16th International *Symposium on* Aquatic Plants

University of Antwerp

INTERNATIONAL AQUATIC PLANTS GROUP

ECOSPHERE

Table of contents

Organising committee
Jonas Schoelynck & Bart Slootmaekers

Scientific committee
Teresa Ferreira (chair), Portugal
Takashi Asaeda, Japan
Elisabeth S. Bakker, Netherlands
Patricia Chambers, Canada
Julie Coetzee, South Africa
Jay Ferrell, USA
Élisabeth M. Gross, France
Seppo Hellsten, Finland
Matthew O'Hare, United Kingdom
Sabine Hilt, Germany
Deborah Hofstra, New Zealand
Wei Li, China
Eva Papastergiadou, Greece
Rob Richardson, USA
Tenna Riis, Denmark
Jonas Schoelynck, Belgium
Iris Stiers, Belgium
Krzysztof Szoszkiewicz, Poland
Sidinei Magela Thomaz, Brazil

Financial support and sponsorship
University of Antwerp
Ecosphere Research Group
Elsevier
FWO (Research Foundation Flanders): project WOG
Zoogeochemistry
EU Biodiversa+: project BiNaTuR

This publication should be cited as follows:
Jonas Schoelynck, Bart Slootmaekers & Giulia Lodi (Eds) 2023. Book of Abstracts, 16th International Symposium on Aquatic Plants, Antwerp, Belgium, 13–17 November 2023. University of Antwerp, Belgium, 140 pp.

Cover picture
Grensmaas at Hochter-Bampd in Lanaken - Annelies Jacobs
Layout
Nieuwe Media Dienst

Five years after the previous International Symposium on Aquatic Plants in Queenstown, New Zealand, we can finally come together again with our international community of aquatic plant scientists. When Covid-19 struck in 2020, this made it impossible to organize a meeting in Denmark. Now, November 2023, we are able again to exchange the latest advancements we made on a remarkable variety of science topics related to macrophytes.

We are really excited to welcome all of you in Antwerp. The IAPG is a dynamic community comprised of dedicated researchers, scientists, and practitioners from universities and research organizations across the globe, and the wide variety of abstracts submitted is a real testimony to its role as a hub of expertise in the multifaceted realm of aquatic plant science, encompassing various domains, including botany, genetics, ecology, physiology, conservation, and management.

In keeping with our tradition, every two to three years, we come together for a conference that serves as a platform to share the latest scientific advances, foster engaging discussions, ignite debates, and encourage fruitful collaborations. This event will not only bolster our knowledge but will also reinforce the spirit of camaraderie that has been a hallmark of our group.

A specific mention is in place for Ludwig Triest. Prof. Triest's extensive research expertise in biodiversity and ecology of macrophytes spanning Europe, Africa, and Asia have been invaluable contributions to the field. Marking his formal retirement, we are really delighted to present him as a keynote speaker.

Aquatic ecosystems, with their rich tapestry of life and vibrant vegetation, play a pivotal role in maintaining the health and balance of our planet. They are vital sources of biodiversity, providing habitat and sustenance for countless species, while also offering an array of ecosystem services crucial for human well-being. Aquatic vegetation, including submerged plants, wetland species, and seagrasses, is at the heart of these ecosystems, serving as the foundation of the food web, oxygen production, and nutrient cycling.

However, the delicate balance of aquatic ecosystems is increasingly threatened by anthropogenic pressures. Pollution, habitat destruction, overfishing, and climate change have collectively disrupted their functioning. These disruptions have far-reaching consequences, affecting not only the health of aquatic ecosystems but also the livelihoods and well-being of human communities that depend on them.

Efforts to restore and protect aquatic vegetation and the ecosystems they support are imperative. Preserving the integrity of these ecosystems not only safeguards their intrinsic value but also ensures the continued provision of ecosystem services, from water purification to carbon sequestration, that are essential for a sustainable future. Science that recognizes and fosters the importance of aquatic ecosystems and their vegetation is a critical step toward safeguarding the health and resilience of our planet.

On behalf of the organizing committee, we wish you a pleasant time and fruitful meeting!

Jonas Schoelynck, Bart Slootmaekers & Eric Struyf

Program 2023

Program 2023
13/11 Monday

- Location: University of Antwerp (Stadscampus), Hof van Liere, Prinsstraat 13, 2000 Antwerp
- Location Reception: University of Antwerp (Stadscampus), Klooster van de Grauwzusters, Building S, Lange Sint-Annestraat 7, 2000 Antwerp
- Poster presentations are shown during Coffee & Breaks

12:00 - 13:00 Lunch

13:00 - 13:30 Official opening

13:30 - 14:30 Keynote Lecture by **Ludwig Triest**

Session 1 Lessons learned by Mediterranean ecosystems: aquatic plants research and conservation in freshwaters affected by climate change

14:30 **Alice Dalla Vecchia** Incorporating intraspecific trait variability into functional diversity indices of freshwater macrophyte communities to open new perspectives on the analysis of their dynamics

14:45 **Konstantinos Stefanidis** Exploring patterns of aquatic plant functional diversity in riparian corridors of Eastern Mediterranean rivers

15:00 **Joanna Rosińska** Effects of increased temperature and intra- and interspecific competition on the performance of submerged plants: the case of *Myriophyllum spicatum* L. and *Ceratophyllum demersum* L.

15:15 **Francisca Aguiar** Macrophytes in uncertain freshwater futures: effects of climate change in a Mediterranean regulated river

15:30 - 16:00 Coffee & Tea Break

16:00 **Blanca Gallego Tévar** Ecophysiological seasonal responses of native *Spartina maritima*, invasive *S. densiflora* and their reciprocal hybrids from SW Iberian Peninsula

16:15 **Daniel Gebler** Improving the predictive assessment of biological quality using macrophytes: empirical testing and method selection

16:30 **Zhong Wang** Decouples of plant nitrogen-sulfur correlation under saline stress in alpine and arid wetlands

16:45 **Rossano Bolpagni** Towards the measuring of Characeae functional traits: A compelling challenge for aquatic ecology

Session 3 Plant-animal interactions in aquatic plant beds (Zoogeochemistry session)

17:00 **Heleen Keirsebelik** Chinese mitten crabs (*Eriocheir sinensis*) damage macrophytes (demonstration)

19:00 - 21:00 Opening Reception at Klooster van de Grauwzusters

14/11 Tuesday

- Location: University of Antwerp (Stadscampus), Hof van Liere, Prinsstraat 13, 2000 Antwerp
- Poster presentations are shown during Coffee & Breaks

8:30 - 9:00 Coffee & Tea

Session 2 The macroecology of aquatic plants in freshwaters

9:00 **Daniel Larkin** Thin lines between native and invasive aquatic plants and their implications for management

9:15 **Nompumelelo Catherine Baso** The Enemy Release Hypothesis and beyond: *Lagarosiphon major* invasion dynamics and management options for New Zealand using native natural enemies from South Africa

9:30 **Janne Alahuhta** Climate, geodiversity and land use associated with beta diversity of river plant communities in Europe

9:45 **Lars Baastrup Spohr** Global drivers of aquatic plant height

10:00 **Lindsay Trottier** The Macroecology of Aquatic Plant Functions (MAP) Project: How it started, progress to date, and next steps

10:15 **Richard Lansdown** Aquatic Plant Conservation: Priorities and plans

10:30 **Zarah Pattison** The freshwater biodiversity crisis: what role do plant invasions play?

10:45 - 11:15 Coffee & Tea Break

Session 3 Plant-animal interactions in aquatic plant beds (Zoogeochemistry session)

11:15 **Kirstine Thiemer** True love? Aquatic plants in relationship with fish

11:30 **Kerstin Bouma** The impact of grazing by red deer (*Cervus elaphus*) on vegetation development during a wetland restoration project

11:45 **Balázs A. Lukács** Traits for transport: do alien wetland plants have advantage?

12:00 **Emily Strange** Mosquitoes & Macrophytes: a dangerous mix?

12:15 **Michał Brzozowski** Biotic and abiotic factors potentially responsible for charophyte decline in temperate hardwater lakes

12:30 - 13:30 Lunch

Session 4 Genetic diversity and structure in aquatic plants (continental and coastal habitats)

13:30 **Petr Koutecký** Molecular and genome size data allow delimitation of *Ranunculus* sect. *Batrachium* taxa and reveal unexpected hybridization and cryptic diversity

13:45 **Nigel Willby** Birds, boats and buoyancy: effects of connectivity on lake macrophyte communities

14:00 **Junyao Sun** Response of macrophyte species community to the pond connectivity in an agricultural multi-pond system

14:15 **Jasper Dierick** The importance of clonal and sexual reproduction for the maintenance, persistence and resilience of seagrass meadows under disturbance

14:30 **Laura Bossaer** Salinization as a driver of genetic differentiation in lowland populations of Stuckenia pectinata

14:45 **Estelle-Marie Blanquart** Genetic and taxonomic diversity of isoetid communities in Aquitaine shallow lakes

15:00 - 15:30 Coffee & Tea Break

Session 5 Causes and patterns of macrophyte decline and recovery

15:30 **Sandor Szabo** Sustaining stable states between submerged and free-floating vegetation

15:45 **Fan Lui** Enzymes related to carbon metabolism in the leaves of submerged macrophytes play a crucial role in ammonium detoxification

16:00 **Ling Xian** Exploring ammonium utilization strategy of submerged macrophytes using whole plants

16:15 **Sabine Hilt** Feedback between changes in submerged macrophytes and phosphorus concentrations propel rapid eutrophication of a mesotrophic lake

16:30 **Antonella Petruzzella** Achieving the goal “more natives, less invasives”: Priority effects as a potential tool for restoration

16:45 **Lucas Van der Cruysse** Investigating the (Re) introduction of Submerged Macrophytes in River Systems in Flanders (Belgium)

17:00 **Anne Lewerentz** Macrophyte diversity in a changing world: lessons from deep lakes in Bavaria

17:15 **Yexin Yu** Integrating depth and nutrient to illustrate regime shifts of deep lakes

17:30 **Lei Li** Within-lake resource gradients modify periphyton shading effects on macrophytes

15/11 Wednesday

- Location: University of Antwerp (Stadscampus), Hof van Liere, Prinsstraat 13, 2000 Antwerp
- Location Conference dinner: Horta Grand Café, Hopland 2, 2000 Antwerp
- Poster presentations are shown during Coffee & Breaks

08:30 - 09:00 Coffee & Tea

09:00 - 10:00 **Keynote lecture by Julie Coetzee**

Session 5 Causes and patterns of macrophyte decline and recovery

10:00 **Sabiha Akter** Interactive effects of nitrate and heatwaves on submerged and floating plants of a freshwater ecosystem

10:15 **Deborah Hofstra** Accelerating the re-establishment of macrophytes

10:30 **Riccardo Pieraccini** Seagrass restoration, every seed counts: increasing restoration success by improved germination

10:45 **Michał Rybak** Multi-element stoichiometry transformation and homeostasis disturbances among *Myriophyllum spicatum* organs in response to accelerated eutrophication

11:00 - 11:30 Coffee & Tea Break

Session 6 Friends or foes: Wanted and unwanted effects of herbicides on aquatic plants facing multiple stressors

11:30 **Gertie Arts** Effects of the fungicide tebuconazole on macrophytes in a mesocosm study

11:45 **Elisabeth Maria Gross** The chemical fingerprint of *Myriophyllum spicatum*: A harbinger of regime change in shallow lakes exposed to nitrate, pesticide and warming?

12:00 **Arie Vonk** Herbicide exposure and toxicity to aquatic primary producers

12:15 **Gray Turnage** Ecology and Management of Cuban bulrush in the United States

12:30 - 13:30 Lunch

Session 7 Macrophytes as Nature Based Solutions in urban ecosystems (BiNatUr session)

13:30 **Silvia Martín Muñoz** Aquatic-Nature-based Solutions: designing cities for biodiversity

13:45 **Seppo Hellsten** Invasion of *Elodea canadensis* in northeastern Finland – nuisance or useful biomass?

14:00 **Jan Köhler** The impounding effect of aquatic vegetation in the lowland river Spree and its management by mowing

14:15 **Louis Skovsholt** Riverine plant community changes on a gradient of land use in lowland New Zealand streams

14:30 **Susanne Schneider** Mass development of aquatic macrophytes - causes and consequences of macrophyte removal for ecosystem structure, function, and services

14:45 **Liesbeth Bakker** Top-down and bottom-up effects on the establishment of aquatic plants in ecosystem restoration project Marker Wadden, The Netherlands

15:00 - 15:30 Coffee & Tea Break

Session 8 **Macrophyte monitoring** (Biomonitoring based on macrophytes/Environmental monitoring based on macrophytes)

15:30 **Amritha Nair** Mapping stress in submerged aquatic vegetation using multispectral imagery and Structure from Motion(SfM) photogrammetry

15:45 **Takashi Asaeda** The application of hydrogen peroxide concentration to elucidate the submerged macrophyte distribution in a lake

16:00 **Paolo Villa** Assessing Spectral Metrics to Estimate Aquatic Plant Diversity from Hyperspectral Imaging: Preliminary Results

16:15 **Teresa Ferreira** Assemblage-based monitoring of freshwater ecosystem using similar macrophyte indices: how difficult can it get

16:30 **Morgan Botrel** Changing submerged aquatic vegetation in inland waters: new tools for high frequency monitoring at broad spatial scales

16:45 **Maarten De Jonge** Macrophyte monitoring by the Flanders Environment Agency (VMM): Status, trends and relations with environmental variables

17:00 **Krzysztof Szoszkiewicz** How to estimate efficient sampling effort and the accuracy of river macrophyte monitoring

19:00 - 20:00 Conference dinner at Horta Grand Café: Welcome reception

20:00 - 23:00 Conference dinner at Horta Grand Café: Seated dinner

16/11 Thursday

- Location: University of Antwerp (Stadscampus), Hof van Liere, Prinsstraat 13, 2000 Antwerp
- No sessions held!

08:00 - 17:30 Excursion to Kruibeke, Mesodrome and Meise Botanic Garden

19:30 - 21:30 Excursion to KMSKA

17/11 Friday

- Location: University of Antwerp (Stadscampus), Hof van Liere, Prinsstraat 13, 2000 Antwerp
- Poster presentations are shown during Coffee & Breaks

08:30 - 09:00 Coffee & Tea

Session 9 Management of macrophytes

9:00 **Jeffrey Hutchinson** Evaluating the suppression of Hydrilla verticillata by manual removal and planting native aquatic plants

9:15 **Colin Burke** Unravelling the consequences of extreme floods and dam-induced river fragmentation on macrophyte populations: A case study of the Mid-Brisbane River, Australia

9:30 **Roelf Pot** Removing nuisance aquatic macrophytes with a rakeboat

9:45 **Hélène Groffier** Alkalinity and nitrogen: drivers of Myriophyllum heterophyllum invasion success?

10:00 **Iris Stiers** Bugs 2 the Rescue: a citizen science project

10:15 **Olga Delange** Towards assessing post-management recovery of native flora by comparing seed banks composition in Ludwigia spp. – invaded; – managed and non – invaded ponds in Belgium

10:30 **Nguyen Nguyen** Regeneration of macrophytes from a lake propagule bank after removal of the invasive Cabomba caroliniana using herbicide and manual control

10:45 - 11:15 Coffee & Tea Break

11:15 **Eva Rekkers** Early phytoplankton responses to invasive floating plant control in subtropical freshwater systems

11:30 **Tressia Chikodza** The effect of biological control on the population dynamics of Pontederia crassipes (C. Mart) Solms (Pontederiaceae) and Salvinia minima Baker (Salviniaceae)

11:45 **Darren Reidy** Does Myriophyllum aquaticum, a freshwater invasive species, have capacity to invade brackish waters in Ireland?

12:00 **Gabrielle Thiébaut** Is removal a solution for management of the alien aquatic plant species Egeria densa? A mesocosm approach

12:15 **Brittany Chesser** Information and Education: Texas A&M AgriLife Extension Service Models Used to Combat Aquatic Vegetation Issues

12:30 - 13:00 **Final words by the organisers, awards for best presentation and poster**

13:00 - 14:00 Lunch

14:00 - 15:30 Meeting of the Scientific Committee
On invitation only

Keynote speakers

Coetzee, Julie A.

Rhodes University
South Africa

Julie's research focuses on the ecology and biological control of invasive aquatic plants. She started working on biological control agents of water hyacinth in 1998, and has never looked back. Recently the focus of her work has expanded to include understanding invasions by submerged and emergent aquatic plants. As we have gained excellent control of the floating species, this new suite of species has taken advantage of these new habitats, threatening indigenous aquatic flora and fauna. Tackling these new problem plants is a challenge, but southern Africa will benefit from experience gained elsewhere in controlling these species, as well as pioneering new methods of control.

Recent developments in control of aquatic macrophytes: insights from Sub-Saharan African

Sub-Saharan Africa, and particularly southern Africa, has a long history of managing the establishment and spread of invasive floating macrophytes. The past thirty years of research and the implementation of biological and integrated control programmes has led to widespread control of these species in many degraded freshwater ecosystems. Such initiatives are aimed at restoring access to potable freshwater and maintaining native biodiversity. However, in recent years, there has been a decline in populations of floating invasive plants, and an increase in the establishment and spread of submerged and emergent invasive plant species, which poses significant threats to aquatic ecosystems. This talk highlights the vulnerability of Africa's eutrophic systems to successful colonisation by this suite of new macrophytes following the successful biological control of floating invasive macrophytes, and explores a new regime shift in invasive populations partly driven by biological control. A more holistic approach to the control of invasive aquatic plants is required to ensure long-term ecosystem recovery and sustainability as Sub-Saharan Africa faces the pressures imposed by global climate change.

