. The physiological responses were not significantly different, where both values of blood glucose and lactate were higher only in the presence of the acrylic structure for the peaking events. In contrast, behavioral results were markedly distinct for both structures usage, where the transparent LUNKERS was barely used by fish when compared to the opaque one. Behavioral results evidenced a higher usage frequency on all metrics during peaking events for the wood structure, where individual behavior and swimming activity also increased. The wood structure proved to trigger flow-refuging behavior on Iberian barbel individuals during the peaking events, at the same time it promoted sheltering during the low-flow periods. In addition, LUNKERS while providing overhead cover refuges, enhance river habitat quality, since it provide sheltering for fish species and support bank stabilization. The visual factor was clearly the major trigger for the Iberian barbel to find flow-refuging; thus, LUNKERS may act as an effective hydropeaking mitigation refuge.

Session **SP14**

A New Method for Predictive Mesohabitat Modelling

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Presenting author: Erik Van Rooijen

In the past, many rivers have been altered for human use. In many cases, this has had negative effects on the biota living in the rivers as their habitat was reduced or destroyed. In the future also climate change may have negative effects on stream habitat, by changing the temperature of the water or by changing discharge regimes. Currently many river restoration projects are undertaken to reduce these harmful effects induced by humans in the past, i.e. to recreate stream habitat. Often the focus hereby is on habitat for fish species, partly because they are species well-known by the public and party because they are sensitive indicators of flow alteration.

For river restoration projects a model that is able to predict habitat under future conditions is a useful tool. Several habitat models exist on both the micro- and mesoscale. The microscale models often make use of a hydrodynamic model to obtain distributions of physical variables, which are linked to species presence using habitat suitability curves. However these microscale models assume that the habitat of a fish is a point location in the stream, and that a fish chooses it solely based on the characteristics of that point, thus not considering the surroundings.

The surroundings of a location also play a vital role in whether or not a location will be used and thus its suitability as habitat. For this reason, mesoscale models have been developed which analyze the habitat suitability on a patch scale. However, for these models the patches have to be delineated during fieldwork by an expert. These methods are therefore not capable of being used in a predictive way and tend to be somewhat subjective.

The goal of this work is to develop an algorithm that automatically delineates the patches based on the output of a hydrodynamic model. This way a mesoscale approach can be used predictively and objectively like a microscale approach.

We collected topographical data on a reach of the Moesa river in southern Switzerland and ran a hydrodynamic model to obtain distributions of depth and velocity under various discharge conditions. We used an adapted clustering algorithm that also takes into account spatial relationships to identify patches within a river based on the output of the hydrodynamic model. Habitat suitability curves were used to link the patches to fish habitat suitability.

Using this approach it was possible to identify the patchy nature of the river reach and its habitat suitability under various different flow conditions. All of this despite the fact that several of the investigated discharges were unobserved, showing that a predictive mesoscale habitat model is possible which in the future may be used in river restoration projects aiming to recreate fish habitat.

Session **SP14**

A Global Overview on Ecological Impact of Small-Scale Hydropower Plants

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Presenting author: Alban Kuriqi

