RIPA-1 : First International Conference on Riparian Ecosystems Science and Management

BOOK OF ABSTRACTS

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Conference organized by the COST Action CONVERGES (https://converges.eu/) and the Plant Science & Biodiversity Center, Slovak Academy of Sciences.

KEYNOTES

- TRAJECTORIES AND STAKES OF RIPARIAN REAFFORESTATION ALONG ANTHROPOCENE RIVERS
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Keynotes

TRAJECTORIES AND STAKES OF RIPARIAN REAFFORESTATION ALONG ANTHROPOCENE RIVERS

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A lot of riparian forests do not exist anymore in Europe and elsewhere due to a various set of pressures on land, related to urbanisation and agriculture. Europe is also characterized by new riparian ecosystems that established within the second part of the 20th c. due to land abandonment for agriculture or grazing or various human-driven cascading effects promoting terrestrialisation through sedimentation or incision or reducing shear stress on emerged bars (flow regime shift, peak flow lowering, channel widening and mining, channel incision…). The chronology of vegetation establishment is fairly diverse because the pressures can occur at different dates according to regions and the spatio-temporal distribution of humans and needs. Moreover vegetation may also react with a certain lag time according to hydro-climatic conditions. These new riparian biomes have different characters. Some (not affected by rejuvenation processes) grow faster with a high abundance of exotic species whereas others are still reshaped by active rejuvenation processes. Some are well connected with the groundwater whereas others can be significantly disconnected. These new biomes have various values, sensitivity to changes or constraints for humans (flood control and roughness, summer heat attenuation through shading, in-channel wood mobility) and may need specific human interventions according to the context. A clear biogeomorphological diagnosis considering characters, functioning and trajectory of forests and rivers is then needed to design sustainable management scenarios. Managing riparian forests cannot be done without considering river processes and inversely.

Keywords : River trajectory, vegetation encroachment, environmental stakes and functions, process-based understanding, diagnosis, sustainable management scenarios

FUNCTIONAL FLOWS: A PRACTICAL STRATEGY FOR RIPARIAN RESTORATION

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While it is recognized that riverine organisms are adapted to the natural flow regime, it is impractical to restore natural flows for most regulated rivers. Functional environmental flows offer a practical alternative - these provide the essential river flow patterns to maintain some fluvial geomorphic dynamics, and to satisfy the life history requirements for aquatic animals and riparian plants. Function flow regimes are especially applicable in dry regions and involve deliberate dam operations that provide: (1) occasional higher flows for physical disturbance, (2) elevated river stage during seed dispersal to allow colonization at higher positions that avoid scour, (3) ramping (gradual recession) to allow the elongating seedling roots to maintain contact with the receding alluvial groundwater, and (4) sufficient flows through the warm and dry intervals to avoid drought-induced mortality. For survival, (5) moderate flows in the following few years reduce inundation and scour. Functional flow regimes capitalize on opportunities with high flow years, when water demands for irrigation or other uses are readily satisfied. Ecosystem fortification in wet intervals improves the resilience for dry periods. This presentation will describe the successful implementation of functional flow regimes that promoted the restoration of riparian ecosystems along six regulated rivers in western North America. Along with an understanding of the local river hydrology and vegetation ecophysiology, the successes relied on three social factors: (1) clear restoration objectives that may include endangered fish or birds, (2) partnerships with a range of organizations, including indigenous nations, and (3) management opportunities such as with the implementation of a new dam, the relicensing of an existing dam, or legal rulings related to river resource management. Finally, the challenge of allowing physical disturbance will be considered. This may capitalize on the unpredictable flood events, with the years following floods expanding the restoration opportunities.

Keywords: Environmental flows, recruitment, river regime, poplars, willows.

EVIDENCE-BASED REVIEW OF THE CAUSAL EFFECTS OF HUMAN-INDUCED PRESSURES ON CHANGES AND STATUS OF RIPARIAN VEGETATION

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Riparian vegetation frequently supports multiple pressures which alter the taxonomic, landscape and functional characteristics of riparian corridors. Among others, flow regulation by dams and reservoirs, agriculture, grazing, urbanization, channelization and gravel mining are the most frequently reported human activities related to vegetation changes. In order to design proper management and restoration activities, a precise knowledge of causality between pressures and vegetation changes is needed. Based on the existing literature, simplified conceptual models visualizing relationships between processes, variables and status may be designed to understand mechanisms inducing changes.

In this work, simplified diagrams of process-based conceptual models linking pressures with riparian vegetation status are presented. To assess the scientific causality among them, we have carried out a systematic literature reviewed and weighted the emerged evidence using the eco-evidence approach proposed by Nichols et al., 2011. Out of a total of 193 articles, we reviewed 94 articles related to flow regulation, 43 articles related to grazing, 15 articles related to agriculture and 26, 8 and 7 articles related to urbanization, channelization and gravel mining, respectively. Our findings suggest a frequent low quality of evidence and certain degree of uncertainty in summarizing causal effects of the analysed pressures. The difficulty to generalize conclusions about the effects of altering processes and variables on the development and succession of riparian vegetation is discussed, taking into account the multiple geographical and geomorphological filters that may act limiting or modulating the variety of vegetation responses observed across the reviewed case studies.

Keywords : Riparian corridor, vegetation responses, causality, eco-evidence, process-based diagrams

BAYESIAN NETWORKS AND EXPERT KNOWLEDGE IN RIPARIAN ECOSYSTEM MANAGEMENT

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The multidimensionality of drivers affecting riparian ecosystems (e.g. climate change, biological invasions) demand the involvement of different disciplines to address their causes, effects and management. Bayesian networks (BN) can enhance interdisciplinary approaches in ecosystem management. BN are probabilistic graphical models that represent the cause-effect relationships between variables, allowing the incorporation of quantitative and qualitative data across disciplines and from different sources (e.g. empirical data, bibliography, experts), and easily updated when new information becomes available. Integrating expert knowledge in BN is increasingly done in ecology and management (e.g. ecological risk or management assessment), especially when available data is limited, as it is common in emerging environmental challenges as forest pathologies.

Alder decline due to the oomycete complex Phytophthora alni depends on several interacting abiotic, biotic and social factors. To predict the vulnerability of alder forests to this invasive pathogen within an interdisciplinary perspective, we designed a BN (ADnet) that aims to facilitate alder forest management by assessing their vulnerability to prioritize areas for conservation. ADnet integrates field data, bibliography and expert knowledge. An international (19 experts from 12 institutions and 6 countries) and interdisciplinary panel of experts (e.g. plant pathologists, riparian ecologists, geomorphologists, ecophysiologists) was included in two consultation rounds to contribute to all phases of the ADnet construction (conceptual network, conditional probability tables). In the first meeting, a participatory focus group (FG) approach was performed in which experts were organized in three parallel thematic groups according to their expertise and generated a preliminary version of the ADnet. Based on the outputs of this meeting, the core team of facilitators prepared reference documents that provided a basis for a second meeting, where experts altogether validated the previous network and filled data gaps. The main strengths and limitations (e.g. practicality, scalability, accuracy) of BN and FG participatory approaches will be presented.

Keywords: alder decay, Bayesian modelling, focus group, forest pathogens, participatory approaches

RIPARIAN VEGETATION COMMUNITIES UNDER FLUVIAL DISTURBANCE DECLINE

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Riparian vegetation communities are created and maintained by fluvial processes, which govern their establishment, development and succession. Mutual interactions between riparian plants, river landforms and flow conditions usually result in a gradient of fluvial disturbances and riparian plants communities. In this sense, functional riparian zones have been proposed across the lateral margins of channels, from the more intensive and frequent flow disturbance by erosion and deposition in the more proximal zones to the riverbanks, where recruitment and growth of pioneer riparian species take place, to the less intensive and frequent flow disturbance by inundation in the more distal zones of the riparian zone, where late-seral species are predominantly found. Human-induced pressures decreasing flood magnitude and frequency may reduce the areas more exposed to flow disturbance and induce changes in species composition of riparian vegetation, leading to the decline of pioneer species.

We present preliminary results of the evolution of riparian corridors along several rivers of Madrid region (Central Spain). We studied the woody and herbaceous communities along transects in different reaches and river segments. We identified species composition, relative abundance and distance to the channel bank, and estimated age classes of woody plants. We search for significant differences in composition, richness and Shannon and age diversity along transects, reaches and river segments, reflecting lateral gradients of fluvial processes. A general decline of pioneers (e.g., shrub Salix species) has been detected, aligned with the decrease of channel mobility and bare gravel bars. At the same time, a general replacement of pioneer species by late-seral species growing in the more proximal areas of the channel indicates the loss of dynamism of the studied rivers and the evolution of riparian corridors under the persistent fluvial disturbance decline.

Keywords : Riparian corridor, riparian changes, Salix shrubs, channel mobility, Mediterranean rivers

TEMPORAL ANALYSIS OF FREE-RANGING COWS' MOVEMENT ON WET GRASSLANDS OF AXIOS DELTA IN GREECE

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Axios River is directly associated with livestock husbandry, as the entire area close to the river is grazed by livestock for many decades. Axios Delta belongs to the Natura 2000 network. Moreover, it is mainly grazed by free-ranging cows throughout the year. The use of GPS devices is an effective implement to monitor free-ranging animals, which has a capability of providing many recorded tracks. The objective of the present study was to investigate the temporal movement of cattle in Axios Delta for two consecutive years (2016-2017). Five different suckling cows, young at age (4-6 years old) were chosen each season and year. Their grazing behaviour was investigated by mounting these cows with GPS collars (Lotek) around their necks, which in turn recorded their tracks per six minutes on a 24-hour basis during three seasons (spring, summer and autumn). Differences in animal movement among the three seasons per year were tested by one way ANOVA and the means by the LSD test ($P \leq 0,05$). As a result, suckling cows' movement was significantly differed among seasons and years concerning the maximum distance that they traveled as well as regarding the spatial distribution. In addition, animals presented higher mobility during the day compared to the night due to the fact that they were resting during the nights. Shed was the starting and ending point each day, because they were suckling their calves from 08:00-10:00 every day in 2016 and from 08:00-11:00 every day in 2017, respectively. These differentiations could be attributed to fodder availability, which depended on grazing season and climatic data per year. The results of the present study could be a valuable tool for the sustainable management of this riparian ecosystem.

Key words: Cattle, Lotek GPS collars, wet meadows, season, year, grazing behaviour

FOREST CONNECTIVITY AND WATER STRESS: CHARACTERIZATION AND MAPPING OF THE IMPACT OF CHANNEL INCISION ON RIPARIAN FOREST STATUS THROUGH REMOTE SENSING.

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The health of forests across the globe is a growing concern in a changing climate where droughts can lead to increased water stress. In a riparian context, forests rely on their hydrological connection to the river system. Connections can be affected by human pressures through channel incision and groundwater depletion as a result of dams or gravel mining in the riverbed. As such, assessing and monitoring the status and connectivity of riparian forests is important to better design preservation and restoration policies.

In France, the Ain River is a tributary to the Rhône River where human activities in the 20th century have resulted in a riverbed incision. To assess the impact of the incision on riparian forest characteristics, airborne hyperspectral and LiDAR data were acquired over a reach including both incised and non-incised sub-reaches of the river. Coupled with field forestry surveys conducted by the French National Forestry Office, these remote sensing data were used to characterize each surveyed plot.

Variations in species compositions within patches and individual preferences for drier or wetter soils can be linked to topographic information extracted from the LiDAR data, such as the elevation of each plot relative to the low flow water level. Canopy reflectance also discriminates fairly well between plots above or below the elevation separating the presence and absence of species related to wetter or drier soils through indices and spectral bands correlated with leaf water content. A map of the potential water stress in the riparian forest highlights an upstream – downstream connectivity gradient resulting from riverbed incision that has propagated downstream over the past 60 years.

Keywords: hyperspectral, LiDAR, riparian forest, remote-sensing, water stress

ECOSYSTEM SERVICES OF RIPARIAN FORESTS IN UNCERTAIN HYDROLOGICAL AND LAND-USE FUTURES

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Over the past few decades, numerous research and technological development projects were funded for the conservation and management of freshwater biota, given the huge concerns on human impacts. The research agenda for the upcoming decade are devoted to studying the effects of anthropogenic pressures on ecosystem functions, processes, and services, using socio-ecological dimensions and adaptive management approaches and improvement of these ecosystems in the face of uncertain futures.

Grounded on interdisciplinary work, the RIVEAL project (https://www.riveal.pt) is focused on the study of ecosystem services (ES) of riparian forests and the importance of co-occurring fluvial communities to their provision. It ultimately aims to predict the gains/losses of biodiversity and ES under diverse climatic, land use, and water management scenarios in the Portuguese fluvial landscapes. The project focuses on three ES and values: the "Value of Green", evaluation of Carbon stocks, the "Value of Diversity", ecological integrity of riparian and aquatic biota, and the "Value of Well-Being", cultural services.