Vrije Universiteit Brussel & Université Libre de Bruxelles - Belgium

Prof. Ludwig Triest started studying aquatic plants in 1980. He obtained his PhD in 1986 and Aggregation Higher Education in 1991 on submerged macrophyte taxonomy and molecular-based population studies using isozymes, later followed by population genetics using DNA markers of various plant groups such as Ruppia, Stuckenia, Zannichellia, Najas, seagrasses, papyrus, mangroves and riparian willows. He has experience with European and tropical aquatic wetland and lagoon ecosystems. Practical skills are situated in the field of genetic diversity methodologies, aquatic ecology, monitoring, conservation and nature management. He taught Introduction to Biology and Molecular ecology for BSc students and specialized courses on River and Lake Ecology and on Conservation Genetics at MSc level. He (co-)authored more than 200 papers and supervised more than 30 PhD's at the Vrije Universiteit Brussel.

Genetic connectivity, migration history and dispersal distances in aquatic plants

Dispersal of aquatic plants can occur through hydrological connectivity or through other land-based means. Macrophyte dispersal within rivers, within lakes or a series of lakes ensures successful and recurrent hydrochorous spread of vegetative and sexual propagules while aquatic plants in isolated water bodies rely largely on local recruitment, but also seed movement inputs from wind or biotic vectors. Thus, dispersal distances in aquatic plants are very context-dependent. Genetic markers such as nuclear microsatellites are widely applied and, given sufficient allelic and genotypic diversity, may provide interesting opportunities to infer genetic connectivity and isolation-by-distance (IBD). In this way, measures of genetic distance and geographic distance between aquatic sites are usually considered in exploratory methods (clustering and ordination), descriptive statistics of estimators of differentiation (Fst, Rst) under certain population-level assumptions, and in model-based clustering of individuals in subpopulations as gene pools (Bayesian approach). Nevertheless, inferring dispersal distances from genetic connectivity may be challenging, especially in aquatic plants, as they often show strong annual fluctuations in their population size, often causing founder events, bottle-necks, and inbreeding due to within-lake pollination between relatives. Distances over which pollen flow and seed flow can occur are usually interpreted in terms of IBD and significance of regression slopes. Despite an often significant IBD, the context-dependent dispersal of aquatic plants remains difficult to estimate due to their unknown underlying historical migration patterns during the Holocene. Haplotype networks and approximate Bayesian computation of entire chloroplast genomes allow testing demographic event models of a species and testing population origin models with an estimation of their divergence times and effective population sizes. Different approaches to infer historical migration, contemporary short-distance dispersal and long-distance dispersal were tested for various submerged and emergent macrophytes, providing guidance on the resilience of evolutionary significant units of populations across aquatic landscapes.

Abstracts

Session 1

Lessons learned by Mediterranean ecosystems: aquatic plants research and conservation in freshwaters affected by climate change

Chair: Eva Papastergiadou (University of Patras, Greece), **Kostas Stefanidis** (Hellenic Centre for Marine Research, Greece).

Mediterranean ecosystems (Mediterranean basin and parts of coastal California, Chile, South Africa, and South-West Australia) have a long history of human disturbances and water scarcity exacerbates pressures around water bodies (i.e., morphological changes, water abstraction, irregular water flow, pollution, eutrophication, water logging, and leisure activities). Ecosystems in warm climates are more sensitive to anthropogenic pressures, such as eutrophication and water extraction, than similar ecosystems in temperate or cold climates. Nowadays global climate change affects freshwater ecosystems worldwide, threatening the survival of sensitive species, increasing droughts, also in tropical and temperate regions, and consequently species extinction rates and freshwater ecosystem degradation. In this session, we welcome submissions addressing the factors that influence aquatic macrophytes richness, diversity, functional traits and habitat features, as well as biotic adaptations and resilience responses to hydrologic disturbances in Mediterranean freshwaters (e.g. streams, rivers, lakes, lagoons, ponds, etc), and in other regions that experienced increasing droughts because of climate change.

Alice Dalla Vecchia, Maria Beatrice Castellani, Andrea Coppi, Lorenzo Lastrucci, Erika Piaser, Paolo Villa, Rossano Bolpagni

University of Parma, Parma, Italy
Institute for Electromagnetic Sensing of the Environment (IREA), National Research Council of Italy (CNR), Milan, Italy
University of Florence, Florence, Italy

alice.dallavecchia@unipr.it

Incorporating intraspecific trait variability into functional diversity indices of freshwater macrophyte communities to open new perspectives on the analysis of their dynamics - Oral presentation

Functional diversity indices are widely used in ecology to describe communities not only in terms of species diversity, but also including information on the amplitude of different functions and adaptations of community, including the responses to external perturbations and climate change. Nonetheless, so far, studies have applied functional diversity indices using only mean species trait values, often derived from databases and measured in different geographical regions compared to the study area. Freshwater macrophytes generally show very high intraspecific trait variability (ITV) in response to the challenges posed by the aquatic environment. Therefore, for these habitats, the measure of functional diversity indices without accounting for ITV could lead to a significant underestimation of the full functional space occupied by a community. This study aims to evaluate the performance of functional diversity indices on freshwater macrophytes (functional richness, functional evenness and functional divergence) including different levels of ITV. For this purpose, we sampled communities of submerged, floating and emergent macrophytes in six lake systems throughout Italy, collecting leaf functional traits and spectral reflectance traits measured on 3 to 8 individuals per sampling plot. We then compared the results of functional diversity indices calculated using: i) different levels of intra-plot variability; ii) mean trait values in each site; iii) overall mean trait values. With this study, we are able to quantify how much an approach based on ITV could go beyond a classical approach including only overall mean values. Eventually, we wish to promote the integration of ITV to fully understand the role and functioning of macrophyte communities. Towards this, the implementation of spectral traits represents a key step to upscale traits collection, enabling to gain a great amount of information on a vast scale in a relatively short time, offering more robust tools for exploring the spatial-temporal drivers of macrophytes.

Konstantinos Stefanidis, Eva Papastergiadou

Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research
Department of Biology, University of Patras

kstefani@upatras.gr

Exploring patterns of aquatic plant functional diversity in riparian corridors of Eastern Mediterranean rivers - Oral presentation

Understanding the key processes that determine diversity and community composition is a central topic in ecology. Exploring patterns of functional diversity may improve our understanding on how aquatic ecosystems respond to environmental changes caused by anthropogenic pressures. Floodplains and riparian zones in the Mediterranean are vulnerable to human disturbances at corridor and basin scales, where high population densities and water scarcity aggravate pressures on freshwater ecosystems. With this study we investigated the role of anthropogenic disturbance on alpha (α-) and beta (β-) functional diversity of aquatic plant communities from an extended network of river reaches of Greece. Quantitative and qualitative traits were assigned on hydrophytes and helophytes according to the LEDA database and multiple indices of α-diversity, like functional richness, dispersion and evenness were calculated. We also calculated total β-diversity and its main components, turnover and nestedness, with the Sorensen dissimilarity index. To assess the effects of the environment we used Generalized Additive Models (GAM) for functional α-diversity indices and Generalized Dissimilarity Models (GDM) for functional β-diversity. In addition, we explored the relationships between beta diversity components and the environment employing Mantel test. Our results supported our hypothesis that human disturbance plays a major role in shaping river macrophyte assemblages, and particularly patterns of functional diversity and trait composition. Hydromorphological factors, e.g., channel features, aquatic habitats, and hydromorphological alterations were more important than water chemistry in explaining the total variance of diversity indices. Furthermore, we found that species richness and functional richness were correlated, which suggests that loss of species due to environmental perturbation will likely lead to loss of ecosystem functions with severe implications for the overall ecological integrity. Overall, the findings of this study can provide useful information for improving current ecological monitoring schemes and conservation plans of aquatic plants of Eastern Mediterranean rivers.

Joanna Rosińska, Maria A. Rodrigo

Department of Environmental Medicine, Poznan University of Medical Science, Rokietnicka 10, 60-806 Poznań, Poland
Integrative Ecology Group, Cavanilles Institute of Biodiversity and Evolutionary Biology, University of València, Catedrático José Beltrán 2, E-46980 Paterna, Valencia, Spain

rosinska.asia@gmail.com

Effects of increased temperature and intra- and interspecific competition on the performance of submerged plants: the case of *Myriophyllum spicatum* L. and *Ceratophyllum demersum* L. - Oral presentation

Global warming has a significant impact on freshwater ecosystems. The increase in temperature causes warmer summers, longer vegetation seasons, which influences the performance of submerged vegetation. Based on morphometric and physiological parameters comparison, we analysed how elevated temperature affects intra- and interspecific competition. Two submerged species (*Myriophyllum spicatum*, *Ceratophyllum demersum*) were chosen to analyse the influence of elevated temperature on the competition by means of a microcosm experiment conducted in laboratory conditions for two weeks. Plants (n=72) grew in water at 22ºC and 27ºC and were planted (i) individually, (ii) under intraspecific competition (two individuals of the same species) and (iii) under interspecific competition (one individual of each species). The relative growth rate (RGR) was calculated based on plant length (RGRL) and biomass (RGRB). Moreover, the chlorophylls a, b, and carotenoids contents were analysed. RGRL values were more affected by competition than by temperature. The mean RGRL values were higher in individual growth (*M. spicatum* 0.05→0.02d^{-1}, *C. demersum* 0.06→0.05d^{-1}, at 22ºC and 27ºC, respectively) than under interspecific competition (*M. spicatum* 0.02→0.04d^{-1}, *C. demersum* 0.05→0.04d^{-1}, at 22ºC and 27ºC, respectively). A significant effect of temperature on the increase of mean RGRB of *M. spicatum* was observed. The trend for individuals was similar (*M. spicatum* 0.02→0.09d^{-1}, *C. demersum* 0.03→0.09d^{-1} at 22ºC and 27ºC, respectively), while in intra- and interspecific competition *M. spicatum* values increased at elevated temperature (intra- 0.04→0.08d^{-1}, interspecific 0.02→0.05d^{-1}), and decreased for *C. demersum* (intra- 0.08→0.03d^{-1}, interspecific 0.09→0.07d^{-1}). The effect of competition was stronger than the effect of temperature. We observed a decrease in chlorophyll-*a* content at higher temperature only in *C. demersum* when grown individually. A significant increase in pigments content in higher temperature was noted in *M. spicatum* for individual, intra- and interspecific competition conditions. In *C. demersum*, a significant difference was found only for chlorophyll-b. Thus, competition had a greater impact on growth rates. Temperature significantly affected the increase of RGRB and pigment content, mainly in *M. spicatum*, particularly in competition conditions. The research was funded by Polish National Agency for Academic Exchange, Bekker programme BPN/BEK/2021/1/00079/DEC/1.

Francisca Aguiar, Maria João Feio, Salomé F.P. Almeida, Ana Raquel Calapez, Daniel Gebler, Ivana Lozanovska, Rui Pedro Rivaes

Centro de Estudos Florestais, Laboratório Associado Terra, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal
MARE - Marine and Environmental Sciences Centre, Department of Life Sciences, Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal
Department of Biology and GeoBioTec – GeoBioSciences, GeoTechnologies and GeoEngineering Research Centre, University of Aveiro
Department of Ecology and Environmental Protection, Poznan University of Life Sciences, Poznan, Poland
MARE – Centro de Ciências do Mar e do Ambiente e ARNET – Rede de Investigação Aquática, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal

fraguiar@isa.ulisboa.pt

Macrophytes in uncertain freshwater futures: effects of climate change in a Mediterranean regulated river - Oral presentation

Multiple pressures imperil aquatic macrophytes worldwide, particularly river damming, habitat loss, eutrophication, and invasive species. Additionally, these threats interact in space and time and are amplified by climate change. Acknowledging the complexity of these combined factors, the present study is focused on the effect of climate-change-driven flow regimes on macrophytes of a Mediterranean river impaired by a hydropower plant. For this, we assessed the habitat availability for the aquatic macrophytes, using the mesohabitat approach. A mesohabitat (run, riffle, pool) is considered a physically uniform habitat unit in the river promoting the establishment and growth of specific taxa. Macrophytes, including macroalgae were sampled in June-July 2019 in 31 mesohabitats along 17 sampling sites in the Lima River, North of Portugal, downstream of the Touvedo dam. We also sampled diatoms and macroinvertebrates to better understand the effects of climate change on other in-stream communities that interact with macrophytes (ex. food, refuge). Mesohabitat characterization was explored via Principal Component Analysis revealing river eco-hydraulics as a major factor. Furthermore, a Linear Discriminant Analysis (LDA) performed on these variables achieved a very good mesohabitat classification capability. Macrophytes present a set of indicator taxa of specific river mesohabitats. Expected flow regime scenarios were computed from the Hydrological Predictions for the Environment (HYPE) model according to the latest IPCC scenarios (RCP2.6, RCP4.5, RCP8.5) and adjusted by the expected hydropower production changes forecasted for Portugal.

The flow regime scenarios were modeled in a representative 2 km river stretch of Lima River, to determine river hydraulics and assess the mesohabitat availability using LDA classification. Results show that climate change-driven flow regimes will influence river hydraulics towards less contrasting flow conditions, modifying mesohabitat proportionality towards run prevalence over riffles and pools. Changes in macrophyte's indicator taxa metrics ranged from 15% decrease to 38% increase in abundance/coverage, being proportional to the severity of the climate change scenario. Other assessed biological groups (diatoms, invertebrates) revealed higher changes (from decreases of 76% up to 67% increase), which can be also connected to the macrophyte responses. Further research is needed on the interspecific interactions between macrophytes and other affected in-stream biota to disentangle possible surrogacy relationships and the potential chain of events facing flow regime changes. Despite their negative impacts, dams may become important allies in counteracting climate change effects on downstream communities through the maintenance of more sustainable river flows.

Blanca Gallego Tévar, Jesús M. Castillo

University of Seville, Spain

bgallego@us.es

Ecophysiological seasonal responses of native *Spartina maritima*, invasive *S. densiflora* and their reciprocal hybrids from SW Iberian Peninsula - Oral presentation

The current phenomenon of global climate change is accentuating the typical seasonal climatic variations of regions under Mediterranean climate. In salt marshes, the increase in aridity is promoting extreme drought, warming and salinity increment during the dry season, while sudden cold events and torrential rains are more frequent during the wet season. These extreme weather events are expected to differentially impact on plant species with contrasted tolerances to stressful conditions, such as native and alien species, as well as the hybrids between them. As a consequence of the different acclimation ability of these taxa, the composition of plant communities can be modified under extreme climatic scenarios and, thus, the ecosystem services they provide. However, there are few studies that evaluate the seasonal responses in native and alien species and their hybrids. With this objective, we analyzed the physiological responses of the native *Spartina maritima*, the alien invasive *S. densiflora* and their reciprocal hybrids to seasonal changes in the San Bruno Marsh (Guadiana River, SW Iberian Peninsula). Samples of foliar material of the four taxa were sampled during a cold wave in winter and in summer and the concentration of pigments (chlorophylls, carotenoids and anthocyanins), polyphenols and malondialdehyde (MDA) was quantified, and maximum photosynthesis rate and total antioxidant capacity were determined. Our results showed common seasonal responses to the four taxa, such as higher maximum photosynthetic rate and anthocyanins content in winter, while other responses were taxon-specific. The parental species *S. maritima* exhibited a high protection against oxidative stress in winter, however, it accumulated high concentrations of MDA in this season. The parent *S. densiflora* presented low seasonal variation for the traits analyzed. Both hybrids were transgressive for the low accumulation of MDA (*S. maritima* x *densiflora* in winter and *S. densiflora* x *maritima* in summer) and the increased concentration of polyphenols in winter, and *S. densiflora* x *maritima* for the high chl:carotenoids ratio in both seasons. This high seasonal acclimation of the hybrids in relation to their parental species may partially explain the high vigor of the natural populations of these hybrids and highlights their potential invasive capacity.

Daniel Gebler, Francisca Aguiar, Pedro Segurado

Poznan University of Life Sciences
School of Agronomy, University of Lisbon

daniel.gebler@up.poznan.pl

Improving the predictive assessment of biological quality using macrophytes: empirical testing and method selection

Oral presentation

Bioassessment in Southern European rivers has been hampered by difficulties in reference data availability and the unknown effect of the interacting multiple stressors on plant communities. This study aims to develop and evaluate macrophyte-based predictive models of the biological status of rivers using various modelling techniques. We compared models of multiple linear regression (MLR), boosted regression trees (BRT) and artificial neural networks (ANN). Secondarily, we investigated the relationship between two macrophyte indices with diverse conceptual basis (Riparian Vegetation Index – RVI, and Macrophyte Biological Index for Rivers – IBMR) and a group of environmental variables. We used a database of 292 Mediterranean perennial rivers (mainland Portugal) with macrophyte and environmental data, including climatic conditions, geographical characteristics, land use, water chemistry and habitat quality of rivers. In all cases, the quality of IBMR modelling was higher than RVI, which indicates a better relation of the former with the input variables used. The best quality of models was obtained for IBMR using ANN followed by BRT, for which the r-Pearson correlation coefficient was 0.877 and 0.801, and the normalised root mean square error was 10.0 and 11.3, respectively. Importance analysis revealed that longitude and geology, hydrological/climatic conditions, water body size, and land use had the highest impact on the IBMR models. Despite the differences in the quality of models, all showed similar importance to individual input variables, though in a different order. Our findings suggest that BRT and ANN can be used for decision-making on the environmental management of rivers.