Small-scale hydropower plants (SHP) are very often presumed as environmentally friendly renewable energy sources. However, recent studies have reported several environmental impacts associated with SHP that should be carefully considered. This study synthesises some of the main findings resulting from published literature on four types of SHP, considering 1075 case studies from 30 countries around the world. The study highlights the SHP's potential effect on the flow alteration, physical and ecological conditions both, along the upstream and downstream rivers reaches. Additionally, we analysed the most common methods used for environmental flow definition. The results show that pondage high head with diversion" and "run-of-river high head in-weir" schemes pose a relatively high potential impact on the riverine ecosystem, mainly related to the connectivity during low flow periods. We found reports of impacts of SHP on 17 fish species, being the most impacted: brown trout (Salmon trutta), rainbow trout (Oncorhynchus mykiss), Atlantic salmon (Salmo salar), barbel (Barbus bocagei), lamprey (Lampetra fluviatilis), and eel (Anguilla anguilla). Literature also shows that SHP have a relatively high impact on benthic/macroinvertebrates by decreasing their diversity, abundance, density, and richness. Riparian vegetation was reported to be impacted as well. The water temperature, Ph, conductivity, turbidity, dissolved oxygen (DO), water depth, flow velocity, sediment transport, phosphate, nitrate, ammonium concentration and alkalinity were reported to be the most affected by SHP abiotic factors. SHP also caused low-intensity hydropeaking in 23% of the studied cases. The hydrologically-based environmental flow methods were the most frequently applied along reaches affected by SHP, particularly, percentage of Mean Annual flow (%MAF), Minimum Mean Flow (MMQ), and percentiles of the flow duration curve (e.g., Q75, Q95). Generally, these methods were not consistently applied. In this study, we outline how river systems are likely to be impacted by such hydropower plants schemes and identify the key issues arising from their continued development. Finally, we propose possible mitigation measures and discuss the main areas of future research needed to overcome current knowledge gaps and support the sustainable development of SHP."

Session **SP16**

River-born and climate drivers control summer hypoxia on the North-Western Black Sea Shelf

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Presenting author: Jana Friedrich

The Black Sea receives major freshwater inputs mainly from the Danube, Dnieper and Dniester rivers, discharging onto the shallow north-western shelf. During the warm and calm seasons, this freshwater input creates strong thermohaline stratification, restricting ventilation of the bottom water layer and making this shelf prone to oxygen deficiency near the seafloor. During autumn and winter, frequent storms erode the thermohaline stratification, thereby re-oxygenating the water column. During the second half of the 20th century, the rivers transported surplus nutrients from wastewater of more than 100 million people, from agriculture and industries in the catchment into the Black Sea, triggering eutrophication. Decomposition of the surplus organic matter increased the oxygen demand and caused widespread recurrent hypoxia during stratification. Despite reduction in anthropogenic nutrient inputs since the 2000s leading to a substantial decrease in spatial and temporal occurrence of hypoxia, summer bottom-water hypoxia is still there.

To understand drivers of the summer bottom water hypoxia formation and re-oxygenation, a mooring was deployed in 30m water depth in the Portita region - north of Constanta and south of the Danube River Mouths in 2010 and in 2016 during summer and autumn. The mooring consisted of an Aanderaa SEAGUARD sensor package attached to an acoustic release. The in-situ high-resolution time series oxygen, temperature, turbidity, salinity, and current velocities and directions , combined with CTD profiles, benthic oxygen consumption rates based on ex-situ incubations of sediment cores, and pelagic oxygen respiration rates, and meteorological data and Danube River data provide a set of information that allows river-born, climatological and biological controls on bottom-water hypoxia to be identified.

The results reveal that bottom-water hypoxia is indeed still occurring between mid-July and mid-October intermittently on the north-western shelf. A current strong climate driver for seasonal bottom water hypoxia is the duration of thermohaline stratification on the shelf, controlled by summer warming and calm weather. Earlier onsets of stratification and warmer summers may intensify hypoxia on the shelf in the future.

A current strong river-born driver is the freshwater inflow by the large rivers Danube, Dniester and Dnipro, also driving stratification, and the trophic state of the north-western shelf, largely driven by river-born nutrients. If river-born nutrient input increases again due to industrial agriculture in the catchments in the future, hypoxia is likely to intensify. In conclusion, the north-western Black Sea shelf is very sensitive to climate change (warming), and the effects of human-induced eutrophication, which may likely intensify the spatial and temporal extent of summer bottom-water hypoxia.