We selected two case studies: River Lima impaired by the run-of-river Touvedo dam and River Alva by Fronhas, a storage reservoir. This presentation will summarize the main project results and present the conceptual base of a Bayesian Network that combines drivers of change and ES values to enable decision-makers to quantify trade-offs associated with management choices and prioritize investments to increase ES.

The RIVEAL Bayesian Network consists of five components: 1) the socio-economic and climate-change scenarios that will mainly affect land-use and dam operation, 2) the resulting disturbance processes, 3) the response of the different biological indicators, 4) the ecosystem response to changes, and 5) the response of ecosystem service values. By introducing changes to different scenarios in the input nodes, it becomes possible to know the response of ecosystems and their services and make more effective decisions to mitigate the effect of disturbances.

Keywords: altered landscapes, Bayesian networks, biological indicators, climate change, dams, riparian changes

HABITAT QUALITY OF RIPARIAN ECOLOGICAL INFRASTRUCTURES AND THEIR POTENTIAL FOR THE PROVISION OF BIODIVERSITY-RELATED ECOSYSTEM SERVICES IN HUMAN-DOMINATED LANDSCAPES

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The Riparian Ecological Infrastructure is a network of natural and/or semi-natural riparian patches, vital to support biodiversity and Ecosystems Services (ES) in human-dominated landscapes. In this study, we evaluated the habitat quality of REI patches and their potential for the provision of ES. Fieldwork was carried out in the riparian and floodplain areas of the rivers Tagus and Sorraia (Portugal) during Spring-Summer of 2019. Three types of land use were assessed: Intensive Agriculture, characterized by maize crops and rice paddies; Extensive Agriculture, characterized by sparse cork oak plantations; and Forest Production, including blue gum and maritime pine plantations. We have developed a new multimetric index, termed Habitat Ecological Infrastructure's Diversity Index (HEIDI), based on the characteristics of riparian vegetation and associated habitats, to evaluate the potential of REI patches in supporting the ES provided by three faunistic groups: short-range dispersers (ants), medium-range dispersers (pollinators), and long-range dispersers (birds, bats and non-flying small mammals).

The results showed that the REI patches located in the Forest Production land use achieved the highest HEIDI values, and thus the highest potential to promote the ES provided by short- and medium-range dispersers, such as seed dispersal, soil mobilization and pollination. This can be explained by the more relevant suitability of the existing floristic resources and higher cover of REI patches. In the Extensive Agriculture, REI patches achieved intermediate HEIDI values and appeared to be particularly relevant in supporting the ES provided by long-range dispersers, such as seed dispersal and agricultural pest control, even though providing less available habitat for the considered biological communities.

This work highlights the importance of maintaining and restoring the structural and compositional attributes of REI patches located in production systems dominated by human activities. The results from this work may contribute to safeguard and enhance biodiversity in river restoration projects.

Keywords: riparian vegetation; biological dispersal; ecosystem; HEIDI; land-use/land-cover; REI

RIPASOFT – AN ONLINE TOOL FOR ASSESSING THE ECOLOGICAL STATUS OF THE RIPARIAN ZONES

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Riparian habitats represent an important ecosystem providing a number of functions and services that are important to humans - such as promoting biodiversity, reducing erosion risk, or transporting pollutants from the surrounding landscape into waterways. At the same time, unfortunately, it is an environment that has very often come under considerable pressure as a result of agricultural cultivation of the landscape or the development of industrial and human settlement activities. Thus, a large number of riparian ecosystems have disappeared or deteriorated. The assessment of the overall ecological status of riparian habitats is therefore an important source of information for the needs of water management and landscape planning in the riparian landscape, the aim of which should be to maintain the good status or improve the currently unsatisfactory status of these habitats. In the Czech Republic, there is not yet a comprehensive assessment procedure that considers not only the important sub-variables influencing the current status (e.g. the morphological condition of the watercourse or the predominant land use categories in the surrounding area), but also the potential reference status. For this reason, the Riparian Habitat Quality Index (RHQI) was developed by the author's team to assess the ecological status of riparian habitats. The created online tool "RipaSoft" allows streamlining the whole assessment process. Our contribution describes the assessment procedures and selected results of applying the RipaSoft tool to several case study sites (small stream watersheds). The results can significantly contribute to the identification of sites suitable for the implementation of nature-based solutions aimed at mitigating vulnerability to hydrological risks (not only the risk of droughts and flash floods, but also the pollution of surface waters due to the transport of fertilizers and other pollutants from the surrounding landscape).

Keywords: riparian zone; ecological assessment; hydromorphology; river restoration; Czech Republic

MULTI-TEMPORAL LAND COVER MAPPING AND COMPARISON OF RIPARIAN VEGETATION BELTS OF PROTECTED SITES: THE CASE OF TRENTINO, ITALY

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Land cover dynamics and landscape changes were mapped and interpreted in three Natura 2000 riparian habitat sites in Trentino (Southern Italian Alps). The sites are located along two rivers in Adige valley, the river Noce, with Rocchetta and Rupe sites and the river Avisio with Foci-Avisio site. Multi-temporal maps created along 160 years were base on six distict maps. The first map was based on the Austrian cadaster (Theresianischer Kataster) dated 1859, while the following five maps were based on five aerial photographs at high spatial resolution made from 1954 to 2015. The changes were associated to human activity and to major socio-economic processes occurring in the area Few years before the Austrian cadaster (1849-1852) there was a huge correction of Noce river in the Adige valley which signficantly modified his bed for about 10 km causing big impact especially at Rupe and secondary at Foci-Avisio site. In 1859 the riparian forests were limited, occupying 2.2, 13.7 and 24.4% of the total, respectively for Foci Avisio, Rupe and Rocchetta. The severely reduction of riparian forest was the results of the absolute dominance of the agricultural and pastoral use of the site areas together with the scarcity of fertile and flat agricultural land at the bottom of the valleys. The transition in 1954 increased riparian forest, especially in the less agricultural vocated site, Rocchetta, where it reached the 48.3 % of the land cover. From 1973, and even more from 1994, there was a general constant increasing the riparian forests in all sites, but not in Foci-Avisio where the main provided ecosystem services (ES), biodiversity protection and recreational use, needed to find a trade off with the fload protection. Dramatic changes in ES, in the three sites along 160 years period have motivated recent work, including identifying trade-offs and synergies.

Keywords :Natura2000; biotope; remote sensing; landscape metric; landscape ecology; Free and Open Source Geospatial.

AUTOMATIC DETECTION OF VEGETATION DYNAMICS BY REMOTE SENSING IN RIPARIAN ZONE OF BRAIDED-WANDERING RIVER SYSTEM

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River channels are crucial elements for maintaining landscape by transfer of energy, matters and nutrients, and it is necessary to preserve this unique high diversity ecosystem and functionality of its services. The dynamics of these landscape entities are defined by their spatial dynamics rather than specific structure. The unique and rare wetland ecosystem of the braided-wandering river system of the Belá River was selected for assessment. The Standardised Precipitation-Evapotranspiration Index has been used for estimating the meteorological drought. The in-channel process was identified from aerial images 2012, 2015, 2018, SkySat2018 and Sentinel-2 data. Three main vegetation classes expressed successional stages in the study area were identified using multiresolution hierarchical classification: grass, shrubs, and riparian forest. The accuracy assessment was performed using the validation matrix generated from 100 m fishnet and containing 942 points and 73% overall accuracy was reached. Further, the riparian zone pattern was identified for comparison vegetation and moisture indices in different riverine landscape spatial zones. This pattern was determined based on the combination of four spatial units: 1) planform type, 2) distance from the channel, 3) in-channel processes, 4) vegetation type. Along the longitudinal direction was identified single thread planform type with one main channel, an avulsion channel type with several side arms, a wandering channel with prevailing lateral channel migration and channelized channel with dikes and other anthropogenic modification. Several vegetation indices were calculated for each Sentinel-2 image: NDVI, GRVI, GCI, SIPI, MNDWI, NDWI, MSI. Spatial distribution of vegetation and moisture indices are not affected by distance from the channel and differences are visible in different channel platform comparison. The seasonal variance of VI and MI follows the phonology curve during the year and local hydrologic conditions. The research was supported by the Scientific Grant Agency VEGA, number 2/0086/21.

keywords: riparian vegetation, channel planform, satellites, multispectral imagery, vegetation indices, Sentinel-2

RIPARIAN VEGETATION DENSITY MAPPING OF AN EXTREMELY DENSELY VEGETATED CONFINED FLOODPLAIN

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The most important function of the confined floodplains is to support safe flood conveyance, however any obstacles can hinder this function. The aim of the research is to determine the vegetation density of riparian vegetation types and to assess the spatial distribution (3D) of densely vegetated patches, which might influence the flood conveyance. Applying a decision tree and machine learning, six vegetation types were identified with an accuracy of 83%. Within each type, the vegetation density was determined applying the normalized relative point density (NRD) method. In each submerged vegetation zone (1-2 m, 2-3 m etc.) the vegetation density was calculated, thus the obstacles for floods with various frequency could be mapped. In the study area young poplar plantations offer the most favourable flood conveyance conditions, as their vegetation density (NRDmedian: 0.005) in the potentially flooded 1-5 m zone is the lowest, due to their continuous maintenance by their owners. In the old native poplar forests (NRDmedian: 0.017) the flood conveyance is also slightly obstructed, as tall trees and closed canopy limit the penetration of sunshine, thus the understorey vegetation is hardly developed. The invasive Amorpha thickets (NRDmedian: 0.031) and the native willow forests (NRDmedian: 0.026) provide the worst conditions for flood conveyance, as they can have very dense stands. The study also revealed, that the dense and very dense vegetation patches are common (i) along the banks hindering the overbank flow, (ii) in the southern part of the study area impounding flood waves, and (iii) in all vertical zones, thus not only the regular small floods, but also the centurial record floods are heavily influenced by the vegetation. The results could be applied by hydrologist and forest managers to make plans for sustainable riparian forest management, while the described method could be extended to other areas as well.

Key words: riparian vegetation, LiDAR, machine learning, NRD, Tisza River.

NUMERICAL APPLICATION OF THE THRESHOLD CONDITIONS FOR VEGETATION REMOVAL DURING RECORD FLOOD IN THE MEUSE RIVER

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Riparian vegetation affects both hydrodynamics and morphodynamics of river environments. But, at the same time, flow velocity and sediment scouring may promote the removal of plants during flood events. A recent formulation proposed by three of the authors investigates the critical thresholds in terms of flow velocity and Froude number for which riparian plants are prone to be uprooted. The threshold values mainly depend on the vegetation parameters of growth rate, decay rate and maximum carrying capacity. Such parameters are fundamental in governing the dynamics of plant density in fluvial environments.

In this work, we test the analytical approach to plant uprooting for the record flood event occurred in the Meuse River in July 2021, with a peak flow discharge of 3200 m3/s. We carry out numerical simulations of a 240km long reach of the Meuse River (from Lixhe to Keizersveer). The calculation of the thresholds for plant removal does not need to know the amount of bed erosion, whereas other formulations require to know the scour depth at the roots of plants. Therefore, we decide to perform the simulations with the Delft3D FM suite in terms of the hydrodynamics only.

Results of the simulations, such as water depth and flow velocity, are directly used as input parameters for the uprooting relationships. We account both for the submerged and emergent conditions of the riparian species, according to the flow depth that occurred in the floodplain and the growth stage of plants, such as poplars and willows. Additionally, we examine different scenarios of vegetation covers to highlight the differences between species in the removal conditions and in the patterns of uprooted plants. Outcomes of the analysis are compared to literature data and discussed in the context of the presence of active vegetation dynamics in regulated and trained rivers.

Keywords: riparian vegetation, plant uprooting, vegetation dynamics, numerical simulations, Meuse River

FLOODPLAIN INUNDATION IN GERMANY – AN EMPIRICAL MODELLING APPROACH WITH CURRENT DISCHARGE DATA

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As is typical for Central European rivers, Germany's large rivers have also lost up to 90% of their morphological floodplain through river regulation, constructions for navigation and maintenance works. The flow regime is regulated for more than 70% of German large rivers (BfN 2021) which is impacting inundation of floodplains and thus their functioning. The motivation of this study is to estimate the inundation extent as a yearly average and to answer whether the given discharges allow regular floods and enough inundation for ecosystem functioning?