Zhenjun Zuo, Haocun Zhao, Lei Yang, Tian Lv, Xiangyan Li, Fei Ma, Zhong Wang, Dan Yu

Department of Ecology, College of Life Sciences, Wuhan University, Wuhan, China

wangzhong@whu.edu.cn

Decouples of plant nitrogen-sulfur correlation under saline stress in alpine and arid wetlands - Oral presentation

Salinization alters the elemental balance of wetlands and induces variations in plant survival strategies. Sulfur (S) plays vital roles in serving regulatory and catalytic functions in stress resistance of plants. Yet, how plant S and its relationships with nitrogen (N) vary across natural environmental gradients are not well documented. We collected 1,366 plant samples and 230 water and sediment samples from 230 wetlands in Tibetan Plateau and adjacent arid regions of western China, to analyze the effects of environmental variables on plant S accumulation and N-S correlations. We found that plant S correlated with N in unimodal patterns. Salinity, rather than temperature or nutrient supply, promoted disproportionate accumulation of S but limited N uptake, inducing decoupling of N-S correlation in plants. Toward high salinity, the faster increasing rates of total S than that of glutathione, the most abundant organic-S compound in plant resistance, provided potential evidence explaining the decoupled plant N-S correlation. A salinity of 3.9‰ was calculated to be a threshold at which substantial changes in plant N-S correlation occurred. We designed a conceptual model to illustrate the mechanisms driving variations of N-S correlation in plants and environments along salinity gradient. Furthermore, high salinity filtered out the salt-sensitive species and reassembled the communities. In conclusion, increased salinity affected wetland plants by inducing S accumulation in plants and selecting salt-tolerant species with high S concentrations at community level, providing evidence for plant adaptive mechanisms to salinity in arid regions.

Rossano Bolpagni, Alice Dalla Vecchia, Mattia Azzella

Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parma (Italy)
Institute for Electromagnetic Sensing of the Environment, National Research Council of Italy (CNR-IREA), Milan (Italy)

rossano.bolpagni@unipr.it

Towards the measuring of Characeae functional traits: A compelling challenge for aquatic ecology - Oral presentation

Functional traits represent a valuable tool to explore a number of ecological questions related to organisms and their environmental interlinks at multiple scales. This is especially true for aquatic macrophytes which show a marked morphological variability and a great ability to respond and adapt to sudden physical-chemical variations of colonized habitats. Despite this, for stoneworts (Charophyceae) there is a lack of data and experiences aimed at their functional characterization. This is a key group of macroscopic algae, recognized as typical of various aquatic habitats and ecosystems (from deep lakes to temporary pools) and threatened globally. To fill this gap, a systematic study was started in 2022 with the aim to: 1) develop a methodological protocol for quantifying the morphological and biochemical traits of stoneworts and 2) collect the first data for a subset of species collected in stonewort European reference sites, starting from the Lake Bracciano (Italy) – one of the diversity hot spots for this algae group in Europe. The first data referred to five different taxa (*Chara aspera*, *C. globularis*, *C. polyachanta*, C. *tomentosa*, and *Nitellopsis obtusa*) for a total of 11 populations – placed at different depths in the range 1.5 to 11.0 m. We present here what has been done so far, focusing on the observed interspecies variability as a possible explanation of the different ecological needs and the typical differentiated depth distribution of the investigated species.

Zhipeng Pan, Fan Liu, Wei Li

Wuhan botanical Garden, Chinese Academy of Sciences

601095152@qq.com

Non-stressful environmental changes aquatic plant communities through interspecific interactions - Poster presentation

The stress of environmental factors and the interspecific interactions of plant species are supposed to be the two major aspects of plant community establishment. Under current aquatic environments, the water level and nutrient pulses triggered by global climate change, which have long been known to shape aquatic plant community structures, can be buffered by the aquatic environment so that they do not cause stress to aquatic plants. The effects of non-stressful environmental changes on species interactions and community composition are far less understood. Here, by using the seed bank from Poyang Lake, we exploited the water level fluctuations and nutrient pulses mimic to the flooding caused by climate changes as well as the effects on the strength of community interspecific interactions to assess the stabilizing niche and fitness differences that govern species coexistence and plant community establishment in each regime. Our results showed that water level and nutrient pulses qualitatively shifted community competitive results and community structures. In addition, influencing the interspecific competition appears to be how environmental effects on the community are achieved. Our findings highlight the importance of interspecific interactions on aquatic plant community establishment instead of environmental factors.

Eva Papastergiadou, Georgios Dimitrellos, Dionysios Tsoukalas, Kostas Stefanidis

Department of Biology, University of Patras, University Campus Rio, GR 26500 Patras, Greece
Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, Anavyssos, Greece

evapap@upatras.gr

Aquatic macrophytes as indicators of environmental degradation of Mediterranean rivers - Poster presentation

Aquatic macrophytes and riparian plants are important components of running waters that have been widely used as indicators of ecosystem health and integrity. Aquatic plants in Mediterranean type-rivers form dynamic assemblages adapted to the high seasonal and annual variability of the hydrological regime Aquatic macrophytes are one of the four biological quality elements (BQE) used for assessing the ecological status of inland waters according to the EU Water Framework Directive (WFD 2000/60). This work aims to examine relationships between species composition and physicochemical and hydro morphological parameters along longitudinal gradients in more than 100 river reaches of mainland Greece, having different water flow and ecological quality. Our aim was to investigate the spatial and temporal variability of macrophyte composition on the taxonomical (species) and functional (life forms) level in relation to environmental factors by means of multivariate analyses (PCA, CCA and RDA). The spatial pattern of the macrophyte assemblages within the monitoring network was analysed using Hierarchical cluster analysis while detrended correspondence analysis (DCA) was performed to visualize the spatial relationships between species and plant assemblages. Taxa primarily responsible for the differences among the assemblages were identified using similarity percentage analysis. The main findings showed that species composition of aquatic macrophyte assemblages varied with the downstream gradient from the springs to the lower parts of the rivers. Mosses and liverworts (bryophytes) dominate the upper part of the river basin, while emergent plants, helophytes, amphibious, and hygrophilous species were abundant in both middle and downstream reaches. Furthermore, it seems that the hydromorphological modifications have a significant impact on the aquatic plant communities and implied that at moderate disturbed stream reaches species richness would be higher. Overall, the links between macrophyte assemblages, environmental factors, and human alterations are critically important in improving freshwater biodiversity management and environmental conservation in east Mediterranean rivers.

The macroecology of aquatic plants in freshwaters

Session 2

Chair: Janne Alahuhta (University of Oulu, Finland), **Jorge García-Girón** (University of Oulu, Finland & University of León, Spain).

Studies on species distribution patterns and diversity have generated a number of macroecological hypotheses and rules across space and time. Unfortunately, the field of freshwater plant macroecology is still in its infancy and explanations for large-scale patterns and mechanisms in macrophytes are still elusive. This session is aimed to share recent advances in the macroecology of freshwater plants across different biogeographical areas, spatial scales, and ecosystems. By doing so, we hope to forge an exciting interdisciplinary discussion that will inspire collective efforts and consortiums aimed at stimulating the incipient rise of macroecology investigations on freshwater plants across broad spatial and temporal scales.

Daniel Larkin

University of Minnesota

djlarkin@umn.edu

Thin lines between native and invasive aquatic plants and their implications for management - Oral presentation

Evolutionary history and speciation shape biological invasions. For example, non-native plants often perform better where they have close relatives among the native flora, and hybridization between native and introduced lineages is associated with increased invasiveness in plants. These phenomena may be magnified in aquatic environments, where low oxygen and light availability impose severe environmental constraints: taxa able to overcome these physiological challenges are equipped to spread widely and, on reaching a new area, are likely to encounter similarly adapted relatives that got there first. Thus, we might expect aquatic invasions to be characterized by "thinner lines" separating native and invasive taxa—and breached lines where native and invasive taxa hybridize. I tested this prediction by comparing evolutionary relationships between native and invasive species in terrestrial vs. aquatic plants of the upper Midwest USA. Based on taxonomic and phylogenetic analyses, aquatic invaders in the region are more closely related to native taxa than are terrestrial invaders. Specifically, aquatic invaders more frequently have native conspecifics than terrestrial invaders do, and their evolutionary distances to native taxa are shorter. The evolutionary legacy of adaptation to aquatic habitats poses challenges for invasive species response. Education and outreach are challenged by finer distinctions between native and invasive; there is more nuance to communicating that a distinct lineage of a species poses a threat than that a species is wholly novel and harmful. Surveillance is challenged by cryptic invasions that escape notice or require expert verification. Control efforts are challenged by high risk of non-target impacts to close native relatives, while failure to control can lead to such relatives being displaced by introgression or competition. Nuanced outreach, robust evaluation of ecological impacts, and rigorous surveillance are needed to respond effectively in this biologically messy context.

Nompumelelo Catherine Baso, Julie A. Coetzee, Angela Bownes, Quentin Paynter

Centre for Biological Control, Rhodes University, Eastern Cape, South Africa
Landcare Research, Lincoln, New Zealand

nompumelelobaso@gmail.com

The Enemy Release Hypothesis and beyond: *Lagarosiphon major* invasion dynamics and management options for New Zealand using native natural enemies from South Africa - oral presentation

The Enemy Release Hypothesis (ERH) argues that plants become superior competitors in non-native environments due to the absence of top-down stressors such as herbivory, parasites, and diseases, that are presumed to be prevalent in their native habitat. The underlying assumption of the ERH is that natural enemies play a critical role in regulating plant populations, exerting more pressure on native species compared to alien plants. Consequently, in the absence of such pressures, the ERH assumes that exotic plants can allocate more resources towards growth and reproduction, while effectively maintaining accumulated biomass. Thus, the aim of this study was to investigate the role of ERH in macrophyte communities. This was done by conducting a literature search and a meta-analysis to synthesize existing studies in this regard. Furthermore, an empirical investigation was also conducted in order to explore the role of ERH on the invasiveness of *Lagarosiphon major* (Ridl.) Moss ex Wager (Hydrocharitaceae) in New Zealand. To achieve this, various plant parameters, including biomass, percentage cover, and macrophyte diversity, were measured and compared between the native range in South Africa and the invaded areas in New Zealand. With regards to the meta-analysis, the strength of the evidence for this hypothesis was limited and varied depending on the scale of study as well as other modulating factors such as plant growth form and study type. For *L. major,* biogeographical comparisons revealed higher biomass, denser stands, and reduced overall plant diversity in invaded sites compared to the native range. These findings emphasize the importance of understanding invasion ecology and theories such as ERH in order to advance aquatic plant management and also present valuable insights for developing effective strategies to mitigate the impact of invasive species on aquatic ecosystems. Specifically, results from the empirical investigation provide evidence in support of the ERH and highlight the suitability of implementing biological control strategies to manage the *L. major* invasion in New Zealand.

Janne Alahuhta, Xiaoming Jiang, Jorge García-Girón, Francisca Aguiar, Jukka Aroviita, Lars Båstrup-Spohr, Willem Kaijser, Krzystof Scoszkiewicz, Xing Sun, Jani Heino

Geography Research Unit, University of Oulu, Finland
State Key Laboratory of Eco-hydraulic in Northwest Arid Region of China, Xi'an University of Technology, China
Department of Biodiversity and Environmental Management, Universidad de León, Spain
Laboratório Associado TERRA, Instituto Superior de Agronomia, Lisboa, Portugal
CEF, Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal
Finnish Environment Institute, Marine and Freshwater Solutions, Oulu, Finland
Freshwater Biological Laboratory, Department of Biology, University of Copenhagen, Denmark
Faculty of Biology, University of Duisburg-Essen, Germany
Poznań University of Life Sciences, Department of Ecology and Environmental Protection, Poland
janne.alahuhta@oulu.fi

Climate, geodiversity and land use associated with beta diversity of river plant communities in Europe - Oral presentation

Aquatic plants are ecologically important components of freshwater ecosystems. Despite their importance, broad-scale studies examining how different environmental gradients shape aquatic plant communities have begun to emerge only recently. There are several global-scale studies on lake plants and few grid-cell-based examples where no distinction between lake and river plants has been done (i.e., no information exists on whether a plant grows in a lake or in a river using information from grids). However, investigations on river plants are largely missing. This is unfortunate, as major environmental factors (e.g., water flow) in lakes and rivers are different, influencing which plant species can grow in both or one of these habitats.
We tackle this shortage by investigating how climate, geodiversity and land use are associated with beta diversity of river plant communities in five different regions (Finland, Denmark, Germany, Poland and

Portugal) in Europe. To harmonize the species data, we applied strict criteria to include only vascular plant and bryophyte species which are classified as true aquatic species based on Ellenberg moisture index (values 10-12 for vascular plants and values 9-12 for bryophytes). As explanatory variables, we used altitude (m.a.s.l.), mean annual temperature (°C), mean annual precipitation (mm), geodiversity (i.e., richness of abiotic components of nature), and human footprint index (%). All the explanatory variables were delineated for hydrobasins of river point (representing catchment areas), where plant community data was gathered.

We aim to provide information on which environmental factors structure beta diversity of true river plant communities in regions with variable degree of human influence and contrasting natural environmental conditions, as well as evaluate whether context dependency dominates these patterns across regions. Moreover, using our data, we can compare whether beta diversity of river and lake plants show similar patterns across Europe. Our preliminary results indicate that beta diversity may be higher in regions situated in southern Europe.

Lars Baastrup Spohr, Lars Lønsmann Iversen, Yang Liu

University of Copenhagen

lbaastrupspohr@bio.ku.dk

Global drivers of aquatic plant height - Oral presentation

Plant height is one of the most important indicators of ecological fitness and is associated with various climatic variables. Previous studies have shown that the maximum height of terrestrial plants decreases with increasing latitudes, primarily due to limited water availability. In contrast, water availability is not expected to limit the height of aquatic plants, which typically have abundant access to water. However, fully submerged and emergent aquatic plants might respond differently to large-scale environmental gradients such as temperature and inorganic carbon availability. To explore whether the height of aquatic plants (both submerged and emergent) varies consistently with latitude and how plant height co-varies with climatic conditions, we collated examined plant heights and environmental variables for 1729 aquatic species with life form information at 237 sites worldwide. We found that the height of emergent aquatic plants decreased towards higher latitudes, but height of submerged plants increased with latitudes. General additive models suggested that heights of emergent plants are primarily driven by temperature while heights of submerged plants are driven by both temperature and the concentration of inorganic carbon. Our study highlights the importance of trait-climate interactions and how they differ across different plant life forms. This deepens our understanding of how various vegetation types respond to global climate change and enhances our ability to predict and manage the impacts of climate change on ecosystems.

Lindsay Trottier, Yingji Pan, Jorge García-Girón, Lars Iversen

Department of Biology, McGill University, Montréal, Québec, H3A 1B1, Canada
Quebec Centre for Biodiversity Science, Montréal, Québec, H3A 1B1, Canada
Key Laboratory of Wetland Ecology and Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, 130102 Changchun, China
Institute of Environmental Sciences (CML), Leiden University, Einsteinweg 2, 2333 CC Leiden, The Netherlands
Geography Research Unit, University of Oulu, PO Box 3000, FI-90014 Oulu, Finland
Department of Biodiversity and Environmental Management, University of León, Campus de Vegazana, 24007 León, Spain

lindsay.trottier@mail.mcgill.ca

The Macroecology of Aquatic Plant Functions (MAP) Project: How it started, progress to date, and next steps - Oral presentation

Aquatic plants play an important role in freshwater ecosystems, providing important ecosystem functions and services, such as water purification, nutrient cycling, and the provisioning of food and habitat. To maintain freshwater ecosystem functioning, it is necessary to understand how plant biodiversity is linked to the abiotic environment via phenotypic and physiological adaptations. Through functional biogeography, we can examine the spatial distribution of functional traits (i.e., physical characteristics of a species that are linked to their growth, reproduction, and survival), and how aquatic ecosystems respond to present-day stressors and predicted future scenarios. To date, research on plant functional traits has largely focused on terrestrial plant species. As such, we lack an understanding of the compromises and synergies that exist between functional traits in aquatic plants (i.e., trait-trait relationships), and how environmental features of inland waters impact their form and function and determine their survival (i.e., trait-environment relationships). In 2021, the Macroecology of Aquatic Plant Functions (MAP) Project was launched to quantify the global trait space of aquatic plants. The MAP database focuses on five functional traits in particular: plant height, leaf area, specific leaf area, leaf phosphorus content, and leaf nitrogen content. Thus far, we have developed a preliminary database, which captures 12.5% of the functional traits for all aquatic species, by compiling functional trait data from other existing online databases (i.e., TRY Database, Wetland Plant Trait Database) and from a few smaller, isolated datasets. This initial exercise enabled us to identify data gaps in the global coverage of aquatic plant species, functional traits, and geographic distribution. Generally, we found that aquatic plants that exist fully submerged under water, have relatively small geographic ranges, and that occur outside of North America and

Europe tended to be underrepresented in our existing database. To fill these data gaps, we are now engaging potential collaborators from around the world and actively seeking data contributions from individuals and/or institutions that hold or have access to aquatic plant functional trait data. As we work toward closing gaps in the MAP database, we now look ahead at how we can employ this global database to understand how ecological patterns and processes in freshwater systems are driven by the form and function of the aquatic plants inhabiting them.