Session **SP16**

Managing river barriers at both sides of the Atlantic - a research plan

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Presenting author: Paulo Branco

Dams have long been built around the world to provide services needed for humans: irrigation, hydropower, water supply, flood control, recreation and navigation. But, albeit these benefits, dams promote a severe breach of longitudinal connectivity strongly affecting fish movements and precluding some fish species from completing their life cycles while imperilling the persistence of fish populations at some river basins. Additionally, the cumulative impacts of barriers are rarely accessed, hampering the correct management of river basins and conservation planning. Nonetheless, dam removals have been increasing due to aging structures and increasing ecological awareness. The research plan we present herein has two chief aims: i) evaluate the impact of isolated and cumulative barriers in overall river network connectivity; and ii) promote the enhancement of river connectivity by providing effective river barrier management tools. To attain these objectives a structural and functional connectivity approach using spatial graphs will be pursued coupled with a review and selection of effective barrier removal selection procedures to be applied at the basin scale. The results of this research plan will help the planning and management of barriers in river systems in Europe and South America.

Session **SP17**

Meandering and hydraulic patterns in a dynamic lowland river

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Presenting author: Tarun Bisht

Lowland river channels in Europe are mostly modified. We studied one of the last remaining lowland rivers which are still mostly freely meandering on a Euclidean distance of 300 km. The Prut River borders between Romania and Moldova, which flows through a 1 km wide floodplain mostly made up by clay and exhibits a zig-zagged planform, which comprises of 3 archetypal bend shapes: round, angular and fat. A historical analysis of meander migration over the last 100 years showed sharper bends showed remarkable temporal stability compared to the round forms. In order to obtain an insight into the underlying mechanics, we mapped 3D flow patterns in 15 meanders using ADCP. Near meander apices, distinct flow separation areas (Inner-bank flow separation zone, IBFS) were observed, with their size being significantly influenced by bend curvature: a proxy of bend shape. We found the ratio of depth at apex pool to upstream riffle to increase significantly as a function of the ratio of maximum to mean bend curvature (a proxy of bend angularity), suggesting a hydraulic response of increasing angularity in bends. These results suggest implications for trajectories of bend evolution, particularly, between fat and angular types. Results also have implications for estimations of the hydraulic capacity of lowland meandering channels, as the IBFS zone occurring in meanders of lowland rivers largely influences the water levels, effective flow width, sediment trapping and bend migration rates therein.

Session **SP17**

Stochastic model of tunnel discharge impact on land surface vegetation

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Presenting author: Cagri Gokdemir

A drastic decline on water table induced by deep tunnel discharge is expected to adversely affect the moisture content of quaternary deposits and topsoil, and draining of domestic and agricultural water supply. Tunneling activity may cause fragmentation over surface water bodies and lead to a shift over wetlands thus deteriorate irreversibly seasonal surface water system and soil-plant-atmosphere continuum (SPAC). Any disturbance on the water-energy balance of the catchment raises environmental risks detrimental for surrounding vegetative cover by reducing plant available moisture content in the soil. This research investigates the risk condition of a 7 km, deep underground tunnel (Mingtang) in China, where environmental impacts are of major concern. This work aims to create a spatial tunnel discharge induced risk assessment model by integrating landscape vegetation cover, linking between underground rock-mass body and overlaying topsoil. Risk assessment model performance is tested for Mingtang tunnel area based on soil water pressure, h, by integrating with the coupled stochastic topsoil flow model and groundwater model in fractured rock. Initial theoretical results for Mingtang tunnel area suggest that wilting does not occur immediately once the water table is lower than rooting depth. Rather, wilting is more infiltration dependent. Soil water pressure losses caused by declines in deep water levels are compensated for when sufficient infiltration occurs. Our goal is to provide both a theoretic solution and a practical method for analyzing tunnel discharge induced environmental impacts under different vegetative and climatic conditions. Outcomes of this study can support decision making for the tunnel discharge design to reduce the impact on topsoil vegetation.