Natho (2021) showed that for large rivers there is a significant areal difference when considering frequent or medium floods according to the Flood Hazard Map. In addition, medium floods are more destructive and far too rare. Therefore discharge data from 227 gauges along relevant rivers between the years 2000 and 2019 was collected to analyze the occurrence of all water levels exceeding long term average discharge (MQ). As a second step, empirical inundated area-discharge relations obtained from three large rivers in Germany were adapted to the rivers considered and yearly average inundated floodplain extents were calculated.

There was enough data for 196 gauges of the selected gauges to be considered for further calculations. The flood regime of rivers differs greatly in Germany. Whereas some gauges experiences water levels exceeding MQ on up to 311 days of a year, other gauges hardly recorded any. The two scenarios of empirical relation between discharge and area represent rough estimates of either low or high floodplain inundation on the landscape scale. For ecological reasons Flood Hazard Maps should also be calculated for very frequent floods to delineate floodplains highly relevant for regulatory services as nutrient retention, cooling effects, water storage during droughts and carbon sequestration.

Keywords: floodplains, Germany, flood, flood hazard map, empirical model

References:

BfN 2021. (Federal Agency for Nature Conservation) Dataset on floodplain status, condition and habitats, produced under the application of geobasisdata © GeoBasis-DE / BKG (2020)

Natho, S. 2021. How Flood Hazard Maps Improve the Understanding of Ecologically Active

CALIBRATING ECOMORPHODYNAMIC MODELLING WITH FIELD DATA FOR SHORT-TERM RIPARIAN SIMULATIONS

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Water flow and sediment transport drive the morphological evolution of rivers and their floodplain worldwide. However, in non-arid environments, water and sediments do not play alone since also vegetation can significantly shape river morphology. The mutual feedback among vegetation, water and sediments is often referred to as the ecomorphodynamic triad.

The ecomorphodynamic triad started to be extensively studied in the 2000s when hydraulics and ecological perspectives began to converge. Several works concerning field observations, experiments and theoretical models have been carried out so far, shedding light on the main mechanisms occurring in the riparian system. In this picture, numerical efforts to combine vegetation and morphodynamic modelling still have a large room for improvement since the few attempts accomplished up to now have focussed on long-term qualitative analyses of vegetated floodplains only. However, advances in numerical ecomorphodynamic models are hampered by the difficulty of translating the complex riparian dynamics into a simple set of parameters that can be calibrated from field evidence. Moreover, increasing the number of the processes included means raising the model complexity and not necessarily improving its reliability.

In the present work, we address the open issue of finding a trade-off between model simplicity and process reproduction by applying a dynamical ecomorphodynamic modelling to forecast the short-term river behaviour. We investigated a reach of the Orco River (Italy) by coupling numerical software for morphodynamic modelling with an existing module for riparian vegetation dynamics. We extended this module to fit better the processes observed in the study area, particularly focussing on colonization, vegetation growth rates and uprooting mechanisms.

Leveraging the large availability of data for the years 2019-2021, we were able to test the model's capability to reproduce the actual ecomorphological evolution of the Orco River and assess its reliability for short-term prediction. The obtained results feed the discussion about the potentialities and limitations of numerical tools for river management and intervention planning.

Keywords: riparian vegetation, plant uprooting, plant growth rate, river modelling, ecomorphodynamics.

USING BAYESIAN BELIEF NETWORKS FOR ECOSYSTEM SERVICES ASSESSMENT AT THE RIVER BASIN SCALE IN SEMI-ARID ENVIRONMENTS

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Freshwater ecosystems have already affected by climate and land use changes modifying supply and demand of ecosystem services (ES). Research on how ES supply by Riparian Zone (RZ) is affected by the interaction of both stressors is scarce in arid and semi-arid areas like Cyprus. The aim of the study is to capture the relationship between human pressures (P), RZ status (EcSt) and ecosystem services (ES) deliver by incorporating Bayesian Networks (BN) approaches into ES appraisal, identifying key factors driving changes and trade-offs among ES potential under different scenarios.

We followed a geomorphological approach using digital elevetion model (5m) DEM to delineate the riparian zone. We assess riparian zone EcSt, P and ES provisioning in a selected river basin in Cyprus, incuded in the EU Natura 2000 network. We tested the suitability of Bayesian Belief Networks (BBNs) for mapping three plausible scenarios in the change of habitat providing as ES supply by the selected RZ as follows a) a restoration scenario, b) a Business as usual scenario and c) a land take scenario under three climate change scenarion namely low, medium and high emissions. Land use scenarios and parameterization of the BBNs (particularly for the impacts of climate change on habitats) were developed based on experts/stakeholders opinion as part of the Cyprus National Ecosystem Assessment. The results confirm the importance of land use management on ecosystem services provision and demonstrate the need for the development of a national-level database of indicators for riparian zones and floodplains.

The use of the indicators proposed by MAES are perhaps not sufficient to capture changes at the RZ scale. Our approach can be used to a) plan land use changes, b) fine tune the use of EU MAES indicators at the national level.

TOO DARK TO BE SPECIES RICH: VEGETATION CHANGES IN RIPARIAN FORESTS AFTER 60 YEARS

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Riparian forests provide various ecosystem services such as flood protection, carbon uptake, erosion control and timber production, yet it remains unclear how these services are likely impacted by current environmental changes. We took the unique opportunity to resample vegetation plots of lowland riparian forests originating in the 1950s and 1960s and describing the than plant species diversity and composition of riparian forests in three main catchments of the Czech Republic (i.e., Morava, Labe, Ohře rivers). We found strong decrease in plant species diversity. Interestingly, this decrease was only driven by light demanding species with summer phenology. Both mesophilous and wetland summer species retreated. Spring flowering species partly compensated this general decrease by their diversity increase. We hypothesize that these changes were driven by four processes: 1) transformation of riparian forest stands to high shady forests in the first half of 20th century and loss of traditional forest practices (i.e. coppicing, pasture, litter raking, pollarding) led to local extinction of many forest species, 2) drainage of the network of small channels and oxbows, which in the past covered entire area of riparian forests, resulted in strong decrease of wetland species, 3) eutrophication given by extensive application of chemical fertilizers in agriculture led to spread of resource acquisitive and invasive species, which competitively displaced stress tolerant species of riparian forests, 4) the spring ephemeral species were not influenced by increasing canopy area due to their early season growth. Nature conservation should restore traditional forest practices to increase populations of target riparian forest species. Paradoxically, most of these practices are nowadays forbidden from the forest law in the Czech Republic.

Keywords : species diversity loss, floodplain forests, traditional forest practices, vegetation resampling, management restoration, nature conservation

APPLYING THE CSR FRAMEWORK TO PLANT COMMUNITIES OF DISCONNECTING SIDE CHANNELS: A CASE STUDY ALONG THE LOWER LOIRE RIVER (FRANCE)

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River training works for navigation and sediment extraction in the main channel have led to channel incision in many hydrosystems. Therefore, the main river channels are increasingly disconnected from their floodplains and from their side channels (i.e. former and secondary channels). Restoration works of side channels are necessary to increase hydraulic connectivity, to lower flood risk and to conserve or increase biodiversity at the floodplain scale. Such works may modify flooding frequencies as well as light availability, sediment granularity, nutrient level and seed bank composition. For riparian plant communities, restoration works can modify the intensity and frequency of disturbance and stress levels along local environmental gradients and thus the processes that structure species assemblages.

Here we aimed to understand the respective influence of environmental parameters related to varying levels of disturbance and stress in former river channels on the response of riparian herbaceous communities and their ecological strategies (i.e. Grime's CSR scheme).

The study took place in 14 side channels situated along the 140 km of the lower Loire River reach. We extracted three leaf traits from the TRY database to calculate the competitive, stress-tolerant and ruderal values for each species inventoried in 492 4m² quadrats. Using a modelling approach, we then tested the main and interactive effects between various environmental parameters on the community-weighted means and the functional dispersion of the CSR values.

Results showed that light availability mitigated the influence of relative elevation (i.e. flooding frequency) on the mean and dispersion values for stress-tolerant and ruderal species. Luminous conditions favored stress-tolerant communities along the elevation gradient, while shady conditions favors ruderal communities along the elevation gradient. This highlights that forest clearing of side channels can have strong influences on the ecological strategies of herbaceous communities. To maintain functionally diverse communities, it is therefore important to vary shading conditions.

Keywords: Grime’s CSR strategies, community assembly rules, lateral connectivity, terrestrialisation, floodplain restoration.

PHYTOCOENOLOGICAL CHARACTERISTICS OF RIPARIAN FORESTS IN THE WESTERN PART OF ILYRIAN FLORAL PROVINCE (BOSNIA AND HERZEGOVINA, CROATIA AND SLOVENIA)

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We collected all available vegetation samples (relevés) on riparian forests and scrublands from the western part of the Illyric floral province and organized it into the database. Numerical analyzes (ordination and classification) revealed that forests and scrub can be divided into three main groups.

- The first group includes vegetation types that develop in the upper stream of fast watercourse in the colline and montane belts (Alnion incanae, Salicion eleagno-daphnoidis).
- The second group consists of forests and scrub developing along the lower stream of rivers on nutrient-rich river sediments in lowland (Alno-Quercion roboris, Salicion albae, Salicion triandrae).
- The third group consists of forests and scrub in marshy areas under the long lasting influence of stagnant water (Alnion glutinosae, Betulion pubescentis, Salicion cinereae).

The vegetation types are presented by diagnostic, constant and dominant species, their ecological conditions estimated by bioindicator values and their geographical distribution with the region.

Keywords: ecology, floristics, forest, riparian community, SE Europe, shrubland, vegetation.

SYNTAXONOMY, ECOLOGY AND STATUS OF ALLIANCE TAMARICION PARVIFLORAE I. KÁRPÁTI ET V. KÁRPÁTI 1961 ON THE TERRITORY OF BULGARIA

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The alliance Tamaricion parviflorae includes tamarisk riverine scrub on coarse gravelly soils on lowland river banks, presented by 7 associations on the European level. On the territory of Bulgaria, this vegetation was systematically investigated during the last several years. A total of 37 relévés were collected following the Braun-Blanquet approach. Hierarchical clustering by PC-ORD was performed for classification from class to association and community levels.

Syntaxonomical diversity of the alliance is presented by 2 associations (Tamarici-Salicetum purpureae, Tamaricetum smyrnensis) and 1 plant community. Alliance Tamaricion was restricted to the rivers in the southern part of the country. Phytocoenoses were dominated by Tamarix tetranda, T. smyrnensis and Salix purpurea subsp. amplexicaulis. The herb layer cover was very high (in the range of 60 – 90 %). The herb layer was composed mainly of Anisanta sterillis, Brachypodium sylvaticum, Hordeum murinum, Galium aparine, Dasypyrum villosum, Cynodon dactylon, Elymus repens, etc.

During the spring and early summer, those phytocoenoses are periodically flooded, whereas in the summer and early autumn water level is low or water is completely missing. Soils are shallow to moderately deep with high gravel, sand and clay deposition. Tamaricion parviflorae phytocoenoses are used for pasture of domestic animals, which leads to changes in the species composition.

This vegetation is included in the habitat type 92D0 Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae) according to Directive 92/43/EEC. The main threats are destroying and degradation of shrubland vegetation as a result of long-term and strong anthropogenic pressure, their use as pastures and the deposition of wastes on the river banks lead to a significant extent of ruderalization, distribution of alien species (such as Bidens tripartita, B. cernua, Conyza canadensis, Impatiens glandulifera, Amorpha fruticosa) and the construction of hydro-ameliorative facilities, hydroelectric power stations and extraction of gravel from the rivers.

Key words: classification, habitats, riparian scrub, shrub vegetation

RIPARIAN FOREST VEGETATION IN TURKEY

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In this study, it was aimed to present the vegetation structure of riparian forest ecosystems in Turkey under the frame of phytosociological studies carried out in these ecosystems previously. Turkey is placed at the intersection of three main phytogeographical regions: Euro-Siberian, Mediterranean and Irano-Turanian. This differentiation results in the differences at the tree species composition dominating the riparian ecosystems. At the western and central part of the Euro-Siberian Turkey, Fraxinus angustifolia subsp. oxycarpa, Alnus glutinosa subsp. glutinosa, Ulmus minor, Ulmus laevis, Carpinus betulus and Acer campestre are dominant trees of these ecosystems (Alno – Quercion, Periploco – Fraxinion, Carpino – Fagion) while at the eastern part of the province (colchic Turkey), there is a clear dominancy of Alnus glutinosa subsp. barbata (Alnion barbata). At this subregion, Carpinus betulus and Castanea sativa can also be seen in the floristic composition. In the Mediterranean Turkey, totally different vegetation composition occurs dominated by Platanus orientalis, Alnus orientalis and Liquidambar orientalis (Platanion orientalis). The characteristic tree species of Mediterranean zonal forests, Pinus brutia, can also penetrate through riparian fields. Irano-Turanian phytogeographical region is mostly represented by steppe vegetation. However, at the riparian ecosystems, Populus nigra and some Salix species appear as the dominant trees of the vegetation. Similar with the other parts of the world, these forests in Turkey are under the anthropogenic pressures like overgrazing, hydroelectric power stations, mining, and man-made fires. Therefore, for a better restoration and nature conservation strategies on these ecosystems, their floristic and ecological richness must be studied in detail. At this point, there is still a need of studies to understand all richness and diversity of these ecosystems in Turkey.