Richard Lansdown

IUCN SSC Freshwater Plant Specialist Group

rvlansdown@gmail.com

Aquatic Plant Conservation: Priorities and plans

Oral presentation

The IUCN SSC Freshwater Plant Specialist Group includes 137 members from more than 70 countries. The work of the FPSG is based on publication of Red List assessments on the IUCN database, using these assessments to prepare genus-, species- or region-specific Conservation Action Plans and then supporting individuals throughout the world in the implementation of conservation action priorities both in the field and through policy. It is estimated that the remit of the FPSG includes at least 30,000 plant taxa, including vascular plants, bryophytes and algae which may be considered to be dependent upon freshwater wetlands, however this is likely to be an under-estimate as every project undertaken identifies additional species which are dependent upon small and overlooked wetlands. Projects have been undertaken on the conservation of the *Callitriche*, *Cryptocoryne* and *Isoetes* species, as well as conservation of individual species such as *Crinum malabaricum* and *Rotala malabarica*. In addition to this conservation action, the FPSG is using Red List assessments to develop Red List Indexes. The first of these has involved completion of a baseline of Red List assessments of nearly 600 species of wetland-dependent plants in the Mediterranean region. It is our aim to prepare a global Red List Index of wetland-dependent plants which enable us to track trends in the conservation status of species and the wetlands on which they depend worldwide.

Zarah Pattison, Wayne Dawson, Mark Shirley, Nigel Willby

University of Stirling, Biological and Environmental Sciences, Stirling, FK9 4LA, Scotland
Durham University, Department of Biosciences, Durham, DH1 3LE, England
Newcastle University, School of Natural and Environmental Sciences, NE1 7RU, England

zarah.pattison2@stir.ac.uk

The freshwater biodiversity crisis: what role do plant invasions play? - Oral presentation

Freshwater ecosystems, crucial to humanity, are in crisis and require immediate attention. Freshwater biodiversity has suffered a staggering 83% decline since 1970, a rate far exceeding that of marine or terrestrial systems, and one in three of the 28,000 species dependent upon freshwater habitats are considered to be threatened with extinction. Although biological invasions are one of the greatest modern threats to biodiversity, a global assessment of freshwater invasions and how they vary geographically compared to terrestrial species, is still lacking. To quantify the status of invasive aquatic alien plants in freshwater ecosystems globally, we integrated multiple global datasets such as Global Naturalized Alien Flora (GloNAF) and the Global Inventory of Floras and Traits (GIFT). By categorising alien plant species as aquatic or terrestrial; naturalised or invasive, we mapped the global distribution of aquatic invasive alien plants. These data show that aquatic alien plant species are more likely to become invasive when compared to terrestrial plant species, even though they represent <5% of alien flora. We used Structural Equation Modelling to identify which anthropogenic and background environmental variables drive the distribution of invasive alien plants in freshwater habitats globally, and how this differs from terrestrial systems. Understanding these drivers will enable predictions of future invasion risk and promote resilience of freshwaters.

Jorge García-Girón, Yingji Pan, Lindsay Trottier, Lars L. Iversen

Geography Research Unit, University of Oulu, Finland
Department of Biodiversity and Environmental Management, Universidad de León, Spain
Key Laboratory of Wetland Ecology and Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, China
Institute of Environmental Sciences, Leiden University, The Netherlands
Department of Biology, McGill University, Canada

jogarg@unileon.es

Towards linking freshwater plants and ecosystems via functional biogeography

Poster presentation

Functional biogeography has advanced the field of ecology into a more spatially-predictive science. However, freshwater plants are still underrepresented in these trait-based advancements. We argue that there is a need for developing a functional biogeographical framework for freshwater plants and initiate global mapping efforts focusing on the form and function of freshwater plants. Specific attention should be given to (1) the placement of freshwater plants in the global plant trait space and show how this placement links to global trait-environment relationships; (2) the theoretical framework for major structural trait-trait correlations based on the physical constraints in aquatic ecosystems; (3) the evolutionary and environmental drivers underlying the global distribution of inter- and intra-specific variation in different life forms; and (4) the level of equilibrium between spatial and temporal trait-environment relationships in freshwater plants. By putting freshwater plants in the context of these biogeographical aspects, we could advance our understanding of freshwater plant adaptations and responses to environmental gradients, and thereby facilitate predicting the consequences of global changes for freshwater ecosystem functions and services. Such efforts can be built on the existing work of the ongoing MAP (The Macroecology of Aquatic Plant-functions) project, which is now welcoming collaborators from around the world with different interests and backgrounds in the functional architecture of aquatic plants.

Helle Mäemets, Kadi Palmik-Das, Marina Haldna

Estonian University of Life Sciences

helle.maemets@emu.ee

Oscillations and trends in aquatic vegetation - Poster presentation

Most studies of lake vegetation, supported by individual projects, are scattered in time. Frequency of the regular studies is a subject of discussion. Usually, macrophyte monitoring is carried out periodically (after 3-5 years), not annually. Long-term series of such periodical studies diminish randomness and dependence on the year; however, annual monitoring reveals remarkable dependence on the year. Among natural factors, water level and temperature are more obvious. Only few lakes are under annual macrophyte monitoring in Estonia, and the longest time series is available for the largest, Lake Peipsi (3555 km^2). Our littoral monitoring in 10 stations from 2004-2022 enabled detection of ten taxa (including *Cladophora glomerata* and *Chara contraria*) with significant negative correlation between water level (WL) and their abundance. Paradoxically, among these, seven taxa belong to hydrophytes and three to amphibious plants – less water, more hydrophytes. It is not related to the improved water transparency (SD), at least not in summer, because due to strong mechanical stress, SD decreases in the years of low WL. Resuspension of sediment particles and phosphorus from bottom increases, supporting algal blooms. We do not know how long the favoring low-water period must be: does low spring WL enhance further development of submerged plants or is the WL of the previous autumn more important. Oscillations in aquatic vegetation complicate clearing up of trends and the estimation of ecological status. At low WL appear abundantly the both: taxa regarded as nutrient-demanding, and taxa attributed to the moderate trophy level. Denuded shore of ca 30 m width provides habitat for many species, among them small-sized plants, generally suppressed by the widening and merging of reed stands. Occupation of the littoral by reeds is the main long-term trend of the vegetation and is accompanied by increase in species able to grow in reeds. The other consequences of increased trophy level during the last 60 years are not so clearly traceable, also due to earlier scattered investigations.

Plant-animal interactions in aquatic plant beds (Zoogeochemistry session)

Session 3

Chair: Liesbeth Bakker (Netherlands Institute of Ecology, Wageningen University and Research, The Netherlands), **Jonas Schoelynck** (University of Antwerp, Belgium).

Aquatic plants are food for herbivores and omnivores and thus part of the aquatic food web. However, they are as important as providers of habitat to other organisms. Therefore, aquatic plants play a crucial role in the conservation and restoration of riparian and benthic habitats. With ongoing global change, including eutrophication, exotic species proliferation and climate change, the properties of the plant beds may change as well as the plant-animal interactions that take place within the beds. Alternatively, restoration may make use of plant properties to attract animals whereas the animals in turn may consume the restored plant beds. This session welcomes contributions on the interactions between plants and animals, both trophic and non-trophic, to advance our understanding of the fundamental aspects of plant-animal interactions under water and in wetland vegetation and address emergent properties of plant-animal interactions in a restoration or global change context.

Kirstine Thiemer, Robert Lennox, Astrid Torske, Susanne Schneider, Thrond Haugen

Norwegian Institute for Water Research
Dalhousie University
Norwegian University of Life Sciences
Norwegian Institute for Water Research
Norwegian University of Life Sciences

kirstine.thiemer@niva.no

True love? Aquatic plants in relationship with fish - Oral presentation

Mass development of macrophytes is a problem worldwide and macrophytes are removed when interfering with human activities. Macrophytes provide important refuge and nursery habitats for fish and the effects of partial macrophyte removal on fish movement are not known. In this study, we tagged 94 brown trout (*Salmo trutta*) with acoustic sensors and tracked them using passive acoustic telemetry for 10 months in an oligotrophic Norwegian river with mass development of *Juncus bulbosus* (L.). Trout movements were then linked to habitat use and selection for *J. bulbosus* cover. Removal of *J. bulbosus* reduced the core utilisation area by 23% and both habitat use and selection increased for areas with low *J. bulbosus* cover (<25 %) with corresponding reduction in high *J. bulbosus* cover (>25-75 %). The intensifying habitat selection for areas with low *J. bulbosus* cover suggested reduced competition for preferred habitat after removal. Finally, diurnal differences in space and habitat use were found, with 19% larger utilisation areas at night and higher use of areas with low *J. bulbosus* during daytime. This research provides the most comprehensive study on the effects of macrophyte removal on riverine fish activity in ecosystems with macrophyte mass developments. We found no profound negative effects of removal on trout behaviour but noted an increased use of areas with low macrophyte cover. This research is relevant for water managers and policy makers of freshwaters and provides a template for using acoustic telemetry to study the effects of macrophyte removal on riverine fish.

Kerstin Bouma, Liesbeth Bakker

Netherlands Institute of Ecology (NIOO-KNAW)
Wageningen University & Research (WUR)
OBN (Ontwikkeling & Beheer Natuurkwaliteit)
Staatsbosbeheer

k.bouma@nioo.knaw.nl

The impact of grazing by red deer (*Cervus elaphus*) on vegetation development during a wetland restoration project - Oral presentation

Water level fluctuations are the main drivers of vegetation succession in natural wetlands. However, in densely populated areas like the Netherlands the water level is often kept stable due to the construction of dikes. This results in large homogeneous open water areas with little vegetation and sudden land-water transitions. To facilitate the development of heterogeneous wetlands, a lowering of the water level, including an occasional complete drawdown, is sometimes induced as a management strategy. In the Oostvaardersplassen, a man-made, eutrophic, clay wetland in the Netherlands, such a drawdown is currently being induced after successful restoration of large areas of reed (*Phragmites australis*) vegetation during a previous drawdown. Yet, since the last drawdown, red deer (*Cervus elaphus*) have been introduced in the area, which could potentially influence the expected outcome of this restoration project. Therefore, this research looked into the influence of red deer presence on vegetation succession, and specifically reed development, during a drawdown. Throughout the area, 27 exclosures were built and monitored on vegetation composition, height and soil properties. During the first growing season of the drawdown period, no big differences were found between exclosures and control, probably due to the high productivity in the area enabling rapid and massive pioneer vegetation development. Yet, traces of grazing were already found in the area on several species, including reed. The second growing season showed more differences in which perennial species, such as reed, show much larger coverage and much taller individuals inside the exclosure compared to outside. It seems that the grazing of red deer, from both previous and present years, greatly impacts the return of this species irrespective of the environmental conditions. Therefore, the outcome of this drawdown might be quite different compared to the outcome of the previous drawdown, at least with respect to the duration of the project or the total area of reed recovered in the end. So, when applying restoration measures targeted at specific species in wetland ecosystems, the presence of grazers could alter the expected outcomes of this measure and call for other approaches and detailed monitoring of the development.

Balázs A. Lukács, María J. Navarro-Ramos, Orsolya Vincze, Viktor Löki, Renáta Urgyán, Casper H.A. van Leeuwen, Andy J. Green, Ádám Lovas-Kiss

Institute of Aquatic Ecology, Centre for Ecological Research, Bem sq. 18/C. H-4026, Debrecen, Hungary
Department of Conservation Biology and Global Change, Estación Biológica de Doñana, EBD-CSIC, Américo Vespucio 26, 41092 Sevilla, Spain
Department of Aquatic Ecology, Netherlands Institute of Ecology (NIOO-KNAW), Droevendaalsesteeg 10, 6708 PB Wageningen, the Netherlands

lukacs.balazs@ecolres.hu

Traits for transport: do alien wetland plants have advantage?

Oral presentation

The expansion of alien plant species is of global concern, yet our understanding of their dispersal mechanisms is limited. Here we address the potential of alien plant seeds to disperse via ingestion, transport, and egestion in waterfowl (endozoochory). Based on their general rapid expansions, we expected alien plant species to have several advantages for endozoochory compared to native plant species. To test our hypotheses, we compared the endozoochorous dispersal ability of six pairs of congeneric alien and native wetland plant species in a feeding experiment with mallards (*Anas platyrhynchos*). We hypothesized that seeds of alien species would have higher passage rate, longer gut retention times, higher germinability after gut passage, and shorter time to germination after egestion by waterfowl. With gut passage, alien species had higher survival rates and germinated faster, whereas native species had shorter retention times and greater germinability. Controlling for seed traits did not alter these conclusions, but seed traits affected all aspects of the endozoochory process. Among control seeds, alien seeds germinated faster and their germinability was higher than natives. Seed traits explained differences in germinability in control seeds, but not time to germination. This suggests that alien species may have particular traits correlated with a higher endozoochory potential. This may provide alien species with a competitive advantage over native plant species by ensuring higher endozoochory rates in new environments, potentially enabling their rapid expansions.

Emily Strange, Maarten Schrama, Isabelle Don, Julie A. Coetzee, Ryan Wasserman, Sam Boerlijst

Leiden University
Rhodes University

e.f.strange@cml.leidenuniv.nl

Mosquitoes & Macrophytes: a dangerous mix? - Oral presentation

Invasive floating macrophytes form dense mats, blocking light to the water below, threatening the structure and functioning of freshwater systems. Biodiversity in these invaded water bodies can significantly decline. However, some organisms may benefit from the presence of these invaders, such as mosquitoes. Capitalizing on reduced predation and finding protection for their larval development in the leaves and roots, mosquito populations could be boosted by aquatic invasive plant spread. These alien invaders are spreading rapidly throughout Europe and in 2020 the Netherlands confirmed the first case of someone contracting West Nile Virus and found the disease present in local mosquitoes. Despite growing research into invasive alien macrophytes and mosquitoes independently, we know almost nothing about their interaction. A pilot experiment conducted at Leiden University found that larval development and survival rates of the common house mosquito [*Culex pipiens*] increased when co-occurring with floating invasive plants [*Pistia stratiotes* and *Azolla filliculoides*]. The results of this experiment - which will be presented - have spearheaded a new exciting research project to explore this interaction; MOZiMAC. The MOZiMAC project will conduct cross-continental research in Europe and Africa to help understand the connections between the spread of invasive alien macrophytes and the prevalence and survival of a major global disease vector.

Michał Brzozowski, Patrick Heidbüchel, Marta Alirangues Nuñez, Andreas Hussner, Uta Müller, Constancia Levertz, Rüdiger Mauerberger, Sabine Hilt

Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Department of Community and Ecosystem Ecology, Müggelseedamm 301, 12587 Berlin, Germany
Förderverein Feldberg-Uckermärkische Seenlandschaft e.V., Martin-Luther-Str. 5a, 17268 Templin, Germany

michal.brzozowski@igb-berlin.de

Biotic and abiotic factors potentially responsible for charophyte decline in temperate hardwater lakes - Oral presentation

Charophytes are a key group of submerged macrophytes in temperate hardwater lakes. Their decline started more than 100 years ago, but currently, this process is continuing in many European lowland lakes despite an overall reduced nutrient loading. Existing studies suggest that changes in abiotic parameters such as increasing nutrients concentrations or decreasing concentrations of dissolved inorganic carbon (DIC) and calcium (Ca) could play a role. In addition, changes in biotic parameters such as fish abundance, community composition and periphyton may have an effect. In a large project financed by the German Federal Agency for Nature Conservation, we investigated the potential impact of several biotic and abiotic factors on charophyte abundance in German oligo-mesotrophic hardwater lakes using field and laboratory experiments. Here, we report on selected results focusing on fish, periphyton, DIC and Ca. We performed a large-scale enclosure experiment stocking benthivorous bream (*Abramis brama*) at biomasses of 0, 50, 100 and 250 kg/ha to large enclosures (35 x 60 m each) in a lake containing charophytes and estimated periphyton cover in underwater videos. Periphyton cover was positively related to bream density in enclosures and to water depth. Fish removal may thus positively influence charophyte recovery. Indeed,

one of the project lakes showed a significant charophyte recovery after removal of 85 kg/ha bream and roach (*Rutilus rutilus*). We also measured the concentrations of DIC and Ca in about 30 lakes with different charophyte abundance. In these lakes, charophytes were absent at Ca concentrations below 0.87 mmol/L and DIC concentrations below 1.25 mmol/L, suggesting that these could be threshold concentrations limiting abundant charophyte meadows in hardwater lakes. In a full-factorial design laboratory experiment, we tested the effects of low and high concentrations of DIC (0.42 and 1.65 mmol/L) and Ca (0.25 and 1.25 mmol/L) on the growth of two charophyte species with different environmental preferences (*Chara globularis* and *Chara rudis*). Combinations of low DIC and low Ca resulted in the lowest charophyte growth rates. Based on these results we will discuss options for charophyte restoration in hardwater lakes.