Session **SP17**

Thermal discontinuities along a lowland river: the role of land use

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Presenting author: Roshni Arora

Despite increasing knowledge on the spatio-temporal dynamics of river temperature, a master water quality variable, it remains a challenge to identify the landscape variables influencing thermal heterogeneity along entire river courses. The present study investigated the spatial heterogeneity of stream temperature (ST), and the role of landscape variables, at 20 locations along the 195 km course of the intensively managed lowland River Spree (NE Germany) over a period of nine months. Along the river, four distinct thermal sections were identified, created by thermal discontinuities induced by lakes and an urban area. Three approaches, namely heat budget modelling (estimating the unresolved residual heat flux), both in Eulerian and Lagrangian form, semi-empirical air2stream modelling, and statistical correlations were applied to quantify the observed thermal heterogeneity and the role of climatic (air temperature) and landscape variables (land use, lakes, stream azimuth). Urban areas and lakes were identified as heat sources (in summer), which induced ST discontinuities at different time scales (daily, monthly and during the entire study period). Statistical correlations showed that heat inputs and ST increased with increasing urban area and decreased with distance from lakes. Furthermore, comparison of observed STs and those simulated via the Lagrangian model revealed that heat advection was the dominant thermal process in a lake-influenced section and persisted over a distance of up to 20 km. Simulations showed that this effect could not be significantly diminished even by complete riparian shading along the section, as the sub-daily ST reduced by an average of only 1.5 °C.

Session **SP17**

SMART Research: Outcomes of a nine-year international interdisciplinary doctoral programme in river science

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Presenting author: Guido Zolezzi

River science is an emerging interdisciplinary scientific field that aims to provide a multidimensional knowledge basis needed to understand the complex functioning of river systems that is essential for their sustainable management. Here we present an assessment of the 'Science for MAnagement of Rivers and their Tidal systems' Erasmus Mundus Joint Doctorate (SMART EMJD), a nine-year European programme in river science (2011-2019). A new generation of 36 young scientists (15 EU and 21 non-EU nationals) was trained to engage in state-of-the-art interdisciplinary research within an international context.

Training was delivered by three high-ranking national academic institutions with complementary specialisms: University of Trento (Department of Civil, Environmental and Mechanical Engineering), in collaboration with the hydrobiology research unit at the Edmund Mach Foundation; Freie Universität Berlin (Institute of Biology), in collaboration with the Leibniz-Institute of Freshwater Ecology and Inland Fisheries; and Queen Mary University of London (School of Geography). Through mandatory secondments, additional training was provided by associate partners, including also government agencies. Each candidate was assigned to a primary institution, which defined general regulations for conferral of the joint doctoral degree, and a secondary institution, where they undertook coursework and/or conducted research for a minimum of six months.

Three aspects of the SMART EMJD were investigated in this study (1) interdisciplinarity in research; (2) internationalism; (3) global impact; and (4) science for management. Seventy scientific publications have so far been produced by the SMART candidates, which have been cited 831 times to date. Publications were reviewed together with the doctoral theses and official reports. We also administered two surveys (one to alumni and one to supervisors) to gain feedback on the four key aspects.

Candidates were supervised by at least two supervisors of different disciplinary backgrounds. The study showed that more than 90% of candidates and supervisors dealt with at least one new subdisciplinary research area in relation to their background. The average duration of a doctoral thesis was 3.4 years, and 86 % of all candidates successfully finished their thesis. After finishing their doctorate 50% of the candidates worked in academia, 17% in governmental institutions, 11% in the private sector, 8% in research institutions or NGO and only 1 was unemployed. Only 36% returned back to their home country.

Interdisciplinarity was recognized as one of the most rewarding aspects of the program. The main challenges of the program were related to the short duration and differences between backgrounds of candidates and supervisors. This study can provide guidance for similar initiatives aimed at training early stage researchers in river science that might develop in the future.

Session **SP17**

Advanced Methods for Remote Sensing of Fluvial Hydromorphology

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Consistent, accurate, and timely information on hydromorphology is critical for a wide range of river science and management applications including habitat modeling and river restoration. In this context, remote sensing approaches provide an efficient means of characterizing fluvial systems across large spatial and temporal extents. In spite of sound background in coastal studies, remote sensing of riverine systems still requires significant advancements. With the increasing availability of high spatial resolution satellite imagery, applications of satellites have recently been expanded to riverine environments as well. This research aims to develop advanced methodologies for processing high resolution satellite imagery to map and quantify a set of key hydromorphological attributes including (i) river boundaries, (ii) bathymetry, and (iii) riverbed types and compositions.