Keywords: Biological diversity, floodplain forests, riparian ecosystems, Turkey, vegetation.

STRUCTURE AND DYNAMICS OF THE RIPARIAN VEGETATION ON THE BRAIDED-WANDERING BELÁ RIVER

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Riparian vegetation in the high-energy rivers is important mainly for its stability function during flood discharges. In these river systems, the significance of riparian vegetation is mainly related to the evolution of the multi-thread planform. Its influence on fluvial processes on the studied braided-wandering Belá River 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 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, sparse, dense vegetation, island). 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 area without and sparse vegetation of central bars and the greater spread of small areas with a dense vegetation cover have a negative impact on the Belá River in terms of degradation of the braided and wandering planform. On the larger scale, on the selected unmanaged river reach of the Belá River, we compared bio-geomorphologic changes between 2012 and 2018 aimed to determine the geomorphic feedback between in-channel processes and vegetation succession. Phytocoenological registrations, grain size and vegetation homogeneous 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. The research was supported by the Scientific Grant Agency VEGA, number 2/0086/21.

Keywords: riparian vegetation, structure, dynamics, succession, braided-wandering river, Belá River

MODELLING AND CLASSIFYING ALLUVIAL FORESTS AND SWAMP WOODS

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Riparian alluvial forests and swamp woods are ecologically unique, flooded habitats offering various ecosystem services. They are regarded as endangered by IUCN and their conservation status is considered bad in EU. Agriculture, forestry and development of shore areas have decimated their area and watercourse regulation have impacted their ecological functioning. These habitats are critically dependent on hydrology and, therefore, climate change and altered flood dynamics are serious future threats.

We developed GIS and web-based models predicting occurrence of flooded forests to be used in their conservation and management. We used available flood hazard maps, detailed surface flow models, canopy height based on aerial laser scanning, canopy cover based on satellite images, Copernicus imperviousness degree, and national topographic database. Further, we applied machine learning (Random Forest) methods to partial data from habitat maps of Government Fort service (Metsähallitus).

The model was validated by comparing the predictions against data from our own intensive field surveys, and against habitat maps of nature conservation areas by Government Fort service and specially protected areas by Finnish Forest Centre. The model predicted flooded forests rather well, 70-90 %, but separated swamp woods rather poorly from alluvial forests and gave a slight overestimation of flooded forests. The model can be applied reliably to detect flooded forest areas, though the predicted localities must be verified in the field for conservation purposes.

Field surveys and cluster analysis revealed several distinct flooded, forested habitat types. Year-round wet Alnus glutinosa and Betula pubescens swamp woods in coastal and lake shore areas; eutrophic Prunus padus and Alnus incana flooded forests along smaller rivers; oligotrophic mesic or dry Betula pubescens flooded forest along larger rivers. In Southern Finland, all alluvial forest had some Picea abies undergrowth due to declining spring floods.

Key words: floods, alluvial forests, swamp woods, habitat types, machine learning

ENHANCING ECOSYSTEM SERVICES IN AGRICULTURAL WATERSHEDS THROUGH RIPARIAN RESTORATION.

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Riparian forest in agricultural landscapes represent only a small portion of the crop-intensive areas, while contributing disproportionately to their biodiversity. The high biodiversity that they harbour support numerous ecological processes that are of key importance to supply crucial ecosystem services (ES) for human welfare. Despite their high ecological importance, riparian forest is one of the most threatened ecosystems due to land-use intensification and associated water extraction, especially in Mediterranean semi-arid areas. Restoration of degraded riparian areas has increased in the last few decades but proper evaluation of restoration success is usually lacking. Furthermore, there is little empirical evidence of the effects of riparian restoration on ES supply.

Here, on the one hand, we investigated the effect of hydrological and soil feature on survival and growth of saplings planted in degraded riparian areas in two Mediterranean sub-watersheds located in NE Spain. On the other hand, we assessed nine regulating and supporting ES in riparian areas with different conservation status (from mature reference forests to restored areas and degraded ones) and compared them with other natural and agricultural land-use types in the same watershed.

We found that revegetation success depended mainly on water table depth, soil salinity and soil nutrients (Mg^{+2} and total N). Additionally, our findings suggest that forest patches in agricultural landscapes provide meaningful regulating and supporting ES. In particular, riparian restoration zones increased the supply of regulating and supporting ES (water purification, habitat provision, microclimate regulation and soil C storage) in comparison with degraded natural land-uses and agricultural crops, however they were still far from the magnitude and range of ES provided by mature riparian forests. These results highlight the importance of focusing management practices on conserving forest patches and restoring degraded riparian areas to reconcile agricultural production with the maintenance or enhancement of ES in agricultural Mediterranean landscapes.

Keywords: ecosystem services, riparian restoration, revegetation, riparian forests, microclimate regulation, soil formation, water purification, Mediterranean rivers, agricultural watersheds

LONG-TERM DEVELOPMENT OF RIPARIAN FOREST VEGETATION AFTER BRINGING BACK MORE WATER DYNAMICS TO THE FLOODPLAIN - SUCCESS AND LIMITS OF A RESTORATION PROJECT ALONG THE DANUBE IN GERMANY

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The floodplain forest along the Danube between Neuburg and Ingolstadt, covering 1200 ha, is one of the largest in Germany. However, like most floodplains in Central Europe, it has been affected by river regulation over the last 150 years. Despite 40 years of almost complete separation of river and floodplain since the construction of a hydropower plant, these hardwood forests have survived, but have suffered severely. Thus, a restoration project of the Bavarian Water Management authority implemented in 2010 has aimed to bring back more flow dynamics to the floodplain through a new floodplain stream, ecological floodings and groundwater drawdown.

Vegetation development in the floodplain forest was monitored seven times from 2009 to 2019; during this time, 1 natural and 27 ecological floods and 5 groundwater drawdowns took place. 72 vegetation plots (200 m^2 each) could be classified by hydrologic modelling into 8 hydrologic strata from "flooded on up to 100 days a year" to "not flooded even during 10-year floods". In this spatial and temporal analysis we have considered extraordinary events (drought, natural flooding) and ongoing development over more than 10 years, with a focus on floodplain-specific plant species. Frequently flooded areas changed from the beginning (trees partly died, development towards reed and softwood forest). Less flooded areas initially remained stable in their species composition, but the 10-year flood of 2013 initiated a significant change. The hydrological gradient, which was already evident in the understorey vegetation before the restoration, was significantly extended by the measures, also on non-flooded plots, and diversity in total initially increased, but has declined again since the 2013 flood. The data set makes it clear that even 10 years after the implementation of the project, the development is not yet complete and therefore long-term monitoring in floodplains is irreplaceable.

Keywords: Hardwood forest, long-term monitoring, restoration, ecological flooding

RIPARIAN VEGETATION CONSERVATION AND ENHANCEMENT IN THE TAGUS AND WEST RIVER BASIN DISTRICT, IN PORTUGAL

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The Water Framework Directive (WFD) changed the way ecosystems are considered in water planning and management, being one of the objectives of the River Basin Management Plans to reach good ecological status in all water bodies. The water quality is no longer considered just to satisfy the human needs, such as water supply and irrigation, but also as a supporting element for the aquatic biological communities. Although riparian vegetation is not directly addressed in the WFD, its maintenance and enhancement is crucial, since it shapes the aquatic habitats for the biological quality elements considered in the Directive, such as the fish.

Besides that, the Portuguese Water Law also states the necessity to preserve and rehabilitate the riparian zone in order to guarantee river flow and sediment transport, preventing bank erosion and risk for riverine populations in the presence of floods, being also an important landscape value.

As a consequence of the present legislation, the conservation and enhancement of riparian vegetation is considered at the planning level, more specifically at the Program of Measures of the River Basin Management Plan, and at the management level through licensing of the activities that can affect, positive or negatively, the riparian vegetation.

In Portugal, the conservation and rehabilitation of rivers are the responsibility of the municipalities in urban agglomerations, of the owners in private's river banks in urban areas and in private's river banks and river bed outside urban areas, and of other entities in the other situations.

In this paper, we aim to present how riparian vegetation management and rehabilitation is being done in Tagus and West River Basin District, in Portugal, considering present legislation and the available financial supports.

Keywords: riparian vegetation, water management, river rehabilitation, River Basin Management Plans.

LIFE WILDISLAND - THE DANUBE WILDISLAND HABITAT CORRIDOR

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The Danube is a hub of biodiversity and an essential lifeline for Europe. The large number of Natura 2000 sites (over 100 on the Danube and 230 sites along its course) impressively shows Europe's commitment to preserve this natural heritage.

Rivers and their riparian zones form the backbone of bio-corridors. This is especially true of the Danube, which links more bio-regions than any other corridor in Europe. Islands are core components of vital river ecosystems, they are often the only remaining sanctuaries for characteristic species of dynamic floodplains due to their near-natural state.

Developed by DANUBEPARKS – The Danube River Network of Protected Areas, the Danube Wild Island online tool produced the first ever inventory of the Danube islands. The Danube WILDisland Habitat Corridor contains around 900 islands covering a surface area of over 138,000 ha; 385 islands can be characterized as being in a near-natural state. Of these, 147 islands (14,000 ha) can be described as pristine and characteristic of river wilderness. These form the core of the LIFE WILDislands project.

LIFE WILDisland focus is their conservation and restoration by way of the unique Danube-wide cross-sector cooperation among partners in the Protected Areas (DANUBEPARKS) as well as forestry, waterway and hydropower: Over 70% of the total budget (14,2 Mio. €) are for concrete conservation actions, to restore 34 Danube islands on total 1,267 ha; Waterbodies will be improved on 48 km; 12 forest restoration actions promote naturalness of soft wood forest stands.

Together with strategic partners, LIFE WILDisland is aiming to establish the Danube WILDisland Habitat Corridor with a focus on non-intervention management on Danube islands, to demonstrate best-practice standards for other large rivers in Europe.

https://wildisland.danubeparks.org

INTERPRETATIVE MANUAL OF EUROPEAN RIPARIAN FORESTS AND SHRUBLANDS

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Riparian ecosystems comprise the physical environment and biological communities that develop at the interface of freshwater and terrestrial ecosystems. They are recognized as ecosystems that are highly diverse and contain special ecological communities, as well as providers of multiple ecosystem services.

This manual of riparian forests and shrublands of European rivers offers phytosociological overview of the variety of existing species, communities and vegetation types at European scale. It presents an unavoidable tool for their knowledge and management, including systematic insights of floristic composition (i.e., diagnostic, dominant and constant species), as well as practical synecological information, comments on threats and challenges for the management and conservation of each type of forests. Thus, it represents very valuable information, not only for the scientific community but also for managers as well as for river restoration and conservation practitioners. In fact, this material comprises an overview of the riverine, swamp, floodplain forests and scrub throughout the continent from the Canary Islands to European part of Russia. The preparation of this study was supported by the COST Knowledge conversion for enhancing management of European riparian ecosystems and services (CONVERGES).

This booklet offers an overview of the forests and shrublands along European rivers, and neighboring areas, river islands, depressions and oxbows. These forests are subject to constant change and are maintained by periodic/regular flooding or high groundwater. We call them paraclimactic because they are maintained by occasional catastrophes caused by water. We may find one type of forest in one place, but after a flood it may move to another place the next year. Erosion and sedimentation, the destruction of the vegetation and new establishment alternate. We should keep in mind that these forests also contain different biota. They are very rich and dynamic ecosystems. We can admire this eternal dynamism of life caused by water and we should be aware that these ecosystems are endangered and need to be protected.