Heleen Keirsebelik & Jonas Schoelynck

University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium

Heleen.keirsebelik@uantwerpen.be

Chinese mitten crabs (*Eriocheir sinensis*) damage macrophytes

Demonstration

The Chinese mitten crab was first observed in Belgium in 1933. Nowadays the Chinese mitten crab is omnipresent in all major Belgian waterways and recent catch numbers are alarming. Since January 2018 up till now (October 2023) about 1.9 million crabs, roughly 11.000 kg biomass, were caught in one single trap in one single Flemish river. Because of this, concerns have been raised about their ecological impact. In rivers specifically, their presence has been linked to the disappearance of macrophytes. In an experimental mesocosm study at the University of Antwerp, the decline of macrophytes (*Myriophyllum spicatum*) was investigated following the introduction of different densities (0, 0.3, 1.0 and 2.5 ind. m^{-2}) of mitten crabs. The study demonstrated that Chinese mitten crabs were highly capable of removing plant shoots, the tested crab densities led in most cases to the total elimination of macrophytes over the test period of 25 days. Interestingly, stable isotope analyses of crab tissue showed that although the crabs eat macrophytes, the proportion was not large enough to explain the observed decline. Camera footage showed that next to eating, the crabs interact intensely with the macrophytes by crawling on them and by burrowing between their roots, thereby causing considerable damage to the plants. Measurements of the pinching strength of a broad size range of mitten crabs showed that even juvenile mitten crabs are strong enough to break plant stems. We conclude that high densities of Chinese mitten crabs can lead to adverse effect on macrophytes and that management of this invasive decapod is therefore necessary to safeguard macrophytes in Belgian rivers.

Genetic diversity and structure in aquatic plants (continental and coastal habitats)

Session 4

Chair: Ludwig Triest (Vrije Universiteit Brussel & Université Libre de Bruxelles, Belgium).

Molecular tools became increasingly important in ecology, allowing us to understand underlying diversity patterns in aquatic plants. In aquatic populations, molecular ecology can be used to identify species or hybrids, to understand their survival strategy that can be mixed (sexual/clonal) and their dispersal movement ecology. Habitat modifications may disrupt gene flow and alter genetic connectivity of aquatic plant populations through isolation-by-distance, as well as changing their local structure. This session aims to compile work on how genetic information of populations can be used in aquatic plant ecology to better understand their biogeographical migration history, life strategies, survival, and movement ecology for practically aiding the management of aquatic plant vegetations. Focus will be on the relevance and applications, not on the molecular methods as such. This session will include presentations on:

- Species and hybrid identification (phylogenetics and barcoding)
- Large-scale patterns (phylogeography, long-distance dispersal)
- Gene flow (pollen flow and seed flow), isolation-by-distance
- Survival strategies (sexual, clonal, mixed) and fine-scaled structures
- Movement ecology, spread and dispersal patterns

Petr Koutecký, Jan Prančl, Zdeněk Kaplan, Jiří Košnar, Magdalena Lučanová

University of South Bohemia, Faculty of Science
Czech Academy of Sciences, Institute of Botany

kouta@prf.jcu.cz

Molecular and genome size data allow delimitation of *Ranunculus sect. Batrachium* taxa and reveal unexpected hybridization and cryptic diversity - Oral presentation

Water Crowfoots (*Ranunculus sect. Batrachium*) are notoriously difficult to identify due to morphological reduction, environment-driven plasticity, and unresolved taxonomy. Recent studies from central Europe show that genome size estimated by flow cytometry can be used as a rapid marker that allows delimitation of all traditionally recognized (i.e., morphologically defined) species and most of their first-generation hybrids. Molecular data from the nuclear ITS region and two non-coding plastid regions, which are easily sequenced using universal primers, are in line with the genome sizes. All eight species reported from central Europe can be distinguished. Hybridization, including backcrossing, is present, but rather rare. In some species, several sequence variants reflecting their allopolyploid origin are present, and the morphologically reduced species *R. trichophyllus* comprises two cytotypes that are morphologically cryptic but well distinguished both by genome size and molecular data. The same approach has recently been applied to the populations from the Alps. Combination of genome size and sequence data have resolved the status of *Batrachium* populations from alpine lakes that has been controversial so far. Occurrence of *R. confervoides* in the Alps has been confirmed; both data types are identical to populations from northern Europe. Unexpected patterns of hybridization have been revealed. In many rivers and peri-alpine lakes in the north-eastern Alps, i.e., the area that was not glaciated during the Last Glacial, specific genotypes and hybrid populations occur, are widespread and often dominate the aquatic vegetation, while they are absent from the glaciated areas. We hypothesize that the local absence of glaciation allowed long-term existence of the parental taxa in the area and their co-occurrence at some localities during the Holocene, which provided enough time for rare hybridization events to occur. The stability of environmental conditions in rivers and large lakes at the foothills of the Alps then allowed long-term survival and spread of these hybrids, despite their apparent sterility, by means of vegetative reproduction.

Nigel Willby, Craig Wilkie, Laurence Carvalho, Dan Chapman, Claire Miller, Henrietta Pringle, Marian Scott, Gavin Siriwardena, Phil Taylor, Charlotte Ward

University of Stirling
University of Glasgow
British Trust for Ornithology
UK Centre for Ecology & Hydrology

n.j.willby@stir.ac.uk

Birds, boats and buoyancy: effects of connectivity on lake macrophyte communities - Oral presentation

Connectivity is a quintessential property of freshwater ecosystems and is often regarded as integral to ecological resilience yet understanding of how different forms of connectivity influence biota or ecological processes, or interact with known stressors, remains surprisingly rudimentary. Being relatively immobile various forms of connectivity have long been implicated in shaping the distribution of macrophytes. Here we assess the relative importance of waterbirds and human vectors alongside indicators of hydrological connectivity as drivers of lake macrophyte communities, using species richness, functional group richness, compositional integrity, and invasion status as responses. Our data come from a set of ca. 250 lakes with well surveyed plant communities and overlapping standardised monthly counts of wetland birds, visitor surveys (stratified by fishing, water sports or general recreation) and for which we generated a set of land-use buffers to infer stress from urban or agricultural land-use, and hydrological connectivity based on density of ponds and lakes or length of rivers. Bird count data was reduced to water bird richness, abundance, and biomass, stratified by season and by potential transport mechanism (internal or external only). Random forests were used to rank candidate explanatory variables by importance ahead of generalised additive modelling to take account of potential non-linear responses. Our model outputs highlight a relatively

significant role for avian connectivity with mostly positive effects on species and functional group richness and negative ones on compositional integrity. Of the available indicators of avian connectivity, the richness of internal transporters was consistently the strongest. Human connectivity did not influence richness but had a negative association with compositional integrity. The effects of lake or pond density in surrounding buffers were generally positive while most models also included examples of interactions between stressors (usually urban land cover) and connectivity indicators. Connectivity clearly has complex and multi-faceted effects on lake macrophytes, but the simple take home message of this tale is not to underestimate ducks.

Junyao Sun, Wei Li, Huan Zhang

Wuhan Botanical Garden, Chinese Academy of Sciences
Institute of Hydrobiology, Chinese Academy of Sciences

sunjunyao@wbgcas.cn

Response of macrophyte species community to the pond connectivity in an agricultural multi-pond system - Oral presentation

Previous studies have demonstrated differences between common and rare species in terms of their dispersal ability and reproductive strategies, resulting in distinct responses to environmental and spatial processes. However, few studies have examined the impact of lake connectivity on the species turnover of common versus rare species. The objective of this study was to examine the impact of hydrological (i.e., watercourse dispersal) and geographical connectivity (i.e., overland dispersal) on the species turnover of both common and rare macrophyte species in ponds. We collected data from 111 ponds in an agricultural multi-pond system, including environmental variables, land use data, connectivity variables (e.g., hydrological versus overland spatial variables), as well as data on the abundance of macrophyte species. Our analysis aimed to identify the factors that influence the abundance of macrophyte species, with a specific focus on distinguishing between common and rare species and explaining the variance in their abundance. The findings of this study suggested that common macrophyte species were a better indicator of overall species richness than rare species. Additionally, we found that the spatial variables used in the analysis were redundant, with only 4.11% of the total variance explained by the spatial eigenvector generated from AEM (the direction of water flow), while the spatial eigenvector based on overland distance only explained 1.17% of the variance in the macrophyte community. These results indicate that water flow is a more important factor than dispersal by wind or flying animals for the macrophyte community in the multi-pond system. Specifically, for common species, water flow plays a crucial role (adj-r^2=0.0376), along with the environmental variables (adj-r^2=0.0452). In contrast, rare species were more specialized and responded to the Euclidean distance-based spatial variables. Our study concluded that the role of dispersal ability and environmental filtering would vary for common and rare macrophyte species, offering insights into the recovery of freshwater habitats following disturbances. These findings could contribute to a better understanding of the pond recovery processes in the disturbed freshwater ecosystems.

Jasper Dierick, Ludwig Triest, Tom Van der Stocken

Vrije Universiteit Brussel

jasper.dierick@vub.be

The importance of clonal and sexual reproduction for the maintenance, persistence and resilience of seagrass meadows under disturbance

Oral presentation

Seagrasses form an ecological group of marine aquatic flowering plants, adapted to colonize shallow coastal areas. These ecosystem engineers can form dense meadows and provide numerous functions and services which are essential for the health and productivity of coastal systems. Seagrass meadows are threatened globally by human-induced land use, causing eutrophication, sedimentation, and physical destruction. *Enhalus acoroides*, a large-sized tropical seagrass species, appears to be highly resistant toward environmental change compared to other seagrass species and reproduces either sexually by pollination, with the subsequent dispersal of floating fruits by ocean currents, or asexually by the extension of rhizomes whereby new shoots as clones are formed. Here, we present ongoing research on the contribution of clonal and sexual reproduction for the maintenance, persistence, and resilience of *E. acoroides* populations under intense environmental stress. We show cases where genetic markers in combination with satellite imagery are used to assess the relation between reproductive strategy, genetic diversity, genetic connectivity, and human-induced disturbance.

Laura Bossaer, Jasper Dierick, Ludwig Triest

Vrije Universiteit Brussel
Université Libre de Bruxelles

laura.bossaer@vub.be

Salinization as a driver of genetic differentiation in lowland populations of *Stuckenia pectinata* - Oral presentation

With sea level rise and prolonged periods of drought, seawater is expected to intrude coastal areas at shallower depths. The anticipated salinization will put more pressure on freshwater ecosystems with potential adverse impacts on their communities. While some macrophyte species are known to tolerate brackish conditions, it is poorly understood how their freshwater populations will react to salinization. The aim of this study is to investigate patterns of genetic diversity and compare reproductive strategies of *Stuckenia pectinata* (L.) Börner between habitats of different salinities, using microsatellite markers. Preliminary results suggest a strong influence of salinity on genetic differentiation and gene flow. The information will be used to help predict the resilience of coastal populations to salinization.

Estelle-Marie Blanquart, Aurélien Jamoneau, Olivier Lepais

INRAE, Ecosystèmes Aquatiques et Changements Globaux (UR1454 - EABX) 33612 Cestas Gazinet, France
INRAE, Univ. Bordeaux, UMR 1202 BIOGECO, 33610 Cestas, France

estelle-marie.blanquart@inrae.fr

Genetic and taxonomic diversity of isoetid communities in Aquitaine shallow lakes - Oral presentation

The Southwestern freshwater shallow lakes of the Aquitaine coast in France harbour a unique aquatic plant diversity, playing a crucial role in maintaining vital ecosystem functions. However, anthropogenic activities and global changes pose significant threats, leading to local extinctions. This project combines two research questions to enhance our understanding of these ecosystems and guide conservation efforts. First, we will investigate the genetic diversity of nine macrophyte species isoetid communities across five lakes. Using sequence-based nuclear microsatellites genotyping, we analysed the genetic variation in ca. 4,000 sampled individuals. Assessing the distribution of genetic diversity within and between lakes, we aim to (i) uncover population-level processes, (ii) identify historical and contemporary factors shaping population structure, and (iii) understand community assemblages. These findings will shed light on adaptation capacity, demographic history, dispersal abilities, and population structure of macrophytes communities. In addition, we aim to explore ecological processes at a larger biological scale by examining the correlation between genetic and taxonomic diversity using the species-gene diversity correlation (SGDC) framework. This approach determines whether similar ecological processes operate across different biological scales and whether taxonomic diversity can serve as a reliable proxy for genetic diversity. By integrating these two research questions, this project should provide valuable information for conservation management plans in the Aquitaine region. Genetic insights will help to assess the adaptive potential of macrophytes populations and to inform conservation strategies to mitigate threats. Furthermore, the examination of ecological processes will strengthen our understanding of community structure and responses to anthropogenic impacts. This knowledge is crucial for developing effective conservation strategies, with the essential collaboration of managers, to protect biodiversity and ecosystem services in the face of ongoing environmental challenges.

Mohammed AlDakhil, Salem Alghamdi, Hussein Migdadi, Muhammad Afzal, Ahmed Ali

King Saud University

maaldakhil@kacst.edu.sa

Morphological Characterization and DNA Barcoding of Duckweed Species in Saudi Arabia – Poster presentation

Duckweeds, or Lemnaceae, are widespread aquatic plants. Morphology-based identification of duckweed species is difficult because of their structural complexity. Hence, molecular tools provide significant advantages for characterizing and selecting species or clones for sustainable commercial use. In this study, we collected and characterized ten duckweed isolates from nine different regions in Saudi Arabia (SA). Based on the morphological characterization and phylogenetic analysis of intergenic spacer sequences of chloroplast DNA using six barcoding markers, the clones were classified into three genera, represented by seven species: *Lemna gibba* L., *Lemna minor* L., *Lemna japonica* Landolt, *Lemna aequinoctialis* Welw., Lemna perpusilla Torr., *Spirodela polyrhiza* (L.) Schleid., and Landoltia punctata G. Mey. Lemna gibba was revealed to be a distinct dominant duckweed species in many regions of SA. Five barcoding markers showed that *L. gibba*, *L. minor*, and *L. punctata* were the most widely distributed species in the country. However, *L. punctata*, *L. perpusilla*, and *S. polyrhiza* were the dominant species in the Al-Qassim, Madinah-1, and Madinah-2 regions, respectively. Moreover, the morphological traits revealed variations for these clones, relative to other studied duckweed clones. According to the results obtained in this study, three out of six plastid markers (trnH-psbA, matK, and atpF-atpH) helped to identify the dominant duckweed species in Saudi Arabia. Further evaluation based on adaptability, molecular genetic studies, and functional genomics is needed for these species to be used at the commercial level in Saudi Arabia.

Laura Bossaer

Vrije Universiteit Brussel

laura.bossaer@vub.be

Founder populations of *Stuckenia pectinata* in restored ponds originate from genetically diverse propagule pool: A case study of urban ponds in Brussels, Belgium - Poster presentation

The role of urban waterbodies in biodiversity conservation has been promoted over the past two decades, through the integration of more blue spaces in urban development and the restoration of existing and degraded systems. However, urban environments remain sources of anthropogenic stressors that need to be managed in order to have a positive impact on biodiversity. In urban ponds, eutrophication is considered a major problem for biodiversity and water quality. While biomanipulation techniques have great restoration potential, it remains difficult to predict if and how macrophytes will recover naturally. Here, we used genetics in a comparative approach to investigate the recruitment and recolonization strategies of the submerged macrophyte *Stuckenia pectinata* (L.) Börner. More specifically, we compared the founder genetic diversity of recovering populations to the genetic diversity of spontaneous, contiguous populations that settled over an extended period of time and were within the same catchment. Our results showed that turbid ponds may contain a persistent propagule bank that allows for an immediate re-establishment of genetically diverse populations of *S. pectinata* once a desired state of clear water is restored. Therefore, biomanipulation without sediment removal proved to be very successful for founding populations to become immediately integrated with their established populations, thus maintaining the overall diversity of this species within local areas.

Causes and patterns of macrophyte decline and recovery

Session 5

Chair: Sabine Hilt (IGB Berlin, Germany),
Andreas Hussner (Ministry of the Environment, Nature and Transport of NRW, Germany).

In many freshwater bodies, the abundance and community composition of submerged and/or floating macrophytes is of key importance for several ecosystem functions such as habitat, nutrient retention or carbon processing. Understanding the causes and patterns of changes in macrophyte communities is thus crucial for a sustainable management of these water bodies and their functions. In recent decades, a number of general concepts have been developed, such as regime shifts between alternative stable states in eutrophic shallow lakes and lowland rivers, the occurrence of crashing/recovery states or boom-bust cycles of invasive species. Yet we are still far from understanding the complex patterns and causes of spatial and temporal changes in macrophyte communities. A pelagic focus in limnological research and a lack of macrophyte data in sufficient temporal and spatial resolution have been reasons for this knowledge gap. However, recent developments in macrophyte monitoring due to legislation (e.g. EU Water Framework Directive) and new methods (remote sensing, hydroacoustics) have improved this situation and allow for new insights. In this session, we welcome fundamental and applied contributions with a mechanistic or methodological focus on causes and patterns of macrophyte decline and recovery at all spatial and temporal scales. Key session objectives are:

- Unravel patterns of shifts in macrophyte abundance and community composition
- Identify key drivers for shifts in macrophyte abundance and community composition.