Extraction of river area and boundaries is a primary task required for characterization of riverine environments. The delineation of river channel from satellite imagery is inevitably subject to uncertainties concerned with spectral mixture of water with surrounding land covers within the boundary pixels. Mixed boundary pixels can suppress the extraction of river area, geometric features, as well as the cross-sections. To deal with this problem, optimal band analysis for normalized difference water index (OBA-NDWI) and modified binary pixel swapping are proposed for unmixing and super resolution mapping, respectively. The proposed sub-pixel mapping methodology improved user/producer accuracies on the order of 10% with respect to conventional hard classification in mapping the Sarca River (Italy) using WorldView-3 (WV-3) imagery. In the context of bathymetry and riverbed mapping, three different data sources are examined which include spectroscopic measurements in a hydraulic laboratory, radiative transfer simulations, and WV-3 image. This research introduces multiple optimal depth predictors analysis (MODPA) that combines previously developed depth predictors along with other measures such as the intensity components of HSI (hue-saturation-intensity) color space. The results indicated the robustness of MODPA with respect to heterogeneity of bottom types, inherent optical properties (IOPs) and atmospheric effects. Following retrievals of depth and diffuse attenuation coefficient (kd), bottom reflectances are then estimated using a water-column correction method. The results demonstrated significant enhancements in streambed mapping based upon retrievals of bottom reflectances when compared to those using above-water spectra. It is also found that the WV-3's red-edge band, i.e., 724 nm, considerably improves the characterization of submerged aquatic vegetation (SAV) densities from both above-water or retrieved bottom spectra using WV-3 imagery.

Session **SP19**

Riparian zone changes and trends of development on national level - Slovakia

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The aim of the study is classification of linear (riparial) landscape elements of non-forested Slovak landscape and the identification of scenario of their evolution in the future. Analyses of two time horizons data (aerial photographs (1985 - 1986) and orthophotomaps (2003 - 2004) in GIS environment have been applied as main tool of research as well as for the prediction of scenario of their evolution in the future. Non-forest linear (riparian) landscape elements of Slovak ecosystems represents 15,929 km divided to four types of riparian vegetation: i) linear element without or very discontinuous riparian vegetation (isolated trees or shrubs); ii) linear element with discontinuous riparian vegetation (dashed linear structure of vegetation, bare river banks); iii) linear element with continuous riparian vegetation; iv) linear element with riparian vegetation as a band corridor. Comprehension of the riparian zone land cover changes and development requires integration of overall (global) and local awareness of the effects attributable to socio-economic and natural forces (attractors). Application of ideas of aggregate complexity emphasizing the synergy of the riparian system operation and a synoptic (situational) approach accepting universal laws in a specific spatial and temporal context make it possible. The most common type is linear element with continuous riparian vegetation with progressive trend of its development (34%), i.e. the width increased significantly. Besides, we registered a markedly progressive trend of linear element with discontinuous riparian vegetation development. Based on the analyzes between 1986 and 2004, we can conclude that in the basin, the most common linear element with continuous riparian vegetation had progressive trend of its development (47%). On the other hand, in lowland landscape types, the type of line element without riparian vegetation seems to be problematic with strongly discontinuous riparian vegetation, which binds to the artificial canal system and has a stagnant trend in the long term evaluation.