Keywords: European, riparian, forests, shrublands, diagnostic, dominant and constant species

ECOLOGICAL RESTORATION OF RIPARIAN VEGETATION – A SUCCESS STORY

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We reviewed studies that evaluate the success or failure of efforts to ecologically restore riparian vegetation along streams and rivers. We established a framework for extracting information from published studies, and collated a database of over 150 papers meeting our criteria. The most common restoration measures were planting and seeding of native species, grazing exclusion, removal of exotic species and embankments, environmental flows and addition of boulders and wood to stream channels. One of our primary interests was to assess the design of restoration evaluations. We found that few studies provided a definition of ecological restoration, but the majority of papers did identify reference conditions representing pristine or undegraded conditions, as well as explicit hypotheses and expectations of the desired outcomes of efforts. When it came to study design, before-after control-impact (BACI) designs were rare, but almost all studies compared restoration outcomes with unimpacted or unrestored controls, or provided before/after restoration data. We also made meta-analyses of the response of riparian plant species richness and the cover of native plants to restoration efforts, using the metaphor package in R. According to the meta-analyses, both riparian species richness and native plant cover were significantly improved as a result of restoration, with higher effect sizes for species richness than plant cover. We conclude that although some restoration techniques might require a long time before full recovery is achieved, and the effect of other techniques may be transient (removal of exotics), riparian restoration is generally effective. There is a danger that this general pattern is overlooked if restoration success is evaluated in separate studies of limited scope with low statistical power. We conclude that restoration of riparian vegetation can be scaled up and implemented in new catchments to meet future challenges of climate change and biodiversity protection.

Keywords: ecological restoration; meta-analysis; plants; riparian vegetation; rivers

GENETIC CONSIDERATIONS IN EUROPEAN RIPARIAN ECOSYSTEMS MANAGEMENT: EXPERTS VIEW ON STATUS AND NEEDS

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Riparian vegetation is a key component of the landscape as it supports high biodiversity and provides numerous ecosystem services. On the other hand, riparian ecosystems suffer from numerous anthropogenic pressures. Successful protection and restoration of riparian ecosystems require substantial knowledge of their functioning at all levels of biodiversity, including genes, populations, and communities. Recent progress in molecular ecology spots the light on many aspects and specificities of genetic resources in riparian vegetation.

This study was conducted in the frame of the COST Action CONVERGES, and aimed at mapping the status and needs for conservation of genetic resources in riparian vegetation across European countries. We first identified experts in riparian genetic resources conservation and management across Europe, addressing the highest possible diversity of stakeholders, from researchers to practitioners. Then, we designed a set of questionnaires asking those identified experts several questions related to riparian genetic conservation in their countries. Specifically, we asked about societal awareness, legislative tools, good practices, and conservation or restoration projects taking account of genetic resources in riparian ecosystems.

The experts recognized the ecosystem approach as the most appropriate option for the conservation of riparian communities applied through a combination of in-situ and ex-situ measures and/or integrative conservation. Simultaneous application of conservation measures at the level of priority species, identified by experts, and protection of riparian areas are required. The results of this study revealed the importance of recognizing the ecological processes that shape genetic resources in hydrographic networks (spatial patterns and gene flow, fragmentation) but also the need to overcome socio-economic barriers, such as lack of policy priority, deficiency in funding, and weak legislation framework.

Keywords: biodiversity conservation, genetic erosion, genetic resources conservation, knowledge conversion, riparian genetic diversity, riparian vegetation

ECOTYPIC VARIATION RESEARCH TO ACHIEVE FUNCTIONAL TARGETS IN THE CONSERVATION MANAGEMENT OF RIPARIAN FORESTS

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The knowledge of intra- and inter-specific variation of functional traits in riparian species is essential to assess riparian forests diversity, to predict its demographic distribution and to establish functional targets for the conservation and management of riparian corridors. This is particularly important for the Alnus spp. survival at the lower latitude limits, under the predicted future climatic predictions. Research concerning the morphological and physiological distinctions between the recently differentiated Alnus glutinosa [L.] Gaertn. and Alnus lusitanica (Vít, Douda & Mandák) species can benefit decision making in riparian corridors conservation and restoration efforts. This study aimed to (1) assess the phenotypic variation of target functional traits between species A. glutinosa and A. lusitanica and (2) link plant growth performances to functional traits. To accomplish this, we measured a set of morphological, physiological and phenological functional traits from two-year old seedlings of thirteen A. glutinosa and A. lusitanica wild populations across the latitudinal range of the species distribution (from Sweden to Morocco). Seedlings were grown under common environmental conditions and their growth performance was modelled per species. Low-latitude A. lusitanica populations showed higher growth performance, explained by longer growing season in their geographical origin, higher transpiration values and leaf pigments concentration. The A. lusitanica populations presented several functional traits attributed to drought adaptation, such as higher root elongation and a decrease in specific leaf area, correlated with higher values of minimum and mean temperatures in their geographical origin. The species factor was a significant contributor to growth performance in the best ranked models, with higher growth associated to the A. lusitanica populations. A deeper study of the ecotypic variation in functional traits of A. lusitanica adult trees at drier sites can lead to a better understanding of their potential for demographic maintenance under future climatic conditions.

Keywords: A. lusitanica, A. glutinosa, germination, environmental cline

IMPACT OF RIPARIAN FOREST ON EPTS DISPERSION ACROSS EUROPEAN BIOGEOGRAPHICAL REGIONS

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Ephemeroptera, Plecoptera and Trichoptera (EPTs) are three orders of aquatic macroinvertebrates with a similar life-cycle: they live in aquatic freshwater ecosystems until they disperse by flying upstream. The aerial dispersion depends on the landscape connectivity, with landscape features influencing it, as topography in mountainous areas (Chiu et al. 2021) or permanent pools in temporal rivers (Cañedo-Argüelles et al. 2015). Riparian vegetation can also influence the landscape connectivity for EPTs. For example, deciduous forest can facilitate the dispersion of weak flyers (Peredo Arce et al. Unpublished) while coniferous forests are known to act as a dispersion barrier for aquatic macroinvertebrates (Hering et al. 1993). The impact of riparian forest on landscape connectivity can generate differences in the EPT community composition: a location supporting a community with a high share of weak dispersers has to be located in a highly connected site. Although the effects of riparian forest on aerial dispersion can differ between taxa and ecological contexts, regional differences on this relation have never been explored. In this study the relation between riparian forest and EPT dispersion across European biogeographical regions is compared, using data from Mediterranean (Mondego, Portugal), Continental (Middle Rhine, Germany) and Alpine (Inn, Austria) catchments. In each catchment area several locations were selected on similar streams. The EPT community composition was surveyed in each location and used to estimate its dispersion capacity using a dispersion index (Species Flying Propensity, Sarremejane et al. 2017). Riparian vegetation was quantified using land use data and aerial photography in the buffer 5 km up and downstream of each location. We expect to find that locations with more area covered by riparian forest support EPT communities with a lower dispersion capacity and to detect differences in the relative importance of the riparian forest for this relation across European biogeographical regions.

Keywords : Riparian forest, aquatic macroinvertebrates, connectivity, aerial dispersion, Europe

LINKING WOOD FLUX VIDEO MONITORING AND SEMI-CONTROLLED EXPERIMENT OF DOWNSTREAM WOOD DIFFUSION TO BETTER UNDERSTAND WOOD TRANSPORT

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Even though the ecological and morphological role of wood are well known, there is still a gap in the understanding of wood regime in river corridors. To bridge this gap on the Allier river, we quantified wood flux of four flood events using video monitoring combined with experiments to understand conditions of wood mobility and patterns of wood pulses during flood events. More than 63 000 wood pieces were annotated whose length varied from 0.1 to 35 m. Our results allowed to confirm some previous findings on the relationship between wood flux and river flow characteristics. Similarly to previous studies, we observed unregular wood flux pulses during the flood events. To understand this phenomenon, we carried out a semi-controlled experiment on the Allier during high flow period (Q2) in order to study wood piece diffusion. We introduced 180 wood pieces of calibrated length at the same time in the river at 13, 9 and 6 km from the reference site, which is a bridge equipped with the video camera. In addition, 80 of them were equipped with RFID tags. Wood pieces were introduced into the river with a regular time interval of 3 seconds. We recorded the passing time of each wood piece through the bridge and registered automatically by two RFID antennas. The average return rate was equal to 45 % and in general increased when the travel distance decreased. At arrival, the dispersion pattern differed from the departure and in average elongated with increasing travel distance. Our findings can help to advance the understanding of wood entrance and transfer conditions, establish generic rules of diffusion and contribute in calibrating wood flux prediction models.

Key words: wood flux, wood dissipation, video monitoring, Allier river, pulses

MONITORING RIPARIAN VEGETATION: TOWARD A CITIZEN SCIENCE APPROACH

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Despite the remarkable efforts of EU countries at implementing the WFD, recent data demonstrate that only 40 % of European rivers have a good ecological status. Though riparian conditions significantly impact geomorphological processes and ecosystem functioning, their analysis is still poorly defined and inconsistent across a variety of protocols assessing rivers' ecological status. The present study explores the feasibility and the reliability of a new citizen science methodology and related App called RiVe, to monitor riparian vegetation. Riparian vegetation was analyzed at three layers, describing both mature and regeneration forest stages. For the demo/test version of the App an initial set of 12 target woody species was used to identify functional groups of ecological importance, namely native (hygrophilic and mesophilic) and invasive. The app includes questions dealing with both the general condition of the riparian area and pressures that commonly affect it. Each citizen followed consistent training to gain basic knowledge both on the functions of riparian species and their identification. To elicit potential weaknesses in the methodology and detect needs to adapt the App to cover regional specificities, questionnaires were submitted to the volunteers from different geographical contexts. Thus, training events were organized in Italy, Spain, Portugal and France. Results underlined the need to create regional projects containing species representative for different areas. Encouraging citizens to use Apps like Plantnet and to pick up more photos to be checked by the experts in the database can significantly enhance data quality and reduce bias. This method could also be used as a quick survey integrated with remote sensing analysis. Moreover, citizen science activities have educational and social benefits and, enhancing volunteers' perception of the pressures acting on rivers and the related environmental and social issues, they contribute to shaping more informed and resilient societies.

Keywords: citizen science app, invasive species app, fast monitoring, riparian quality, vegetation layers, volunteer monitoring

DIGHOMI MEADOW CIVIC INITIATIVE TO SAVE THE UNIQUE RIPARIAN FOREST IN TBILISI FROM ECOLOGICAL CATASTROPHE

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Dighomi Meadows, located on the banks of the Mtkvari River, is the last remaining natural riparian forest in Tbilisi, Georgia. Stretching 5 km along the shore, it was a rich and biodiverse area supporting a wide range of flora and fauna, including rivers otters, and various species of birds that are not commonly found in the region. Moreover, the Dighomi meadows área had a strategic meaning for the city, as a water- and air- filtering and water-protection buffer. Once a wildlife oasis in the city center, the Dighomi Meadows, has transformed into an epicenter of environmental crimes in recent years. While government agencies and local authorities turned a blind eye, criminal activities of large-scale illegal waste dumping and resource extraction drastically damaged the environment, caused deforestation, altered habitats, and endangered local biodiversity.

In Summer 2020, a small group of residents, convinced that the destruction of the forest was the intentional first step in violent privatization and urbanization of public wealth, started a civic protest campaign to halt the criminal, save and, if possible, rehabilitate the area. In one year, through ground activism, legal challenges, and an active informational campaign, the Dighomi Meadows initiative managed to completely ban the illegal activities and save only up to 20% of the initial forest.

Now the focus of the Dighomi Meadows Initiative is turned towards strengthening environmental regulatory and enforcement instruments, most importantly, advocating for restoration and sustainable management of the riparian forest. Georgia lacks experience of restoring and re-establishing habitats and biodiversity in the urban setting, the Dighomi meadows initiative looks for the international experience and hopes that the case of Dighomi meadows will serve as a paradigm for Georgia on how to reverse destruction in favor of Nature.

Keywords: human-induced pressures, degradation, ecological catastrophe, conservation, restoration, civic initiative

LOUSADA GUARDA RIOS: ACTIVE CITIZENSHIP IN THE PROTECTION OF NATURAL RESOURCES

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Lousada Guarda RIOS is a social engagement project that aims to protect and monitor the ecological condition of river ecosystems in the Lousada municipality, northern Portugal, through research, environmental awareness and public participation. The project is based on four main areas: i) mapping and characterization of the main water courses in the municipality; ii) social engagement through the creation of Guarda RIOS patrols and citizen monitoring of the river; iii) environmental improvement actions on priority sections; iv) formal inspection actions for identified and/or reported threats. Since 2019, 166 sections of 250 m have been characterized in a total of nine water courses. 105 sections have been identified as priorities in terms of water pollution, presence of waste in the bed or in the margins, no access to the watercourse, and / or erosion of the margins. 121 sections were made available for adoption by volunteers, 66 were adopted. The environmental improvement activities have already involved 913 participants in the collection of about 2.6 tonnes of solid waste, in the restoration of approximately 5 km of eroded banks and in the plantation of 1380 native trees / shrubs. 200 problematic occurrences have been inspected due to solid waste disposal, cutting of riparian vegetation and aquatic pollution. Lousada Guarda RIOS reinforces the collective environmental awareness that the Municipality has been promoting, and establishes good practices, replicable in neighboring municipalities and other geographical areas.