Sandor Szabo, Gergo Koleszar, Zoltan Nagy, Mihaly Braun, Sebastian Birk, Edwin Peeters

Department of Biology, University of Nyiregyhaza, Nyiregyhaza, Hungary
Institute for Nuclear Research, Eötvös Loránd Research Network, Debrecen, Hungary
Aquatic Ecology, Faculty of Biology, University Duisburg-Essen, Essen, Germany
Aquatic Ecology and Water Quality Management Group, Wageningen University and Research, The Netherlands

szabo.sandor@nye.hu

Sustaining stable states between submerged and free-floating vegetation

Oral presentation

Both submerged and floating vegetation can sustain their stable dominance in ditches, lentic water bodies and channels. By analysing the vegetation cover of European water bodies, as well as in aquarium experiments, our goal was to reveal the background mechanisms and environmental thresholds for maintaining stable states between the two vegetation types. Analyses of vegetation cover and chemical components of the water showed that both rooted (*Elodea nuttallii, Myriophyllum spicatum*) and rootless (*Ceratophyllum demersum*) submerged vegetation were dominant in water bodies with free-floating plants (*Lemna gibba, L. minor, Spirodela polyrhiza*) in which the total nitrogen concentration of the water was below 3 mg L^{-1}. On the other hand, the dominance of floating vegetation appeared more and more frequently above a nitrogen concentration of 5 mg L^{-1}. The cover of submerged plants was negatively correlated with the total nitrogen and total phosphorus concentrations, while the floating vegetation showed a positive correlation. Between the two vegetation types, the dominance of floating plants showed a negative correlation with submerged plants. The species of the two plant groups were grown together in aquarium experiments in static and semi-flowing nutrient solutions where the changes in the chemical components of the water were monitored. At low nitrogen concentrations (0.5–2 mg L^{-1}), submerged plants (*E. nuttallii, C. demersum*) strongly reduced or even completely stopped the growth of free-floating plants. Here the nutrient concentration not only decreased in the water, but also in the plant tissue. At high nitrogen concentrations (5–10 mg L^{-1}), however, floating plants gradually covered the water surface and became dominated over the submerged macrophytes. The anoxia created by shading eventually led to the complete death of the submerged plants. The field and laboratory results confirm the theory that, within a certain nutrient concentration range, submerged plants strongly inhibit the floating plant dominance. In this way, they are able to sustain the dominance of submerged plants in lentic shallow small waters and slow-flowing channels.

Fan Liu, Ling Xian, Muthui Samuel, Ochieng Wyckliffe, Wei Li

Core Botanical Gardens/Wuhan Botanical Garden, Chinese Academy of Sciences
Sino-Africa Joint Research Centre, Chinese Academy of Sciences

fanliu@wbgcas.cn

Enzymes related to carbon metabolism in the leaves of submerged macrophytes play a crucial role in ammonium detoxification

Oral presentation

Submerged macrophytes prefer ammonium over nitrate since the former requires less energy to assimilate. Though an important resource, increased loading of ammonium in water bodies has led to the degradation of water quality and lowered the ecological integrity of aquatic systems. Moreover, high ammonia concentration in water is toxic to submerged macrophytes since it generates physiological stress and inhibits fundamental growth processes. Thus, proper comprehension of the ammonium detoxification mechanisms in submerged macrophytes is vital in understanding basic response and colonization techniques as well as management of different species. Here, we subjected three common submerged macrophytes (*Potamogeton lucens, Potamogeton maackianus* and *Myriophyllum spicatum*) to extreme ammonia concentrations up to 50 mg/L for a period of 4 days. The activities of the carboxylation enzymes PEPC and PPDK increased almost one-fold for both *P. maackianus* and *M. spicatum*, compared with the control. While these enzymes are well known for their central role in CO_2 fixation, their implication in conferring resistance to NH^{4+} stress in submerged macrophytes has not been well defined before. In this study, we demonstrate that the overproduction of PEPC and PPDK led to improved photosynthesis, better NH^{4+} assimilation and overall NH^{4+} detoxification in the leaves of *P. maackianus* and *M. spicatum*. These findings propose a complementary primary ammonium detoxification pathway that targets carbon metabolism.

Ling Xian, Fan Liu, Wei Li

Wuhan Botanical Garden, Chinese Academy of Sciences

xianling@wbgcas.cn

Exploring ammonium utilization strategy of submerged macrophytes using whole plants Oral presentation

As a paradoxical nutrient in water ecosystems, ammonium can promote plant growth but excess of it causes phytotoxic effects. Nevertheless, the strategies of ammonium utilization at the whole plant level of submerged macrophytes are unclear and the mechanisms of ammonium detoxification in tolerant species have not been clearly elucidated in previous studies. In the present research, we explored six common submerged macrophytes and selected the most tolerant and sensitive species, then combined the methods of isotopic labeling and enzyme estimation to investigate strategies of ammonium utilization and detoxification mechanisms. The results showed that the above-ground part was not only the main part for ammonium uptake, but also the major pool of exogenous ammonium. Besides, the activity of glutamate dehydrogenase (GDH) in the leaves of the tolerant species, *Myriophyllum spicatum*, performed a dose-response curve while glutamine synthetase (GS) activity changed just slightly. However, the activity of GDH recorded no major changes, while GS increased slightly (17% compared to the control) in the sensitive species, *Potamogeton lucens*. This study reveals the important role of the above-ground part of submerged macrophytes in ammonium utilization, providing new insights into the studies of nutrient utilization by plants and theoretical support for water restoration by phytoremediation.

Sabine Hilt, Klaus van de Weyer, Sebastian Meis, Jens Päzolt, Thomas Gonsiorczyk, Mark Gessner, Michael Hupfer

Department of Community and Ecosystem Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
lanaplan, Nettetal, Germany
UmweltSoft, Caputh, Germany
Department of Plankton and Microbial Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Stechlin, Germany, and Department of Ecology, Berlin Institute of Technology (TU Berlin), Berlin, Germany
Department of Ecohydrology and Biogeochemistry, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

sabine.hilt@igb-berlin.de

Feedback between changes in submerged macrophytes and phosphorus concentrations propel rapid eutrophication of a mesotrophic lake - Oral presentation

Submerged macrophytes are an integral part of many lakes, where they fulfill numerous ecological functions and provide a variety of ecosystem services. In nutrient-poor hardwater lakes of temperate climates, macrophyte communities are typically dominated by charophytes. However, this type of vegetation has strongly declined over the last century. The observed trend has been ascribed to lake eutrophication processes. As a result, today most charophytes species are threatened and oligo-mesotrophic hardwater lakes with charophyte vegetation are protected by the EU Habitats Directive. Although nutrient loading to inland waters has been greatly reduced in recent decades in many countries, the decline of charophyte vegetation continued in many lakes. However, the underlying mechanisms and consequences of this decline are not well understood. Here we present data from a deep clearwater lake in northeastern Germany that suggest potential feedback between the rapid replacement of dense charophyte meadows by non-rooted vascular plants and a drastic increase in lake water total phosphorus (TP) concentrations. The TP concentration in the surface water (0-20 m) of the lake in May after spring overturn rose about fourfold from 13 to 61 µg P L^{-1} between 2008 and 2020, while no such trend was seen in autumn. Secchi disk transparencies dropped and mapping of macrophytes by experienced divers along 13 transects in 2008, 2014, 2016, 2020 and 2022 revealed a decrease in the maximum colonization depth of macrophytes from 13.5 to 9.5 m. Furthermore, a shift in dominance from wintergreen meadows of the charophyte *Nitellopsis obtusa* to only

summergreen *Ceratophyllum demersum* was observed. Part of the additional P availability in spring may thus have originated from lost charophyte stands that used to immobilize P in their biomass and encrustations, even during winter, and also trapped particles and prevented sediment resuspension. Differences in TP concentrations in the surface water between May and October, when the lake is stratified, were significantly correlated to the total coverage of *C. demersum* in the transects potentially indicating P removal from the surface water during summer. While the tissue P content of this macrophyte species is two- to fourfold higher than that of *N. obtusa, C. demersum* also differs from the wintergreen charophyte in that it dies off in autumn and thus releases P back into the lake water. These processes could have triggered a negative feedback loop propelling the dramatic eutrophication of the formerly oligotrophic lake over the past decade.

Antonella Petruzzella, Samuel Motitsoe, Martin Hill, Lulutho Mancunga, Sive Kolisi, Sonwabise Maneli, Hlumelo Mantshi, Zizile Mlungu, Esethu Nkibi, Julie Coetzee

Centre for Biological Control (CBC), Rhodes University, South Africa

antonellabio@gmail.com

Achieving the goal "more natives, less invasives": Priority effects as a potential tool for restoration - Oral presentation

Controlling aquatic invasive plant species is often seen as beneficial to native biodiversity recovery, however, native plant communities do not always re-establish following control. Active restoration of native plant communities is recognized as a strategy to limit invasions, although restoration attempts have shown moderate success. These unsatisfying results are often due to a failure in accounting for priority effects i.e., the effect of species on the survival and performance of other species depending on the order of arrival at a site. 'Being first' does not guarantee success and factors such as overlapping niches, species composition and diversity and environmental conditions may affect the strength of priority effects. However, priority effects have only recently been considered for restoration practices and remain little explored, especially in freshwater systems. Using a whole-pond manipulation set up (5 x 40 000 L ponds), we evaluated the importance of priority effects of native plant species, and the factors affecting their strength and direction, in order to enhance ecological resistance of invaded freshwater ecosystems. This experiment was designed to mimic a situation of a highly invasive floating plant invaded system at first, followed by successful invasive plant control. After control, native submerged vegetation was actively re-established, and a new invader (submerged plant) was introduced to the system. We evaluated whether differences in community assembly influence the success of subsequent invasion, and if so, assessed whether invasion success is related to variations in native plant biomass production and/or community composition and diversity. This project will advance our understanding of how we can guide restoration efforts to maximize the establishment of desired plant species by strengthening native species priority effects to curb future plant invasions.

Lucas Van der Cruysse, Andrée De Cock, Koen Lock, Pieter Boets, Peter Goethals

Ghent University
Provincial Centre of Environmental Research, Eastern-Flanders

lucas.vandercruysse@ugent.be

Investigating the (Re)introduction of Submerged Macrophytes in River Systems in Flanders (Belgium) - Oral presentation

The implementation of the European Water Framework Directive (WDF) in 2000 has significantly improved water quality in Western Europe. However, the availability of well-developed habitats, like habitat 3260, remains limited within Flanders' river systems. This limitation can be attributed to the decrease, fragmentation, and degradation of these habitats. Consequently, the submerged macrophyte species associated with these valuable habitats often remain rare or geographically sparse in Flanders. To address the lack of submerged macrophytes, this research aims to identify the underlying factors influencing the presence and absence of these species. Based on an extensive dataset, provided by the Flemish Environmental Agency (VMM), our preliminary results indicate that physicochemical conditions alone do not serve as primary drivers of species occurrence. Consequently, additional analyses incorporating hydrogeomorphology, stream bed quality, stream velocity, water pollution and other relevant variables will enhance our understanding on the occurrence of submerged macrophytes in Flanders. Based on the obtained results regarding the determinants of species occurrence, monitored reintroductions in the Flemish Ardennes of native submerged macrophytes, cultivated under controlled conditions, are planned. Through these reintroductions, this project seeks to achieve several objectives. Firstly, we aim to improve water quality by restoring populations of submerged macrophytes that play a crucial role in nutrient cycling and water purification processes. Secondly, the reintroduction efforts aim to enhance river biodiversity by recreating suitable habitats for associated macrophytes and the species that depend on them. Additionally, the presence of submerged macrophytes can influence water velocity and flow. Consequently, this research will investigate the potential of submerged macrophytes in mitigating droughts by reducing water velocities and increasing water retention. In conclusion, this research project combines extensive data analysis, field studies, and reintroduction efforts to restore populations of submerged macrophytes in East-Flanders' River systems. By doing so, we anticipate positive ecological outcomes, including improved water quality, increased biodiversity, and potentially a reduction in sediment transport.

Anne Lewerentz

Karlsruhe Institute of Technology
University of Würzburg

anne.lewerentz@kit.edu

Macrophyte diversity in a changing world: lessons from deep lakes in Bavaria - Oral presentation

Bavaria's lakes are undergoing a transformation: on the one hand, water quality is improving due to the implementation of political decisions; on the other hand, they are facing a changing climate. These environmental changes influence the growth and survival of submerged macrophytes. Therefore, we ask: 1) What are the current distribution patterns of submerged macrophytes in Bavarian lakes? 2) What are the underlying causes? 3) Will future climate and land-use changes result in the decline or recovery of macrophyte species richness? We used monitoring data from EU-WFD surveys to investigate the current distribution of submerged macrophytes in large, deep Bavarian lakes. Generalised additive mixed-effect models were applied to identify the drivers of species diversity. Additionally, an eco-physiological growth model for submerged macrophytes was used. Simulations were performed for oligotrophic, mesotrophic, and eutrophic species groups. The ability of the model to predict current conditions was assessed by comparing modeled potential species richness with observed species richness. Simulations were then carried out to assess possible changes in species richness and characteristics in response to environmental change. An analysis of 41 lakes identified 71 submerged macrophyte species. Lake size and phosphorus content emerged as the main drivers of species diversity. The study revealed a hump-shaped distribution of species diversity along the depth gradient, with the amplitude primarily determined by lake size, whereas the skewness depended on physico-chemical factors such as turbidity and stratification depth. The eco-physiological model successfully replicated the observed patterns of potential species richness with depth, with discrepancies attributed to within-lake environmental heterogeneity and unaccounted processes. Under simulated environmental changes, species richness increased with temperature across lake types, species groups, and depths. The effects of turbidity and nutrient changes varied depending on the lake type and depth. In a scenario of increased turbidity and nutrient conditions, species with high consumption and sensitivity to disturbance declined, while species with high biomass production recovered. These results highlight the importance of eco-physiology for understanding the complex dynamics of submerged macrophyte distribution patterns, decline, and recovery. Furthermore, differential responses to environmental changes highlight the importance of considering lake type in management strategies, as drivers of change may have contrasting effects depending on lake depth and characteristics.

Yexin Yu, Yehao Li, Chi Xu, Haijun Wang, Annette Jansen, Haojie Su, Qingyang Rao, David Hamilton, Erik Jeppesen, Ping Xie

The Yunnan Provincial Department of Science and Technology (202001BB050078; 202103AC100001)
The Youth Innovation Association of the Chinese Academy of Sciences as an excellent member (Y201859)
The TÜBITAK program BIDEB 2232 (project 118C250)
The National Natural Science Foundation of China (No. 32061143014)

yyxshuichanyangzhi@163.com

Integrating depth and nutrient to illustrate regime shifts of deep lakes

Oral presentation

The regime shifts between a macrophyte-dominated state and phytoplankton-dominated one have been profoundly studied for shallow lakes, whereas the question whether such processes take place in deep lakes remains unclear. In this study, to answer the questions of how to illustrate the changes in ecosystem states with eutrophication for deep lakes, 9 lakes with varying water depths and nutrient levels in the Yunnan Plateau, southwest of China, were investigated. Our results showed that: 1) Relative biomass of macrophyte over phytoplankton is the best indicator of ecosystem states, compared with submersed macrophyte biomass, phytoplankton chlorophyll a, transparency, and turbidity; 2) A multiplication of nitrogen or phosphorus concentrations (TN, TP) with water depth (Z) provides the best explanation on changes in ecosystem states for deep lakes compared to the single variables of nutrient concentration; 3) The thresholds of TN*Z was 10.9 mg/L m for the macrophyte-to-phytoplankton shift and 2.0 mg/L m for phytoplankton-macrophyte one; the corresponding thresholds were 0.61 and 0.05 mg/L m for TP*Z These findings demonstrate that, in management of deep lakes, relative dominance of macrophytes over phytoplankton and the role of water depth should be taken into account when assessing the ecosystem states and the shifts between states.

Lei Li, Lars-Anders Hansson, Jan Köhler, Sabine Hilt

Leibniz Institute of Freshwater Ecology and Inland Fisheries

269330545@qq.com

Within-lake resource gradients modify periphyton shading effects on macrophytes – Oral presentation

Periphyton shading is of key relevance for submerged macrophyte abundance in lakes. However, while the consequences of within-lake resource gradients have been widely assessed for phytoplankton biomass, similar studies for periphyton are largely lacking despite their relevance for macrophytes and consequently the ecological state and functioning of lakes. We tested the effects of spatial and temporal variability in resource availability on periphyton biomass and chlorophyll-a in a eutrophic, polymictic, temperate lake with a maximum colonization depth of submerged macrophytes between 2-4 m. Both light and nutrient availability in lake water are monitored at 5 min and one-week intervals, respectively, and are known to vary in space (light along a depth gradient) and time (light, nutrients). The extent of decreasing light availability with water depth depended on phytoplankton abundance and phosphorus (P)- or nitrogen (N)-limiting conditions occurring in spring and summer, respectively. We hypothesized that nutrient and light availability explain differences in periphyton biomass in time and space, respectively. However, potential interference by temporal differences in the abundance of periphyton grazers were expected. To test these hypotheses, we harvested periphyton from plastic strips and filters attached to nutrient-diffusing agar (controls without nutrients, P addition in spring and summer, N addition in summer) exposed in 1, 2, 3, 4 and 5 m lake water depth for four weeks in April, May and August 2023. In spring, light availability and periphyton biomass were significantly correlated. In April, P addition significantly increased periphyton biomass in all water depths while this effect was not found in May, when grazer numbers were higher. We will discuss the implications of temporal and spatial variation in periphyton for macrophyte species and depth distribution as well as restoration efforts.