Session **SP19**

Riparian habitat quality evaluation in the Czech Republic - development of a new methodological approach

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Riparian habitats represent an important ecosystem providing a range of functions and services important to humans - e.g. biodiversity support, reduction of erosion risk or transport of pollutants from the surrounding landscape to watercourses. At the same time, it is unfortunately an environment that has been very often subjected to significant pressure during the agricultural cultivation of the landscape or the development of industrial and residential activities of human society. Thus, a large number of riparian ecosystems has disappeared or has been degraded. The assessment of the overall ecological status of riparian habitats thus constitutes an important source of information for the needs of watercourse management and landscape planning in the riparian landscape, the aim of which should be to maintain good status or to improve the current unsatisfactory state of these habitats. In the Czech Republic, there is not yet a comprehensive assessment procedure that would take into account not only the important partial variables affecting the current state (e.g. morphological state of watercourses or prevailing categories of land-use in the surrounding) but also the potential reference state. For this reason, a methodology for evaluation of the ecological status of riparian habitats is currently being developed. Our contribution describes the evaluation procedures and preliminary results of the methodology application to selected model area (small stream catchment).

Session **SP20**

Island development in a mountain river as an effect of channel renaturalization: the Raba River, Polish Carpathians

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Islands are very dynamic and species-rich landforms and thus their re-establishment may be an important factor in the restoration of hydromorphologically degraded mountain rivers. This hypothesis was verified in a study of the Raba River, Polish Carpathians. In the 20th century the river was heavily channelized and incised deeply in its mountain course, but about 10 years ago an erodible river corridor was established in its 2.5 km-long reach. After two large floods in 2010 and 2014, channel width increased up to 3 times and river islands started to develop. Morphological and botanical surveys of islands were conducted each summer between 2011 and 2017 to determine the processes and patterns governing development of islands and their floristic diversity. In some years, plant species were also surveyed on 10 plots of riparian forest adjacent to the channel in the reach. Hydraulic conditions promoting establishment and persistence of islands were determined with one-dimensional hydraulic modelling of flood flows for 8 unmanaged river cross-sections with islands and 8 cross-sections in the adjacent channelized reaches. Average age, number of islands and their average and total area in the reach markedly increased over the study period. However, the increase was not steady but moderated by island erosion by flood flows, island establishment shortly after major floods and island coalescence in the years without such floods. Hydraulic modelling indicated that river cross-sections with islands are typified by significantly

lower values of mean water depth, flow velocity, unit stream power and bed shear stress at flood flows than cross-sections in the adjacent, channelized reaches. Such conditions promote deposition of living driftwood on channel bars, initiating island development, and reduce the probability of erosion of existing islands. The total number of plant species on islands varied highly and either exceeded or was similar to that recorded on riparian forest plots in particular years. Observations in the Raba River indicated that island re-establishment was initiated by substantial channel widening and that in a highly dynamic mountain river, islands originate as a result of deposition and re-sprouting of living driftwood of Salicaceae. Our results suggest that in early phases of island re-establishment, when the availability of propagules dispersed by hydrochory is limited, the contribution of islands to the overall species richness of the riparian corridor can be highly variable depending on hydrological conditions and the state of islands in a given year.

Session **SP20**

Changes in river-forest-human interactions in a dam reservoir backwater zone of a Carpathian stream

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Presenting author: Maciej Liro

Upstream from a dam reservoir, backwater fluctuations (BF) result in temporary inundation of the river channel and floodplain, which may be greater than in the case of flooding caused by a natural river regime. This artificial inundation influences abiotic and biotic river components, creating a novel, very little studied habitat of Antropocene rivers. We use hydraulic modelling, remote sensing data, and field surveys to explore such adjustments that have occurred on a small gravel-bed Smolnik Stream affected by BF from the Ro?nów Reservoir (S Poland) since 1942. We documented distinct river hydrodynamics (decreased flow velocity and bed shear stress, increased water depth), increased rate of fine sediments deposition (up to 10 cm/year) and specific river morphology (narrow, deep and highly sinuous channel) in a lower part of the studied BF zone. These changes were accompanied by expansion of the medium-aged riparian forest on abandoned agricultural land and channel bars. This forest supports a low number of vascular plant species (from 8 to 25 species per 10x10 m plot), which probably reflects backwater-related water stress, high sedimentation rate and a decreased potential for riparian vegetation rejuvenation during less energetic floods in BF zone. The age structure of backwater forest is interpreted as an effect of temporal clearing, which remains a major management option for abandoned agricultural land in this zone. This study demonstrates that BF create a distinct pattern of feedbacks between river, riparian forest and land management, which differs from those occurring on free-flowing rivers and remains a challenge for river management and riparian ecology.