Keywords : Conservation, river ecosystems, social engagement, monitoring, volunteering

ESTABLISHING MISALIGNMENTS IN RIPARIAN KNOWLEDGE AND PRIORITIES FOR KNOWLEDGE CONVERSION FOR ENHANCED MANAGEMENT

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Riparian zones are crucial for the human well-being but are among the world's most degraded ecosystems. Thus, closer attention to their sustainable management is urgently needed. One of the aims of the COST action Converges was to establish misalignments in riparian zone management. Information about main riparian zone management issues was collected and discussed with riparian zone managers and scientists with a long record of engagement in river related projects throughout Europe. It was clearly recognised that a "riparian zone triangle" considering scientists, managers and policy-makers needs to be addressed to enhance riparian zone management. Using a panel discussion, we devised potential solutions that address recognised issues. Nevertheless, it was clear that varied approaches need to be considered that our outcomes reach all considered groups from scientists, managers and stakeholders to policy makers. At first a Policy brief was prepared that addressed issues and proposed solutions that might be crucial in the enhanced riparian zone management in the future. It is evident that provided recommendations address not just policy-makers but all key groups of "the riparian zone triangle" as fostered knowledge transfer among scientists, managers and policy-makers and policy co-creation is envisaged. Several key solutions for enhanced riparian zone management are related to the science-management interface. Thus, a user guidance providing implementation instructions of key solutions related to enhanced riparian zone management with case studies is in preparation. Moreover, as new knowledge is emerging daily, and teachers have a central role in the knowledge transfer we have been engaged with the preparation of the Manifesto titled "What to include in teaching programs?" Manifesto should provide insight in the importance of up-to-date knowledge transfer across regions, disciplines and among all people. Additionally, adoption of the early start learning, and life-long learning related to importance of the riparian zones and their management are key stones of the sustainability and human well-being.

Keywords: riparian zones, freshwater resources, adaptive management, human well-being, knowledge co-creation

BRINGING THE MARGIN TO THE FOCUS: 10 CHALLENGES FOR RIPARIAN VEGETATION SCIENCE AND MANAGEMENT

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Riparian ecosystems include the physical environment and biological communities of the inland-freshwater interface and are recognized as highly diverse relative to uplands, providing critical ecological functions and ecosystem services that are especially threatened by global changes. In the context of COST Action CONVERGES (CA16208): Knowledge conversion for enhancing management of European riparian ecosystems and services) we conducted an expert consultation across the member network. We carried out an online survey with two open questions: what are the 3 main challenges to enhance riparian vegetation (A) science and (B) management and policies? We analyzed responses with a qualitative coding approach and we identified 10 key challenges to be addressed for riparian science and management improvement: 1) Create a distinct scientific community by establishing stronger bridges between disciplines; 2) Make riparian vegetation more visible and appreciated in society and policies; 3) Improve knowledge regarding biodiversity - ecosystem functioning links; 4) Manage spatial scale and context-based issues; 5) Improve knowledge on social dimensions of riparian vegetation; 6) Anticipate responses to emergent issues and future trajectories; 7) Enhance tools to quantify and prioritize ecosystem services; 8) Improve numerical modeling and simulation tools; 9) Calibrate methods and increase data availability for better indicators and monitoring practices and transferability; 10) Scientific validation of best management practices. These challenges are discussed and critiqued here, to guide future research in riparian ecosystems.

Keywords: socioecosystem, riparian zone, river management

HOW CAN RIPARIAN SPONTANEOUS PLANT COMMUNITIES MODIFY THE HYDRODYNAMICS OF HEADWATERS? RIPARIAN PASSIV ECOLOGICAL RESTORATION OF BROOKS

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River management is very often intrusive and remeandering brooks action is done by civiengineering with caterpillars. We monitored more than a decade of passive ecological restoration (PER) (ie just fence the brook and let the vegetation do) and especially spontaneous riparian trees have grown at different places on the margins, between the fence and the river. The goal is to understand in which situation can the riparian tree influences a passiv remeandring of the brook? Our results show that the development of this simple tool can permit to evaluate the passive ecological restoration. We need to test it for several types of rivers, brooks, different level of energy, but also types of riparian canopy, trees densities, etc. The results also raise some questions : More can be do, considering trees species differences, or trees biodiversity linked to diversity of habitats ? To be linked to the acceptable time-table for river riparian restoration: how long can it be sustainable?

RIPARIAN HABITATS IN MACEDONIAN FORESTS

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Riparian habitats are an interface between terrestrial and aquatic ecosystems along inland watercourses and provide a series of ecological services important for the balance of the environments with which they come into contact (buffer effect against the loss of nutrients, purification of drainage water, anti-erosion action, consolidation of the banks, etc.)
The study of the habitats in Macedonia has been going on for ten years, however, a final list of habitats has not been formed yet. Two classifications of habitats are most often applied - the classification of EUNIS and the Habitat Directive. According to the Habitat Directive in the Republic of North Macedonia so far the following riparians habitats have been registered:

- 91E0 * Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)
- 91F0 Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)
- 92A0 Salix alba and Populus alba galleries
- 92C0 Platanus orientalis and Liquidambar orientalis woods (Platanion orientale)
- 92D0 Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae)

For each of these habitats, a relationships with another type of classification is indicated, such as codes and names from the Palaearctic Classification of the habitats (abbreviated PAL . CLASS.), and habitat type according to the EUNIS classification (abbreviated EUNIS). A brief description of the habitat is given, with registered plant communities found in this type of habitat. Ecological characteristics of the habitat, characteristic plant species, and distribution on the territory of the Republic of North Macedonia will be presented. Defining all these features will enable monitoring of the state of the habitats, defining the threats and taking conservation measures for their preservation and restoration.

Keywords: Macedonian riparian forests, Habitat Directive

WHAT TREES CAN TELL US ABOUT THE ORIGIN OF INSTREAM WOOD?

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Trees established along rivers and their upstream network are the main sources of instream large wood (LW). The presence of LW in a fluvial ecosystem enhances its geomorphic and ecological diversity; but during flood events might also be associated with an increased risk to infrastructure (e.g., bridges, buildings, etc.) and population. Knowledge about the origin of instream wood is therefore crucial for understanding LW dynamics and optimizing river as well as riparian and upland forest management.
We study the Rhone River catchment at the Génissiat dam in France (3,000 km 2), 50 km downstream from Geneva, where all woody material provided by the tributaries, the Arve and the Valserine, is retained in the reservoir. The aim of this work is to infer the origin of the LW that arrives at the dam by differentiating between these sub catchments and along tributaries. To do so, we explore different approaches: taxonomic identification, stable isotopes – i.e., hydrogen (D/H) and oxygen (18O/16O) - and chemical composition. We work with samples from the reservoir and trees standing along the rivers as a reference. T he riparian forest is analyzed in terms of tree species composition, stand density, age, management, phytosanitary status, etc.
Preliminary results showed significant differences in the isotopic composition of samples extracted from living trees located in the two tributaries. In addition, tracers such as minor and trace elements related to the different geological setting of the sub catchments, will be tested and multivariate analyses will be applied to reduce uncertainties and decipher in more detail the origin of LW.
Combining all of this with the forest study we will better understand the relationships between the riparian vegetation dynamics and the LW budget at the catchment scale.

Keywords: river ecosystems, dendroprovenance, stable isotopes, biogeochemistry, riparian forest

UNDER THE DOMINANTS

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Some earlier studies have shown that large species need not operate always as competitors, but under some circumstances they may serve as nurse plants, helping to ensure biomass stability of subordinate species. This has been observed exclusively under stressed conditions. Most studies have documented this phenomenon in relatively harsh ecosystems such as in arid and semiarid areas or in alpine plant communities, where water and nutrients are particularly limiting. Here, we extend this model to cover riparian plant communities that lie at the opposite extreme of the water and productivity gradient. Our results thus show that non-dominant subordinate species may be facilitated by dominant species also in ecosystems where highly asymmetric competition for light is to be expected. We found that dominant species increases temporal stability of subordinate species under various regimes of drought stress. Dominant species supressed drought-tolerant species with low competitive ability, and facilitated less drought-tolerant species with relatively high competitive ability under the permanent drought stress. In riparian communities, drought periods are a common feature of hydrological regimes, even in natural systems unaffected by human activity. Our results indicate that environmental fluctuations lead to higher temporal stability and maintain diversity of subordinate species. Some studies have pointed out that climatically drier or river-regulated areas with insufficient water availability, will have detrimental effects on the diversity of riparian vegetation. Our results indicate riparian vegetation may overcome unfavourable conditions for a certain period without undergoing a major change in diversity due to shifts in the competitive interactions between species towards more facilitative ones.

Keywords : competitive response ability, drought stress, functional trade-off, reduced competition, stress tolerance, temporal stability

THE POTENTIAL OF COPERNICUS "RIPARIAN ZONES" LAYERS FOR THE ASSESSMENT OF RIPARIAN CONNECTIVITY IN TWO EUROPEAN HYDROREGIONS

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The connectivity of riparian forests can be used as a proxy for the assessment of the Ecosystem Services that are provided by riparian zones. In this study, we aimed to test the potential of the Copernicus "Riparian Zones" dataset, from the Copernicus Land Monitoring Service, to characterize the connectivity of riparian forests located in two European bioclimatic regions - the Mediterranean and the Central-Baltic hydroregions, when subject to a gradient of human disturbance. The riparian vegetation patches were extracted using the Copernicus "Actual Riparian Zone" layer (ARZ) and the connectivity was assessed using the Integral Index of Connectivity. We have considered a set of incremental distance thresholds in order to represent the theoretical dispersal ability of several organisms that may depend on riparian habitats. For the gradient of human disturbance, we considered land-use/land-cover changes and hydromorphological alterations at the local- and catchment-scale of analysis. We then compared the results with a "Manual Riparian Zone" layer, obtained by the visual identification of riparian vegetation patches over the very high resolution Esri World Imagery layer. Our results showed a reduced riparian connectivity in both hydroregions, with the exception of the least disturbed river segments in the Central-Baltic hydroregion. The ARZ layer proved to be useful when assessing the connectivity in the Central-Baltic hydroregion, but displayed a consistent pattern of connectivity overestimation in the Mediterranean region in all levels of human disturbance. Given these results, we recommend some improvements in the spatial resolution and thematic accuracy of the ARZ layer for the Mediterranean hydroregion.

Keywords: Copernicus land monitoring service; hydromorphology; land-use/land-cover; riparian zones; connectivity

TWENTIETH-CENTURY EXPANSION OF FLOODPLAIN FOREST IN THE CONTEXT OF CHANNEL TRANSFORMATION OF POLISH CARPATHIAN RIVERS

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A considerable increase in forest cover that occurred in the Polish Carpathians over the 20th century reflected not only the increase in the proportion of forest on hillslopes but also on valley floors. Forest developed on higher parts of former river channels that were no longer disturbed by channel processes as a result of river channelization and/or channel incision. The 20th-century development of floodplain forests is illustrated by the study of four rivers: Czarny Dunajec, Koszarawa, Biała and Raba. Between the 1870s and 2009 all these rivers significantly narrowed but they differed in the timing and scale of the process. The width of the Czarny Dunajec and Raba rivers decreased progressively in the first and second halves of the 20th century, the Biała experienced a narrowing primarily in the first half of the century, whereas the narrowing of the Koszarawa took place in its second half. A scale of the narrowing ranged from 35% in the Koszarawa to 78% in the Raba. The channel narrowing increased the proportion of floodplains in the river corridors; in the Biała valley, it doubled, increasing from 42% to 84%. Forest expansion on the floodplains significantly increased the proportion of forested areas in the river corridors, which in 2009 ranged from 28.5% in the Czarny Dunajec valley to 46.5% on the Koszarawa. The largest increase in forested area over the last 130 years, from 2.4% to 45.3%, was recorded in the river corridor of the Biała. The development of floodplain forest was accompanied by establishing of islands in the rivers; however, these features survived only in unchannelized river sections. The occurrence of floodplain forest exert positive effects on the biodiversity of riverine and floodplain ecosystems in Polish Carpathian valleys. However, a delivery of fallen trees to the channels is the source of hazard during floods.