Sabiha Akter, Jonas Asselberghs, Sammy Kibor, Gudrun de Boeck, Jonas Schoelynck

University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium

sabiha.akter@uantwerpen.be

Interactive effects of nitrate and heatwaves on submerged and floating plants of a freshwater ecosystem – Oral presentation

Eutrophication due to anthropogenic pollution such as nitrogen and phosphorus is already a worldwide environmental concern. Adding to this problem, climate change causes more intensive and frequent heatwaves, which have also a tremendous impact on the ecosystem. Individual effects of temperature, and high nitrate concentrations have been studied on aquatic plants, but less is known about their interactive effects. This study used a 3x3x2 factorial design where submerged (*Myriophyllum spicatum*) and floating (*Potamogeton natans*) plants was exposed to combinations of ecologically relevant nitrate concentrations (0, 50, or 200 mg/L) and different heatwave scenarios (no, short, or long). Throughout the 45-day experiment, the interactive effects of nitrate, temperature, on growth, and the nutrients contained, were evaluated. Both plants' shoots and roots had increased with the nitrate and increasing temperature. In the beginning, we observed a positive synergistic effect of nitrate and heat wave on the relative growth rate of both plants. Though with time nitrate showed a negative effect on the relative growth of submerged plants. With high nitrate and long heatwaves, the N:P and C:P ratio of both plants increased significantly which indicates a limitation of phosphorus in the plants. This phosphorus-limitation may be changing the palatability of the plants and affect the overall ecological balance.

Deborah Hofstra, Ben Woodward,
Mary de Winton, Denise Rendle

National Institute of Water and Atmospheric Research

Deborah.Hofstra@niwa.co.nz

Accelerating the re-establishment of macrophytes – Oral presentation

Many shallow lakes are degraded to the point where they are permanently turbid and aquatic plants no longer have sufficient light to grow. Without the plants, wave action resuspends lakebed sediments, and sets up a feedback loop trapping the lake in the degraded state. Multiple restoration actions are required to reverse this process, including catchment management and in-lake actions to remove barriers to reestablishing native vegetation. If plants have been lost from a lake for a long time, one significant barrier to restoration is the loss or degradation of native seed banks that can prevent plant re-establishment. Interventions to improve recolonisation and introduce suitable plant propagules are then needed. This presentation describes experimental studies using two approaches to overcome the loss of seed banks and accelerate the re-establishment of desirable native macrophytes. As well as a novel method to assess the robustness of different macrophyte species to cope with degraded sediments, to provide guidance on which species could be used when and where, to maximize ecosystem stability in restoration. The re-vegetation methods considered non-wadeable or wadeable scenarios. Using mesocosms, the two approaches were plant-sediment packages ('bombs') for non-wadeable systems or plant-mats (locally referred to as rototurf) for wadeable systems with better shoreline access. Three New Zealand native species, one milfoil, one pondweed and one charophyte, were investigated. The pondweed and milfoil had an 80% establishment rate from plant bombs compared with charophytes that had only 50%. When introduced with plant mats, results for plant species varied depending on the matting product used. The project also assessed the robustness of the three macrophytes species to sediments from a highly degraded lake by examining their root oxygen release rates. We hypothesize that species with higher root oxygen release rates may establish favorable conditions, as first colonizers, allowing for other species to follow.

Riccardo Pieraccini, Lawrence Whatley, Nico Koedam, Tom Van der Stocken, Ann Vanreusel

Marine Biology research group, Ghent University
Ecology and Biodiversity Group, Vrije Universiteit Brussel
Ocean Data Management, Vlaams Instituut voor de Zee

riccardo.pieraccini@ugent.be

Seagrass restoration, every seed counts: increasing restoration success by improved germination – Oral presentation

Coastal aquatic plants such as seagrasses play an important role in maintaining biodiversity and ecosystem functions in the marine environment. Seagrass meadows provide a wide range of ecosystem services: contributing to reduce climate change by carbon sequestration; water filtration by reducing nutrients and pollutants in the water; erosion protection by promoting sedimentation and stabilization; and biodiversity support by providing shelter and nursery habitat to marine organisms. *Zostera marina* is the most wide-ranging seagrass species in the northern hemisphere and is widespread along the European coastline. Unfortunately, seagrasses have drastically declined worldwide, with *Z. marina* being one of the most impacted species. Causes of decline are related to poor water quality, coastal development, mooring, dredging, and pathogens. Restoration of *Z. marina* has been focusing on seed-based methods, as they represent a cost-effective technique that facilitates upscaling while conserving genetic diversity. However, low germination rates and low seedling establishment pose major challenges to the success of restoration actions, with an overall success rate that ranges between 5% and 25% of the total amount of broadcasted seeds. Therefore, understanding the physiological processes governing germination is necessary to substantially raise restoration success rates. Seed germination is a critical step in the life cycle of flowering plants to ensure successful plant establishment. However, seed manipulation, during collection and processing can negatively influence seed viability and increase levels of dormancy. Dormancy is a physiological stage that allows seed maturation and prevents germination under unfavorable conditions. Germination is regulated by both environmental and endogenous factors. Temperature,

salinity, and light are key triggers of germination. Additionally, light quality and photoperiodism influence seed development and dormancy through endogenous regulation of hormones such as gibberellins (GAs) and abscisic acid (ABA). In this study, *Z. marina* seeds were exposed to different priming agents: three light spectra, two photoperiods, and five levels of GAs; and their effects on the germination rate and time and on seedling development were assessed. Exogenous application of GAs significantly improved germination success (40.6%) and mean germination time (1.6 days) compared to untreated seeds (respectively 26.7% and 9.3 days). Synergistic effects of the light spectrum and GAs concentrations were also observed to significantly increase germination success. Our findings aim to improve the restoration practices of aquatic marine vegetation to ensure their success and the effective use of seed stocks.

Michał Rybak, Jakub Szymkowiak, Magdalena Woźniak, Tomasz Joniak, Piotr Klimaszyk, Łukasz Wejnerowski, Izabela Ratajczak, Mandy Velthuis

Department of Water Protection, Faculty of Biology, Adam Mickiewicz University, Poznań, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland
Forest Biology Center, Faculty of Biology, Adam Mickiewicz University, Poznań, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland
Department of Chemistry, Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, Wojska Polskiego 75, 60-625 Poznań, Poland
Department of Hydrobiology, Faculty of Biology, Adam Mickiewicz University, Poznań, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland
Department of Aquatic Ecology and Environmental Biology, Radboud Institute for Biological and Environmental Sciences, Radboud University, P.O. Box 9010, Nijmegen, 6500 GL, Netherlands

m.rybak@amu.edu.pl

Multi-element stoichiometry transformation and homeostasis disturbances among *Myriophyllum spicatum* organs in response to accelerated eutrophication

Oral presentation

Despite ongoing efforts to reduce anthropogenic nutrient inputs, aquatic ecosystem eutrophication remains one of the biggest civilizational problems. This process exerts intense pressure on biogeochemical cycles, the functioning of aquatic food webs, and threats to the sustainable functioning of lake ecosystems. Stoichiometric homeostasis, a theory of ecological stoichiometry, refers to the degree to which organisms maintain a stable elemental content in their tissues and reflects the response of physiological and biochemical allocations within the organisms to the external environment. However, the degree to which submerged macrophytes maintain and allocate elements between organs in various nutrient levels is still unclear. In this study, we explored the stoichiometric characteristics in the leaves, shoots, and roots of *Myriophyllum spicatum* in relation to water and sediment chemical features from different lakes and, consequently, nutrient levels. The classical carbon – nitrogen – phosphorus (C:N:P) approach was extended to other microelements, such as iron (Fe), zinc (Zn) and copper (Cu). All data were analyzed collectively in a GLMM model, as the effect of water and sediment in the aquatic environment could not be separated. The results

showed that *M. spicatum* is able to maintain stoichiometric homeostasis in terms of N, Cu, Zn and Fe in the range of natural nutrient concentrations. Stoichiometric flexibility was observed for C and P content in leaves, as they negatively correlated with sediment C and P availability. Considering the homeostasis in the particular plant parts, we found that the leaves are the most affected by environmental influences, and roots are responsible for the accumulation of metals. Our results indicate that aquatic plants, in contrast to terrestrial plants, may exhibit signs of strict homeostasis for some (but not all) elements, at least in natural lake conditions.

Laura Grinberga

University of Latvia, Institute of Biology, Jelgavas str.1, Riga, Latvia

laura.grinberga@lu.lv

Parnassus-leaved Water-plantain (*Caldesia parnassifolia*) – a new species in the flora of Latvia - Poster presentation

The Parnassus-leaved Water-plantain *Caldesia parnassifolia* is a rare and protected species in Europe. This species is listed on Annex II of the Habitats Directive and under Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). The native range of the species is Europe, Africa, and the Russian Far East to Tropical Asia. *C. parnassifolia* was first recorded in Latvia in 2021 in Lake Lielais Kumpiniķu, reaching the northern border of its range. The northern part of the lake corresponds to habitat 3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. *C. parnassifolia* has been found at 26 sites, mostly in the territory of Latvia but also in Lithuania. The estimated area of the species is approximately 140 m^2. Growing in water at a depth between 0.5 and 1.6 m, in such conditions only the floating-leaved form of the species was present. In Lake Kumpiniķu, *C. parnassifolia* forms small stands along the edges of emergent macrophytes (*Phragmites australis, Scirpus lacustris*), growing between floating-leaved species (*Nuphar lutea, Potamogeton natans*). In 2015, new localities of *C. parnassifolia* were found in Poland and Lithuania. In Poland, the new find is located in the SE part of the country, in a eutrophic lake that is actively used for fishing. In Lithuania, the last found location is more than 100 km north of the previously known localities in the country. This species is declining in Europe and is threatened by habitat loss and pollution; East African localities seem to have suffered the same fate. There is no information available on global population trends, however, this species covers a wide geographic range. It is therefore listed as Least Concern. Further research is needed to determine global population trends and threats.

An Leyssen

INBO, Belgium

an.leyssen@inbo.be

The realized niche of floating water-plantain (*Luronium natans*) in Flanders (northern Belgium) - Poster presentation

Freshwater ecosystems are under worldwide pressure. In Europe, the Habitats Directive attempts to protect and restore the most endangered habitats and species. An exemplary target species is *Luronium natans*, a semi-aquatic plant endemic to Europe, occurring mainly in nutrient-poor stagnant soft water but also in more alkaline lowland streams, rivers, and canals. Understanding the habitat requirements of this apparently tolerant, yet often Red Listed species is necessary to support its management and sustainable conservation. Flanders, located in the center of the distribution range of *L. natans*, still harbours a considerable number of populations. We examine sediment, water chemistry, vegetation, and other site characteristics throughout this region in relation to the criteria used to assess its conservation status in order to determine conditions critical to its favourable conservation.

Giulia Lodi, Julia Cooke, Rebecca A. Pickering, Lucie Cassarino, Mike Murray-Hudson, Keotshephile Mosimane, and Daniel J. Conley

Department of Geology, Lund University, Lund, Sweden
School of Environment, Earth and Ecosystem Sciences, The Open University, Milton Keynes, UK
Okavango Research Institute, University of Botswana, Maun, Botswana
University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium
Université de Bretagne Occidental, Institut Universitaire Européen de la Mer, LEMAR laboratory, Plouzané, France

Giulia.Lodi@untwerpen.be

Silicon isotopes in juvenile and mature *Cyperus papyrus* from the Okavango Delta, Botswana - Poster presentation

The three most abundant stable isotopes of Silicon, ^{28}Si, ^{29}Si, and ^{30}Si, all occur in plants. Most plants, across the spectrum of low to high Si-accumulating, preferentially uptake light Si isotopes from the surrounding environment. The successive precipitation of light isotopes into phytoliths has been used to explain Si isotope fractionation in shoots. The result is an enrichment of heavy isotopes that are then transported along the transpiration stream. Isotope studies are a potential tool to explore uptake and function of plant Si, and it is a developing field. In fact, there is a lack of studies from natural environments, and species from the African continent, and all plant parts including reproductive structures. In this study, naturally grown papyrus plants were sampled from the Okavango Delta and divided into five organs, namely umbel, culm, scales, rhizome, and roots. The samples were analysed for TN, TOC, SiO_2 and PO_4 content (wt%), and for Si isotopes. Each organ of papyrus is represented by two samples, one from juvenile tissue and one mature (apart from the roots where age is difficult to determine). The study confirms that papyrus is a high Si-accumulating species, with concentrations ranging from 0.86 in rhizomes to 6.61 in roots. High BSi precipitation in the roots leads to an enrichment in heavy Si isotopes in the residual mobile Si pool, as light Si isotopes precipitate in phytoliths in the roots. In rice, shoot organs gradually become enriched in heavy Si isotopes along the transpiration stream. The same pattern was observed in papyrus, with an increase in heavy isotopes from rhizomes to scales, stem, and umbel.

Steven Jacobs, Dimitri Van Pelt, Ignacy Kardel, Martijn Van Roie, Patrick Meire, Jonas Schoelynck

University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium
Department of Hydraulic Engineering, Faculty of Civil and Environmental Engineering, Warsaw University of Life Sciences, ul. Nowoursynowska 159, 02-776 Warsaw, Poland

steven.jacobs2@uanwerpen.be

Confirmation of species identification and new locations of *Potamogeton nodosus* Poir. in Biebrza National Park region

Demonstration

In 2013, plants of –presumably– *Potamogeton nodosus* Poir. had been found within the Biebrza River (NE Poland). However, detailed morphological (including microscopic) examination to discriminate between *P. nodosus* and *P. fluitans* complex was never performed, although this is necessary since severe overlap exists between macromorphological characteristics. In this work we confirm the presence of this species by collecting new specimens and using microscopical characteristics. Furthermore, we provide new locations of the species in the Biebrza National Park and discuss that the spread of these plants could be linked to increasing river water temperature levels. Since similar trends are observed elsewhere in Northern Europe, it can be expected that *Potamogeton nodosus* will continue to expand its range within the Biebrza River basin over time.

Friends or foes: Wanted and unwanted effects of herbicides on aquatic plants facing multiple stressors

Session 6

Chair: Elisabeth Gross (Université de Lorraine, France),
Gertie Arts (Wageningen University and Research & Wageningen Environmental Research, The Netherlands),
Ryan Thum (Montana State University, USA).

Herbicides may affect aquatic plant performance unintentionally or through targeted action. Their use in aquatic systems underlies dissimilar regulation in different parts of the world. In Europe, the Water Framework and Pesticide Directive provides guidelines to limit the impact of herbicides and other anthropogenic pollutants on water bodies. In the US, the Environmental Protection Agency (EPA) and relevant state authorities regulate herbicide use, but application in water bodies can be allowed as a decisive tool to control invasive alien aquatic plants. For the admission of herbicides on the market, a dossier needs to be submitted based on – mostly – short-term experiments with standard primary producer species (algae and aquatic macrophytes). What is missing in our understanding of effects of herbicides on aquatic plants, are long-term effects, e.g. carry-over effects to the next season or effects on the recovery and competitive ability of aquatic macrophytes. In addition, aquatic plants are not only threatened by herbicides but by multiple other stressors acting on them, such as climate warming, heatwaves, eutrophication, browning or salinization. A better understanding of single and multiple stressor effects on aquatic plants is key in order to understand effects at the ecosystem level. This session intends to bring together the different views and to provide a platform to outline known targeted and side effects of herbicide use in freshwater systems and to place them in a scenario of multiple simultaneous stressors acting on them. Key session objectives are:

- To bridge ecotoxicology and aquatic plant ecology
- To assess the role of herbicides and other anthropogenic pollutants in aquatic plant decline

Gertie Arts, Silvia Mohr, Antony Mishal, Ulrike Schulz, Ronnie Schmiediche, Valesca Contardo

Wageningen University and Research, Wageningen, The Netherlands
German Environment Agency, Berlin, Germany

Gertie.Arts@wur.nl

Effects of the fungicide tebuconazole on macrophytes in a mesocosm study

Oral presentation

A higher-tier study was performed in stream-pond mesocosms at the artificial stream and pond facility of the German Environment Agency in Berlin to study the effects of a fungicide with a Mode of Action as a growth regulator on aquatic macrophytes. For a long time it was already known that dicot macrophytes, such as *Myriophyllum spicatum*, can significantly be more sensitive to growth regulators than the standard monocot test species *Lemna* sp. Therefore we hypothesized that dicot species are more sensitive than monocot species for such a compound. To test this hypothesis, we studied the effects of the fungicide tebuconazole on different macrophyte species with different growth forms in bio-assays. The sediment-rooted *Myriophyllum spicatum* endpoints were assessed at 14 and 35 days. The pleustophyte *Lemna trisulca* and the free-floating *Spirodela polyrhiza* endpoints were assessed at 14 days. Besides the bio-assays, standing stock populations of *Nymphoides peltata*, *Potamogeton natans* and *Myriophyllum spicatum* were monitored and endpoints assessed at 35 days. Overall, the dicot species *Myriophyllum spicatum* showed the lowest, trustworthy EC10 and EC50 values based on measured tebuconazole start concentrations, of which total shoot length was the most sensitive endpoint. The dicot *Nymphoides peltata* also showed clear effects in the same concentration range. The monocots *Spirodela polyrhiza* and *Lemna trisulca* were less sensitive than the tested dicot species in this mesocosm study. However, in a first-tier laboratory test *Lemna gibba* is more sensitive compared to *Myriophyllum spicatum* in the mesocosm study. These differences will be discussed as well as consequences for the risk assessment.