Session **SP21**

Using riverine rock pool communities for collaborative course-based research experiences in biodiversity and spatial ecology

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Background/Question/Methods

In teaching laboratories for ecological courses, it is common to conduct sampling for macroinvertebrates to teach principles of community ecology. These investigations can be conducted in terrestrial or aquatic habitats and tailored to local ecosystems. Environmental gradients in habitat quality or levels of anthropogenic impacts can be sampled to utilize these species as indicators of ecosystem health. Continually sampling the same system over multiple semesters or years can provide a temporal data set that allows students to ask more complex ecological questions. Here we demonstrate the potential to collaborate across institutions to sample a population of aquatic communities and create a robust spatiotemporal dataset for use in instruction and research. This work is focused on a concentration of river rock pools along the fall zone of the James River in Richmond, VA and aims to develop a curriculum spanning concepts in community ecology and spatial analysis to serve courses ranging from high school environmental science to graduate student investigations. We present a model for facilitating data collection across multiple institutions and skill levels in a field research system that includes over 300 habitat patches.

Results/Conclusions

Our curriculum has been implemented with area high school students as a summer program and as an elective class during the academic year. Undergraduate laboratories have been designed for students at University of Richmond and Virginia Commonwealth University in courses ranging from Introductory Ecology, Geography, and Ecological Techniques, as well as a graduate-level Advanced Community Ecology course. We developed a map of the study site accessible using the app Collector for ArcGIS so that instructors and students could identify sampling locations and enter data using their phones, as well as a sampling protocol that can be implemented with consistency across skill levels. Each teaching venue has emphasized different concepts using this system, including island biogeography, metapopulation connectivity, gradient analysis, disturbance ecology, and predator-prey interactions. Students have developed quantitative skills through learning metrics of species diversity and spatial analysis tools. This system highlights the potential of long-term and collaborative teaching laboratories in spatial community ecology and demonstrates how common curriculum can be scaffolded across institutions. Additionally, the data and associated teaching materials from our rock pools provide the opportunity for students to conduct investigations in classrooms without the ability to sample a similar system.

Session **SP22**

The man impact on channel patterns transformation

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In the last two hundred years, the channel patterns changed. The main cause of these shifts was anthropopressure. The research aim was to answer the question: how and why the channels patterns of Skawa River changed in the last two hundred years? Skawa River is mountain tributary of the Vistula River (Poland). The lower course of the Skawa River begins from the Swinna Poreba dam (the youngest reservoir in Poland with a capacity of 160 million m3). In the 20th century, the changes in channel patterns were the biggest downstream of the dam. And contemporarily the riverbed transformations are the fastest there. I classified the channels in the period 19th-21st. I used the method of Rinaldi et al. (2016). My analysis was based on cartographic materials. I realized an analysis of hydrotechnical documentation, acts of Galicia parliament and technical journals from the beginning of the 20th century. I inventoried hydrotechnical constructions in a riverbed and I analyzed the forms of a channel.

The review of the Austrian archival maps (the 1860s) showed that in the 19th century, Skawa River had a multiple-channel. The width of the riverbed was up even to 860 m. At the beginning of the twentieth century, the entire lower and majority of the upper course of the river was channelized. The immediate cause of the channelized was the construction of Galicia Channel. The flood protection became the official cause of regulation in 1930 when it the building of Galicia Channel discontinued. Since then, Skawa River flows single narrow channel (max. 155 m wide). There would be no complete channelization of Skawa River bed without the building of Galicia Channel. In the second half of the twentieth century, the Skawa River bed underwent spontaneous renaturalization. During floods, the artificial riverbed sections are destroyed and develop the seminatural braided sections. The secondary riprap applies when the road or other infrastructure is endangered. The Swinna Poreba dam works since 2010. The dam aids the stabilization of interchannel areas in anastomosis section and development of the meandering section. In the single thread section with riprap, the channel cuts off.