Keywords: floodplain forest expansion, channel narrowing, river corridor, biodiversity

RESPONSE OF RIPARIAN VEGETATION TO THE RESTORATION OF LATERAL CONNECTIVITY: THE CASE OF THE DISMANTLING OF OLD GROYNE FIELDS ON THE RHÔNE RIVER

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On some of its reaches, the Rhône River was a braided river with a bed of several kilometers wide before major corrections. As a result of two important correction phases, namely rectification and derivation, the geometry of the river has been stabilized into a single channel and the flow of water and sediment has been profoundly altered. To restore the hydrogeomorphological processes, as well as the ecological functioning of some sections of the "old channel" of this large river, the dismantling of several hundred of meters of groyne fields has been implemented. The work consisted of dismantling the old infrastructures and redesigning the banks to promote contrasting topographic profiles and allow erosion. To assess the effects of these works on riparian vegetation, a monitoring program of four restored sites was initiated in 2017. By following the temporal variations in several environmental parameters and in the cover and richness of plant species sampled in quadrats, changes in the structure and dynamics of riparian communities were characterized. The restored sites were quickly recolonized by a large diversity of plants, especially during the first year after restoration by many annual species, sometimes exotic. Over time, the plant communities showed a progressive and coherent structuring along the recreated topographic profiles, including significant variations in species composition. While the ecological gains of this restoration appear undeniable in the short term, the unfolding of the ecological succession should quickly lead to the development of competitive native and exotic species with high cover that could induce a certain homogenization of the communities. This case study illustrates the complexity of the restoration of highly anthropized systems and invites the deployment of more process-based restoration, including the reactivation of the river erosive capacities and channel mobility, associated with bedload transport.

Keywords: channelized river, dike removal, lateral connectivity, restoration, riparian vegetation

ASSESSMENT OF REMOTE SENSING TOOLS FOR RIPARIAN ZONE MONITORING. THE CASE OF RIVER MARTIL, TETOUAN, MOROCCO

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Hydraulic works, adjacent agricultural activity, excessive grazing and uncontrolled waste disposal comprise the most important anthropogenic pressures that degrade riparian zones. The need of geospatial technology to map the time and spatial changes in sensitive ecosystems has evolved innovative remote sensing tools able to facilitate their monitoring and management. Apart from satellite systems, the technology of affordable Unmanned Aerial Systems (UAS) has improved, offering imagery of spatial and temporal resolution of imagery. For the present study, a series of free imagery data from Landsat and Copernicus Sentinel missions was acquired from different years in order to detect and monitor the temporal changes of the last 30 years within a riparian zone of the river Martil, which crosses the city of Tetouan (North Morocco). This process revealed the extent of the anthropogenic structure development and the decrease of riparian vegetation cover along the river. In addition, the tetra-copter Unmanned Aerial Vehicle (UAV) DJI Phantom 4 with its 4K RGB camera was used, in order to prove the utility and effectiveness of small easy-to-use drones for rapid small-scale observation. An aerial photography was conducted, covering a limited riparian area of 14Ha of the same river, out of Tetouan. With the use of Agisoft photogrammetry SW a detailed point cloud was created, producing an orthophoto map (RGB) of 2.5 cm/px spatial resolution, and a 3D Digital Surface Model. This assessment proved the UAS contribution to anthropogenic pressures detection and riparian ecosystems management through orthophoto mapping (e.g. riparian vegetation alteration monitoring, river islets mapping and monitoring and water surface change) and 3D surface models creation (e.g. volume measuring of industrial deposition and sand extraction, riverbank monitoring for erosion changes and biomass volume measurement). Lastly, this study demonstrates the pros and cons of both satellite and UAS remote sensing technics, in terms of imagery quality, data acquisition and process speed, and cost-effectiveness.

Keywords: Unmanned Aerial System, Satellite Imagery, Riparian Vegetation, Image Analysis

MULTISCALE REMOTE SENSING APPROACH TO ASSESS THE HYDRO-CLIMATE CONTROLS ON RIPARIAN TREES ALONG THE RHÔNE RIVER BETWEEN GENEVA AND THE MEDITERRANEAN SEA.

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Rapid changes in global climate should have a profound and lasting impact on ecosystems and related processes. Riparian zones that have already been severely affected by human activities are potentially vulnerable environments. Riparian forests along the Rhône River are particularly concerned due to in dry condition increase following groundwater lowering due to channel incision, flow diversion, and direct pumping. They are currently facing substantial climatic and hydrological changes that are expected to intensify in the coming decades.
Our original study aims to analyze the impact and controls of hydro-climatic factors on the riparian forests of the Rhône along its French course (512 km). Given that our study sites are distributed along the entire length of the Rhône main stem, they are subject to a significant hydroclimatic gradient between the upstream and downstream parts of the river. To consider this gradient, our study is conducted on two different scales. First, by working at the scale of the Rhône course, i.e., by focusing on the climate gradient that affects the riparian forests from Geneva to the sea. Then, in a second step, we analyze the impact of stationary conditions at the local scale of a single riparian zone. To quantify riparian trees responses, we use Sentinel 2 satellite images and extract the Normalized Difference Vegetation Index (NDVI).
Preliminary results, at the entire reach scale, show a remarkable trend of decrease of NDVI from upstream to downstream on all study sites located along the Rhône. This trend may be explained by the importance of the temperature gradient along the Rhône. At the local scale, we observe a significant correlation between NDVI and groundwater levels, especially at sites with the best connection to the water table. This dual-scale approach allows us to investigate the respective influence of local and non-local hydro-climatic factors on riparian forests.

Keywords: NDVI, Riparian Forest, Remote sensing, Rhône River

RIVERWOODS: CREATING A NETWORK OF RIVER WOODS SUPPORTING HEALTHY AND RESILIENT RIVER SYSTEMS ACROSS THE WHOLE SCOTLAND

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Riverwoods is an ambitious initiative launched in early 2019, to create a network of river woods which supports healthy and resilient river systems across the whole of Scotland. The Riverwoods Initiative is led by Scottish Wildlife Trust. It brings together a wide range of partners to identify where riparian woodland can be better managed and lost woodland corridors recreated. A nation-wide programme to create and restore river woods relies on funding from diverse sources. Working together on the £Billion challenge route map, the Scottish Finance Pioneers are exploring how existing financial mechanisms such as grants, philanthropic giving, and sources of private finance can be combined to develop blended finance solutions to support Riverwoods delivery.
Degradation of riparian processes, associated with human pressures is contributing to failing water quality, loss of habitats and a decline in ecosystem services. As an alternative to hard engineered solutions, the recreation and restoration of natural processes and concepts such as ‘nature-based solutions’ seek to bring into river corridors relevant aspects of natural riparian diversity using green/soft engineering principles and river restoration techniques.
Riverwoods Science Working Group of the Riverwoods Initiative has developed a report to provide evidence of the benefits of river woods to inform further work with investors, land managers and local delivery partnerships. Pulling together the available science on the benefits of river woods provides an evidence base to justify financial investment in river woods for society, the economy, and nature itself. Presenting this evidence will build confidence and encourage further investment in river woods, as a nature-based solution that supports mitigation and adaptation to climate change.

Riverwood, riparian vegetation, healthy rivers, Scotland, green investment

SUSTAINABLE RIPARIAN ECOSYSTEM DEVELOPMENT AND LAND USE CHANGES: THE CASE OF KARPENISSIOTIS RIVER (EVRYTANIA- CENTRAL GREECE)

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The designation and assessment of the causes deteriorating fragile riparian ecosystems as well as the causes of the biotic and abiotic factors, (erosion, anthropogenic activities, flood phenomena) in the drainage basins, are among the first stages for forestry research and strategic forest management. Furthermore, accurate information about hydro-geomorphological parameters and riparian ecosystems composition (structure, volume, growth, and extent) are essential for sustainable forest management. Drone remote sensing techniques, in combination with terrestrial observation methods, are excellent tools to surveying riparian ecosystems, mapping hydro-geomorphological features and processes, and supporting intensive sustainable riparian ecosystems management.
The appropriate management of these riparian ecosystems and hydro-geomorphological processes can facilitate the mitigation and reversal of the natural hazards and the eco-environmental impact caused by anthropogenic interventions in the drainage basins.
The main purposes of the present research are to: a. surveying the characteristics of the natural and the built environment of the drainage basin of Karpenissiotis river in Evrytania (Central Greece), b. mapping hydro-geomorphological features and processes of the riparian ecosystems under study, c. identify areas where extreme phenomena of erosion, and floods are expected to occur, d. highlight the manmade interventions, e. evaluate the impact on the fragile riparian ecosystems and f. describe a strategy for the mitigation of the natural hazards and manmade eco-environmental impact, in order to propose improvements over the sustainable management of the fragile riparian ecosystems in the drainage basin of Karpenissiotis river.

Keywords: Drone; Remote sensing; Karpenissiotis river; Riparian ecosystems; Hydro- geomorphological processes; riparian forest management.

SURVIVAL OF BLACK POPLAR (POPULUS NIGRA L.) SEEDLINGS AFTER THE FLOODING AT THE WETLAND IN SERBIA

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Black poplar (Populus nigra L.) is one of the endangered native forest species in Europe, which is also endangered in Serbia, with rare natural forests. One of the native black poplar populations in Serbia is conserved in the natural protected area of „Veliko ratno ostrvo" Island, where this research was conducted. The wetland „Veliko ratno ostrvo" Island is located in Belgrade (Serbia), at the confluence of the Sava and Danube rivers. One of the important endangering factors for vegetation in this area is an irregular change in water levels. This research aimed to determine the survival rate of two-year old black poplar seedlings after the period of flooding on the „Veliko ratno ostrvo" Island. The seedlings were produced in March 2017, from cuttings that originated from 9 trees, previously selected in this area. The seedlings were planted on the field in autumn 2018. This research was conducted in 2019, when the period of flooding and water stagnation on the „Veliko ratno ostrvo" Island lasted 45 days (from middle May to the end of June), with the highest water level at the beginning of June (the Danube water level was 603 cm, while the first flood alert is at 500 cm). The survival rate of seedlings was obtained based on the number of planted and the number of survived seedlings after flooding. Seedlings originating from tree number 9 (clone number 9) had the highest survival rate after the flooding period (85.70%), while the lowest value was recorded in clone number 8 (55.00%). More than 50% of seedlings of all nine clones survived after the flooding. It can be stated that the seedlings of all nine clones have the potential to be planted on the wetlands in Serbia, but this research should be continued with the aim of selecting superior clones.

Keywords: black polar, wetland, flooding, seedlings, survival rate

OVERVIEW OF NATURAL-GEOGRAPHICAL DIVERSITY OF COASTAL ECOSYSTEMS IN BOSNIA AND HERZEGOVINA

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The coastal ecosystem in Bosnia and Herzegovina is an important area for the passage of energy and nutrient resources along rivers and streams, between terrestrial and aquatic ecosystems, where a large number of species live. However, there are contradictions in the literature regarding the concept of the coastal area and its awareness. Scientific studies conducted for Bosnia and Herzegovina mostly focus only on the environmental effects of socio-economic factors. This paper uses the method of document analysis as a qualitative research method. In the research method, numerical data obtained from the competent institutions and obtained in the field were transferred to a computer environment with the help of Arc GIS software, which is one of the GIS programs, for creating databases related to the territory of Bosnia and Herzegovina. Scientific studies that are directly or indirectly related to coastal and river ecosystems have been analyzed in Bosnia and Herzegovina. These areas are accepted as world museums of natural resources due to their geographical diversity of the country with its natural functions and economic values. It is believed that this will make a great contribution to the emergence of new research issues and the development of scientific project topics to increase the level of knowledge on the issue of recognition of coastal ecosystems in Bosnia and Herzegovina with this work. Since river coastal ecosystems are natural resources and regulations of the aquatic environment, it is thus necessary to focus on these ecosystems in planning the economic development of Bosnia and Herzegovina. After a detailed study of coastal ecosystems in Bosnia and Herzegovina, an analysis was given for the forestry sector with the exploitation and production of the wood processing industry.

Keywords: coastal ecosysyem, natural-geographical and social-geographical factors, Bosnia and Herzegovina.

ANTHROPOGENIC MODIFICATIONS AND RIPARIAN VEGETATION RESPONSES IN EAST MEDITERRANEAN RIVERS

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River floodplains and riparian zone are among the most sensitive ecosystems in the Mediterranean as they are significantly altered by human disturbances at basin and corridor scales, where high population densities and water scarcity aggravate pressures around water bodies. However, human manipulations and fluvial geomorphological processes led to the loss of structure and the extent of the habitat types and riparian vegetation communities. Alterations in flow regime and the hydromorphology are often responsible for changes in the riparian plant community, habitat loss, narrowing of the riparian buffer zone and loss of longitudinal connectivity. Not surprisingly, river scientists have shown increased interest in new tools and methods for quantifying the relationships between hydromorphological alteration, land cover changes, and the status of the riparian habitats. Hydromorphological modifications of the riparian habitat types were assessed with the implementation of the indices of Riparian Quality and Habitat Provision, in a Mediterranean lowland river catchment. Additionally, the riparian zone was mapped in a fixed buffer zone of 200 m and multi-temporal maps created over a period of about 60 years based on aerial photographs, help to assess land cover changes occurring in the second half of 20th century. The results from the spatiotemporal analysis show that the land cover changes were associated with human interference and major socioeconomic processes occurring in the area during the study period. Moreover, human interventions have changed the riverbeds, the structural quality of riverine and alluvial habitats, increased landscape fragmentation and led to the degradation and loss of the riparian communities. Overall, the findings of this study can provide useful information towards the development of an effective management plan for the river basins of east Mediterranean.