There were four periods of the functioning of the Skawa riverbed in the last two hundred years. In the first period (before 1900), the natural riverbed was single-thread (meandering) or multi-thread (braided, island braided, anabranching high energy). In the second period (1900-1940) the riverbed was complete channelized (artificial bed - sinuous or straight). In the third period (1940-2010), the riverbed has artificial, braided and sinuous sections. In the fourth period (after 2010), the riverbed has anabranching high energy and meandering sections too.

Rinaldi, M., Gurnell, A.M., del Tánago, M.G., Bussettini, M., Hendriks, D. (2016). Classification of river morphology and hydrology to support management and restoration. Aquatic Sciences, 78(1), 17-33.

Session **SP22**

Hyporheic zone and resilience in intermittent mountain streams

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Presenting author: Maria Cristina Bruno

In Northern Italy, alpine and perialpine streams are facing an intensification in magnitude, frequency and timing of droughts due to the combined effects of global and local pressures. These aquatic ecosystems are changing from perennial to intermittent systems with possible but still largely unknown detrimental ecological effects. In this context, a great attention has been paid on the response of stream invertebrates because of their importance in terms of biomass, diversity, and functionality. We investigated the impacts of droughts in low order systems that have recently become intermittent in the Po River watershed (NW Italy), focusing on the biotic exchange between the benthic and hyporheic habitats occurring over different time scales. A first site was selected the headwaters of the Po River (Piedmont) with two stations (one perennial, one intermittent) with piezometers installed in the riverbed, instrumented with temperature and pressure dataloggers, where we monitored two supraseasonal droughts over a period of two years (2017-2019) over a large time scale (sampling conducted approximately monthly during. A second site was chosen in the Po Valley, where during a drought event in summer 2018we monitored at short-time intervals (3-4 days) three Apenninic tributaries of the Po River with a gradient of intermittence. The composition, abundance, functional groups of meio- and macro-invertebrates collected in the hyporheic habitat showed which faunistic components used of the hyporheic zone as a refuge from drought, and its role to increase the resilience/resistance of the aquatic system. In general, we observed a loss of taxa susceptible to drying rather than a replacement of perennial-flow specialists with intermittent-flow specialists along flow intermittence gradients. This work was realized within the framework of the Project of national interest (PRIN) NOACQUA Risposte di comuNità e processi ecOsistemici in corsi d'ACQUA soggetti o intermittenza idrologica"--codice 2O1572HW8F, funded by the Italian Ministry of Education, University and Research."

Session **SP22**

Resilience assement of the large river basins in the Russian Arctic

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Research of changes in hydrological processes and society is main task for 2013-2022, proposed by IAHS. Moreover the analysis of river basins as socio-ecological systems is a key approach at the modern stage. The aim of this work is to adopt an assessment of large river basins of the Russian Arctic as a socio-ecological systems. This type of assessment is important for improving the quality of long-term water use forecasts and for supporting the sustainable development of society in a changing environment. This report briefly describes the existing modern approaches to the river assessment, including those used for the state monitoring network. The applicability of these assessments to river basins in the Russian Arctic is evaluated. A scheme is developed that describes how the social and ecological components of Arctic river ecosystems can be included in the assessment. This assessment is limited to the Nadym, Pur and Taz river basins because of the fact that this region is widely developed due to the oil and gas industry, which has an impact on the socio-ecological system. The assessment includes the following parameters: water quality, environmental sustainability, ecological diversity, ecological variability, tight feedback, social capital and ecosystem services. A scoring method was used from 1 to 5 for each of the parameters. As a result, limitations and uncertainties associated with conducting such assessments for poorly studied Arctic rivers are shown. It is noted that rivers under study are characterized by different stability due to differences in economic development despite the similar natural conditions.