PLANT SPECIES RICHNESS IN RIPARIAN FORESTS: COMPARISON TO OTHER FOREST ECOSYSTEMS, LONGITUDINAL PATTERNS, ROLE OF RARE SPECIES AND TOPOGRAPHIC FACTORS

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This study aimed to analyze plant species richness in riparian forests at both local and regional scales across several watersheds in the Sudetes (Poland, Central Europe). Specifically, species richness in the riparian forest was compared to other forest types in the same region. It was also hypothesized that due to high complexity and dynamics, riparian forests share a higher number of rare species. In addition, the longitudinal pattern of species richness was analyzed at both local and regional scales. Finally, the effect of topography on species richness in riparian forests in spring areas and along rivers of various sizes was analyzed.

Riparian forests have significantly higher alpha diversity than beech and ravine forests, but oak forests showed a similar level of diversity. However, a comparison of accumulation curves showed, that riparian forests are the most species-rich at a regional scale. All forest types had a similar share of rare species. Eight uniform groups of rare species were distinguished in riparian forests and reflected the riparian complexity and dynamics.

The number of plant species per plot was highest in spring areas and decreased from headwaters to lower reaches. The estimated total number of species showed a similar pattern; however, the highest number was estimated for riverine forests along 3rd order streams and therefore suggests a unimodal pattern of gamma diversity along a longitudinal (upstream-downstream) gradient. The effect of topographic variables on species richness differed depending on the position in the river network.

Keywords: riparian forest, spring area, species richness, river network, upstream–downstream gradient, topography

RIPARIAN ECOSYSTEMS SPATIAL DELINEATION : A REVIEW OF EXISTING METHODS AND DEVELOPMENT OF A LARGE SCALE TWO-DIMENSIONAL METHODOLOGY FOR SOUTHERN QUEBEC

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Nowadays, riparian ecosystems are strongly affected by human impacts such as land conversion along watercourses. In order to proceed to an optimal conservation of these ecosystems, it is essential to delineate them correctly according to their lateral and longitudinal dimensions. In order to highlight the panel of existing approaches for the delineation of riparian ecosystems, a review of these different methods was carried out. This review showed methods that differed in the criteria's they use to delineate the ecosystem and in the type of variables they take into account for this purpose. Two methods for the way of delineating the watercourse and 5 different types of variables were highlighted. The dimensional aspect of the delineation was also featured. More than 30 existing methods have been analyzed and classified. Then, in order to respond to the Politique de Protection des Rives, du Littoral, et des Plaines Inondables (PPRLPI) of the Ministère de l'Environnement et de la Lutte contre les Changements Climatiques québécois (MELCC), a methodology was implemented for the delineation of two-dimensional spatial units to characterize the state of riparian ecosystems in Southern Quebec. This methodology combines the use of Unités Ecologiques Aquatiques (UEA) (MELCC, 2021) for the longitudinal dimension and the floodplain which extends to the foot of the slope leading to first alluvial terraces for the lateral dimension (Ilhardt et al., 2000). And this with the aim of modelling two-dimensional spatial units called Unités Riveraines Ecologiquement Cohérentes (UREC). For the lateral dimension, a numerical method was developed in order to evaluate a widespread parameter of floodplain delineation models : the maximum HAND (Height Above Nearest Drainage) threshold. The model allows to characterize this parameter automatically for any watercourse thanks to a slope break threshold.

Key-words : Riparian ecosystems, conservation, spatial delineation, spatial units, lateral et longitudinal dimensions, hydrogeomorphology, UEA, UREC, HAND.

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A NEED TO STUDY BIOGEOMORPHIC INTERACTIONS IN ICE-DISTURBED RIVERS

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Riparian areas are important ecosystems that need to be restored and protected in the Anthropocene era. In Quebec, Canada, conservation laws and management strategies focus on ecological services provided by riparian communities, such as erosion and flood control, carbon sequestration, and pollutants filtration. However, there is a need to incorporate fluvial biogeomophological approaches to improve our understanding of those systems. Biogeomorphology explores both the impacts of flood regime and disturbances on plant structure and composition and the role of plant communities in altering hydrosedimentary processes. Approaches anchored in biogeomorphology have proven to be efficient to understand interactions and feedbacks between fluvial dynamics and plant ecology in many contrasted environments, from temperate to arid regions and from small streams to large rivers. However, those approaches have never been applied to rivers disturbed by ice dynamics. Ice jams and mechanical breakups are known to disturb fluvial systems, both geomorphologically and ecologically. Moving ice during breakups has the potential to severely erode banks and transport sediment, thus destroying riparian habitat and disturbing plant succession dynamics. Feedback dynamics between plants and rivers are thus obviously affected by ice disturbances regime. There is a need to understand how fluvial biogeomorphic systems respond to such disturbances to assess better management strategies and improve prevision models in a context of climatic change. In this poster, we expose a research project aiming at exploring and analysing how ice disturbances regime controls the biogeomorphic interactions in two rivers located in eastern Quebec, Canada. To do so, analyses will be held in three distinct spatiotemporal scales: 1) decennial biogeomorphological trajectories, 2) plant community structure and composition on distinct fluvial landforms and 3) adaptative traits of ice-disturbed indicator species.

keywords: fluvial biogeomorphology, riparian ecology, ice regime, ice jams, plant succession

KNOWLEDGE TRANSFER FOR THE CONSERVATION AND RESTORATION OF RIPARIAN HABITATS WITHIN THE PROJECT LIFE FLUVIAL

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The LIFE Fluvial project has, as main objective, the improvement of the conservation status of Atlantic river corridors in the Natura 2000 network, developing a transnational strategy for the sustainable management of river corridor habitats in several Atlantic river basins of the Iberian Peninsula. Of the various actions of the project, which includes the improvement of the state of conservation of habitat 91E0 * in the Estorãos River (ZEC Lima River, PTCON0020), the intervention area on which the action of the Portuguese team focuses, one key action is the Public Awareness and Dissemination. Throughout the development of the project the knowledge transfer to different target audiences was promoted. Not just for the general public, but also specific activities and materials for students (elementary school), technicians/managers/scientific community and to relevant Life Fluvial stakeholders. For general public the project structured a website, in four languages and different social media pages, promotional videos and an annual bulletin. Since the project presentation, which was on the world wetlands day in 2018, other ephemeris were used as awareness-raising days for the local population, as the Natura 2000 day. We also promoted volunteer actions (e.g. for control of alien invasive species). The Life Fluvial as also disseminated through a program in the Portuguese national TV - Biosfera. Riparian Ecosystem Engineers. For students, school sessions were organized, and an electronic didactic game was developed. The project relevant stakeholders met periodically to follow the progress of project. The Portuguese team participated in several national and international conferences, and networking was promoted with different similar projects, including other LIFE project and national/international projects. Networking was conducted through meetings but also with visits to areas of intervention and workshops to promote best practice exchange. For technicians also specialized journeys and technical training sessions were (and will be) organized.

Keywords: nature conservation awareness; knowledge transfer; stakeholder engagement

FLOODING INFLUENCE ON GROWTH AND SEEDLINGS SURVIVAL RATE OF DIFFERENT NARROW-LEAVED ASH HALF-SIB LINES

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Narrow-leaved ash (Fraxinus angustifolia Vahl), one of the most important pioneer tree species of lowland floodplain forests, has seen reductions in its natural habitats and alterations of the forest dynamics due to the modifications of hydrologic regimes of the rivers. One of the crucial stress factors that exert an adverse impact on narrow-leaved ash forests is flooding in the vegetation period causing hypoxia. Depending on the degree of plant adaptation, hypoxia can increase seedlings' mortality rates, partially or entirely retarded growth, and structural damage. Hypoxia adaptations are induced by a physiological signal strongly correlated to plant genetics. Our study aimed to determine the influence of the flood period on seedlings' growth and survival rate of 20 narrow-leaved ash half-sib lines. Reproductive material originated from 20 selected maternal trees is used to establish the pilot stand, by planting 2+0 seedlings on the Great War Island (autumn 2018). The survival rate, height (H), and diameter (DIA) were determined, and annual growth increment was calculated. The first year after planting (2019), during the vegetation period seedlings suffered flooding for 45 days (13th May to 26th June). During this period majority of the seedlings were almost completely under water for 17 days (1st to 17th June). The survival rate after flooding was 41.9% with stem damage occurrence 27.1% among survived seedlings. After excluding damaged seedlings from the further analysis, the highest survival rate (above 60%) was recorded for tree half-sib lines, and 10 lines were excluded from further analyses due to low survival rates (below 20%). Ten analyzed half-sib lines showed significant differences for absolute values DIA (mm) and H (cm), but showed no significant difference for annual height and diameter growth. According to obtained results, in flooded conditions, the seedlings' survival rate is more strongly influenced by genetic control than the seedlings' growth rate. Knowledge of genetic variability, especially adaptive traits and selecting adequate planting material in the future, could improve reforestation success in flooded areas.

Keywords: Fraxinus, flooding, adaptive traits, survival, growth

ASSESSING THE IMPACT OF HYDROMORPHOLOGICAL CHANGES ON THE RIPARIAN PLANT COMMUNITIES OF GREEK RIVERS.

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The riparian vegetation is a significant component of the riverine ecosystems which is threatened by hydromorphological (HyMo) modifications, such as embankments, channel re-sectioning and over deepening. Thus, investigating the effects of hydromorphological changes on the species richness and community composition of riparian plant communities is a crucial topic for the conservation and management of riparian zones. With this study we assessed the impact of HyMo modification on the development and the distribution of riparian plant assemblages in more than seventy river reaches from all over Greece. We employed generalized additive models to quantify the response of diversity indices, including species richness, taxonomic distinctness, and functional richness, to the habitat modification score, a metric which expresses the degree of the total HyMo modifications, at reach scale. We also examined the variation of the diversity indices in relation with specific changes such as channel cross section alteration. We hypothesized that species richness would be higher at moderate levels of perturbation, whereas functional diversity would be higher at low levels of HyMo modifications. Our results showed that indeed HyMo modifications have a significant impact on the riparian plant communities and implied that at moderate disturbed reaches species richness would be higher. However, concerning the functional richness and the taxonomic distinctness the results were ambiguous. Yet, our work suggested that environmental perturbations are responsible for the loss of ecosystem functions with severe implications for the overall ecological integrity. These findings are important since they can be of relevance for improving current ecological monitoring and conservation schemes of riparian systems.

KEYWORDS: aquatic macrophytes; Water Framework Directive; rivers; ecological status; ecological monitoring

SPATIAL PATTERNS OF TAXONOMIC AND FUNCTIONAL PLANT DIVERSITY IN RIPARIAN FORESTS

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Exploring all diversity levels in riparian forests is key to understanding the dynamics of ecological processes. It may contribute to the successful restoration and protection of these unique ecosystems facing severe anthropological pressures. The strongest environmental pattern in riparian habitats is a longitudinal (upstream-downstream) gradient. We implemented a study design covering dendritic networks of two watersheds. The plots were located based on topography – in forests along streams of each order (1-6) and spring areas. The study objects were riparian forests of natural character in two watersheds in the Polish Carpathians – the upper reaches of Wisłoka and San rivers. In total, 70 plots were sampled and all vascular plant species and their percentage covers were recorded. We investigated the plants' diversity at two levels – taxonomic and functional, using trait values obtained from functional trait databases. Despite the differences in species composition between watersheds, the species richness and diversity in the two areas showed a similar pattern. Species diversity generally showed a unimodal response – with the highest values in mid-reaches, but the pattern was not fully consistent. Some plots in the lowest reaches (especially in the San basin) showed an additional increase in species richness and diversity. However, the increase in taxonomic diversity was not accompanied by a functional diversity increase. As the functional diversity tells how plant communities respond to environmental filters, we conclude that the functional diversity is shaped by disturbance regime more than the taxonomic diversity, which can be influenced by other factors. Additionally, we analyzed how the functional traits vary along river gradient, using community-weighted means. Our results show that specific leaf area and role of hydrochory is consistently decreasing along rivers, the opposite pattern was observed for zoochory in the herb layer. The role of anemochory was lower in mid-reaches, compared to large rivers and spring areas.

Keywords: riparian forests, taxonomic diversity, functional diversity, spatial gradients, plant species richness