Elisabeth Maria Gross, Vinita Vijayaraj, Joey Allen, Martin Laviale

Université de Lorraine, CNRS, LIEC, F-57000 Metz, France
Laboratoire Environnement et Ressources de Bretagne Nord de l'Unité Littoral du Département Océanographie et Dynamique des Ecosystèmes du Centre de Bretagne à la station de Dinard, Station Ifremer de Dinard – CRESCO
Université de Rennes, CNRS ECOBIO, F-35000 Rennes, France

gross5@univ-lorraine.fr

The chemical fingerprint of *Myriophyllum spicatum*: A harbinger of regime change in shallow lakes exposed to nitrate, pesticide and warming? - Oral presentation

Macrophytes play a central role in the status of shallow lakes. They are exposed to multiple stressors such as nitrate, pesticides and climate warming, which may affect their growth and physiology. Their specific responses to these multiple stressors may provide information about the status of shallow lakes. We conducted a microcosm experiment comprising two trophic levels. The first level included primary producers in competition for nutrients and light: three macrophyte species (*Myriophyllum spicatum*, *Potamogeton perfoliatus*, *Elodea nuttallii*), phytoplankton and periphyton. The second trophic level comprised primary consumers feeding on one or several of the primary producers: Daphnia, mussels, and snails. The microcosms were exposed to a control, only nitrate, only pesticides and nitrate and pesticides combined (mimicking an agricultural runoff [ARO]). All treatments were replicated at an ambient and an elevated temperature. Response factors measured were macrophyte height, photosynthetic pigments, phenolic content and carbon, nitrogen, and phosphorus (CNP) stoichiometry. *Myriophyllum spicatum* was the dominant macrophyte species. All the stressors affected *M. spicatum* height, with pesticides and nitrate having a negative effect, and elevated temperature having a positive effect. Yet, all the stressors affected *M. spicatum* physiology differently. In general, in the presence of nitrate, phenolic content was lower. In the presence of pesticides, an increase in carbon content was observed. The nitrate-only treatment increased the N:P ratio whereas the pesticide-only treatment reduced the carotenoid content of *M. spicatum*. The combined nitrate and pesticides (ARO) caused a decrease only in the specific phenolic compound, anthocyanins, but when ARO and elevated temperature were applied together, the total phenolic content was reduced. These responses could be linked to changes in water chemistry and/or phytoplankton development. The results suggest that specific stressor effects can be detected in the macrophyte physiology of dominant species and that these effects influence the macrophyte defence system or its potential for growth with negative consequences for the ecosystem services provided by this species.

Arie Vonk, Michiel Kraak

Department of Freshwater and Marine Ecology, University of Amsterdam

j.a.vonk@uva.nl

Herbicide exposure and toxicity to aquatic primary producers - Oral presentation

Herbicides are the most used pesticides and are the most frequently detected pesticide group in North American and European surface waters. Herbicides are often phytotoxic to non-target aquatic organisms such as algae and macrophytes, and these adverse effects on primary producers can cascade up the food web where these primary producers provide food and habitat for higher trophic levels. The aim of this presentation is therefore to give an overview of the current state of science concerning herbicide exposure and toxicity to aquatic primary producers and the relative sensitivity of aquatic plant species compared to other primary producers. We assessed the open literature to address the sources and fate of herbicides in the aquatic environment, their bioavailability and subsequent uptake by algae and aquatic plants. Next, the hazard of herbicides to primary producers was assessed, including their modes of action, and the relative toxicity of various aquatic plant species were determined. Finally, retrospective risk assessments were performed to determine whether the presence of herbicides in water and sediment represented an actual risk to aquatic primary producers in freshwater ecosystems.

Our study revealed the widespread presence of (mixtures of) herbicides in aquatic ecosystems, inevitably leading to the exposure of non-target primary producers. Yet, herbicide concentrations show strong temporal and spatial variations. Concerning herbicide toxicity, it was concluded that the most sensitive as well as the least sensitive species differed per herbicide and that the observed effect concentrations for some herbicides were rather independent from the exposure time. More extensive ecotoxicity testing is required, especially considering herbicide toxicity to macrophytes. For the majority of herbicides, there is no actual risk to aquatic primary producers. Nonetheless, median concentrations of atrazine and especially of diuron measured in China, the USA and Europe represented moderate risks for primary producers. Maximum concentrations due to misuse and accidents may even cause the exceedance of almost 60% of the effect concentrations plotted in SSDs. Using bioassays with primary producers to determine the effect of contaminated water and sediment and to identify the herbicides of concern is a promising addition to chemical analysis, especially for the photosynthesis-inhibiting herbicides using photosynthesis as endpoint in the bioassays. We concluded that to come to a reliable herbicide hazard and risk assessment, an extensive catch-up must be made concerning macrophytes and especially sediment as overlooked and understudied environmental compartments.

Gray Turnage, Allison Squires, Ryan Wersal

Mississippi State University
Minnesota State University, Mankato

Gturnage@gri.msstate.edu

Ecology and Management of Cuban bulrush in the United States - Oral presentation

Cuban bulrush (*Oxycaryum cubense*) is an invasive aquatic plant species native to South America that is spreading across the Southeastern U.S. Cuban bulrush is a perennial floating sedge species that can completely cover a waterbody and disrupt ecological and biological processes as well as hamper human uses of water resources. There are two biotypes in the U.S. suggesting multiple introductions have occurred. In the early stages of invasion, Cuban bulrush survives as an epiphytic plant on other floating objects (other plants, logs, etc.) but in later stages the plant traps sediment in its root system and forms a floating island (tussock) that reduces the need for an underlying substrate for survival. Tussocks can be hundreds of hectares in size and portions of them can break away, drift to new locations, and establish new colonies. Cuban bulrush can also spread via seed production. There is limited literature regarding Cuban bulrush management, biology, or ecology. The purpose of this work was to 1) develop an operational control strategy for Cuban bulrush management and 2) assess the life cycle of Cuban bulrush in order to better time management activities to maximize control. Preliminary work in 2017 and 2018 along with literature reviews identified seven herbicides (diquat, flumioxazin, penoxsulam, glyphosate, 2,4-D, triclopyr, and florpyrauxifen-benzyl) as candidates for Cuban bulrush control. In 2021, field trials were implemented in Mississippi and Florida to assess herbicides alone and as tank mixtures for control of Cuban bulrush. Field trials found that synthetic auxins are capable of providing long term Cuban bulrush reduction; however, plant populations in each state had differing responses to some herbicide treatments suggesting that plant biotype and/or timing of herbicide application may be factors that affect long term control. In 2019, a phenology trial implemented in northeast Mississippi utilized accumulated degree-day (ADD) analysis to predict Cuban bulrush life stages and conceptualize a model life cycle for the species based on observed growth. Cuban bulrush growth began in early-summer (May), biomass peaked in late-fall (Nov/Dec), senescence occurred in winter (Jan/Feb), and seed production occurred from mid-summer (July) through late fall (Nov/Dec). Moreover, ADD analysis identified -4C as a minimum air temperature for Cuban bulrush growth suggesting the species can survive further north than its current invaded range in the U.S. Resource managers should incorporate auxinic herbicides into Cuban bulrush management and calculate ADD when planning control activities to determine Cuban bulrush growth stage.

Bastian Polst, Dick Belgers, Nina Jansen, GertieArts

Team Environmental Risk Assessment, Wageningen University & Research

bastian.polst@wur.nl

Reassessing exposure design: exploring overspray in toxicity tests for herbicides with unexpectedly low toxicity to macrophytes - Poster presentation

Herbicides are commonly classified based on their mode of action, which has implications for their toxicity to aquatic macrophytes. While some herbicides, including contact herbicides, exhibit localized toxicity, there are instances where contact herbicides unexpectedly show low toxicity to emergent and floating macrophytes compared to systemic herbicides. This raises concerns about the protectiveness of current exposure designs in toxicity tests. Standard tests for macrophytes typically involve dissolving the herbicide in the test media to ensure even exposure. However, contact herbicides primarily act through direct contact with non-submerged parts of the plants. As a result, the use of overspray exposure, involving spraying or drift, may provide a more appropriate method for assessing the toxicity of contact herbicides specifically to emergent and floating aquatic macrophytes.

Previous research has indicated increased sensitivity differences in overspray or spray drift exposure scenarios for aquatic macrophytes. Specifically, a study with glyphosate, a systemic herbicide, demonstrated significantly higher toxicity to *Lemna minor* when applied as a spray compared to when dissolved in the test medium. This study investigates the potential influence of overspray exposure on the estimation of toxicity for contact herbicides. To accomplish this, we subjected *Lemna minor* to the contact herbicide Bentazone using two distinct exposure scenarios: overspray and exposure via the growth medium. In accordance with the OECD 221 Lemna Growth Inhibition Test, we conducted a dose-response experiment to evaluate differences in biomass and frond area. The findings from our study will be elaborated upon and discussed.

While no standardized protocols for overspray exposure tests with emergent and floating macrophytes exist as yet, it is essential to address the potential underestimation of toxicity caused by contact herbicides. Thus, it is proposed to include an overspray exposure design in toxicity tests with emergent or floating macrophytes, such as *Lemna*, when the relevance of such exposure scenarios can be justified. Our approach can help stimulate the development of appropriate test protocols and provide a more accurate quantification of hazard and risk associated with contact herbicides, aligning with off-field assessments commonly conducted for terrestrial non-target plants.

Session 7

Macrophytes as Nature Based Solutions in urban ecosystems (BiNatUr session)

Chair: Jan Staes (University of Antwerp, Belgium), **Krzysztof Szoszkiewicz** (Poznań University of Life Sciences, Poland), **Krister Karttunen** (Finnish Environment Institute, Finland), **Jonas Schoelynck** (University of Antwerp, Belgium).

Aquatic ecosystems are increasingly being used and created as sinks and sources for water. In urban environments, there is a need to store and infiltrate increasing amounts of water, generated by runoff on degraded and sealed soils. There are risks and opportunities when using or creating Urban Aquatic Ecosystems. Opportunities, when we can design urban water parks that can fulfill this sink/source function while also generating many other ecosystem services, such as habitat for biodiversity, climate regulation, air quality regulation, health effects, etc… A well-designed Aquatic NbS should also be home to macrophytes as they are essential to the aesthetic quality of the site, water purification and biodiversity. How do we need to design and manage such aquatic NbS to maintain these ecosystem services over time? Especially when these systems are exposed to extremes in terms of water level fluctuations (floods and droughts) and associated water quality issues. A smart design and management is needed because there is especially a risk when we are using and exposing existing high biodiversity ecosystems to such extremes. Currently, there is not much knowledge about the role of macrophytes in Urban Aquatic Ecosystems. What can we learn from the species composition and ecological succession over time? Are macrophytes (and other species) sentinels of ecosystem health? What should we do with exotic/invasive species? Should native species be actively introduced? What can we learn from cases where an ecological design has been applied? What are lessons learned?

Silvia Martin Muñoz, Jan Staes, Jonas Schoelynck

University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium

Silvia.MartinMunoz@uantwerpen.be

Aquatic-Nature-based Solutions: designing cities for biodiversity

Oral presentation

In sight of an increasing urban population and risk of climate change-related hazards, cities must integrate in their urban design elements to both reduce their impact (i.e., air and water pollution, degradation of habitats, loss of biodiversity) and increase resilience to climate change. In contrast to hard engineering works (grey infrastructure), which not only fail to adequately address these issues but also exacerbate them, Nature-based Solutions (NBS) are an efficient strategy which can help cities to become more sustainable. Aqua-Nature-based Solutions (aNBS) tackle water-related problems by enhancing water regulation, reducing drought and mitigating flood impacts. Promoting biodiversity through the design of urban ponds would increase the ecosystem service supply of these aNBS. However, currently there is not much knowledge about how these ponds can have the added value of supporting biodiversity. Show cases and reviews would be exposed to reveal the contribution of macrophytes in the ecosystem service delivery and to show how can macrophytes be promoted in urban ponds. The relationship between macrophyte growth and the ecosystem health will be discussed, with special attention on the invasiveness of alien species.

Seppo Hellsten, Lea Hiltunen, Anna-Liisa Välimaa, Minna Kuoppala, Juha Riihimäki, Satu Maaria Karjalainen, Ritva Nilivaara, Anna Väisänen

Finnish environment institute SYKE
Natural resource institute LUKE

seppo.hellsten@syke.fi

Invasion of *Elodea canadensis* in northeastern Finland – nuisance or useful biomass? - Oral presentation

Elodea canadensis was found in the northeastern part of Finland in the beginning millennium. Within 15 years it invaded all large slightly alkaline clear water lakes by the aid of fishermen, boaters and water fowl. *E. canadensis* wet biomass was more 60 tn/ha and harmed significantly recreational use of lakes and lowered diversity of rare macrophyte species. Eradication of *E. canadensis* is relatively expensive and therefore the use of biomass for blue bioeconomy could improve cost efficiency of restoration. Biomass was well suited to be used as a biogas substrate due to its high methane potential. The residue generated during the biogas production as a result of anaerobic digestion contains significant amounts of main and micronutrients, and it is therefore a valuable fertilizer. Biomass and exudates of *E. canadensis* inhibited growth of Streptomyces bacteria causing potato common scab and some plant pathogenic fungi in laboratory conditions indicating that it can be used for biological control of plant diseases. For further studies it is always necessary to determine the chemical composition and the concentrations of trace elements in advance. *E. canadensis* biomass included also high amount of phosphorous and removal of biomass is also suitable for lake restoration purposes.

Jan Köhler, Jörg Lewandowski, Anne Schechner

Leibniz Institute of Freshwater Ecology and Inland Fisheries

jan.koehler@igb-berlin.de

The impounding effect of aquatic vegetation in the lowland river Spree and its management by mowing - Oral presentation

Aquatic plants narrow the cross-sectional area of flow and induce turbulence around stems and leaves which slow down river flow. Therefore, dense plant stands elevate the water level at a given discharge. This impounding effect may increase the risk of flooding. Globally, many streams and ditches are regularly mowed to reduce this impounding effect of aquatic plants, facilitate drainage and avoid inundation. However, these costly and invasive measures are executed without solid knowledge about their effects. We analyzed long-term data on discharge, water level, and macrophyte biomass along a 32 km section of the lowland river Spree (Germany) to test the following hypotheses: (H1) water level rise and macrophyte biomass are linearly correlated; (H2) macrophytes retain water not only in the river channel but also in adjacent groundwater, mitigating floodplain drought; (H3) weed cutting reduces the impounding effect only for few weeks and short river sections. We established and regularly validated the water level – discharge relationship without macrophytes (during winter) for individual sites. We applied these relationships to periods of vegetation growth to calculate the impounding effect of plants and the hydraulic consequences of mowing. We also modeled effects on mean depth, mean velocity of flow and gas exchange.

The impounding effect of macrophytes developed with recolonization of the Spree by macrophytes in the 1990s as a result of re-oligotrophication and reduced discharge. It followed an annual cycle of spring growth, summer maximum and autumnal decline with mowing-induced drops lasting for a few weeks and extending few kilometers upstream of the mowed site. In recent summers, macrophytes caused a water level rise by 80-100 cm at the beginning of the river section. Changes in river water level propagated over several hundred meters of the groundwater layer within a few hours. The impounding effect of macrophytes increased the water volume stored in the river channel and in the groundwater layer, extended the time of flow along the river section by about 50% and reduced the intensity of gas exchange between water and air by about 40%. We discuss the effects of prolonged retention time, slower flow velocity, and higher water level on river metabolism and nutrient budget. We argue that river management should include the benefits of aquatic plants in flood mitigation.

Louis Skovsholt, Fleur Matheson, Tenna Riis, Ian Hawes

University of Waikato, Aotearoa New Zealand
NIWA Hamilton, Aotearoa New Zealand
Aarhus University, Denmark

ljs@bio.au.dk

Riverine plant community changes on a gradient of land use in lowland New Zealand streams - Oral presentation

While plant community structure in streams is expected to change with increased eutrophication, it's less clear how communities respond within specific stream environments and how much anthropogenic influence can be tolerated before drastic ecological changes occur. Open slow flowing streams are an especially vulnerable ecosystem type, as it has few growth-limiting factors. Here, we present results from a field survey of 30 medium sized, open, lowland streams in Aotearoa New Zealand across a human influence gradient. We compiled land cover data to make an aggregate land-use stress score and used modeled data to estimate individual stressor levels. We characterized plant community structure and quantified the nutrient status of the water, the sediment, and the plants. We used an RLQ multivariate approach to investigate correlations between the stressors and the biota and nutrient pools. We found that increased land-use stress correlated with increased biovolume and number of foreign species. Species traits correlated with high land-use stress were Ellenberg N and L, morphology index, number of reproductive organs and presence of a root-rhizome system. Furthermore, two patterns appeared within this overarching trend. First, catchment soils that are porous and rich in calcium and phosphorus, correlated with presence of oxygen weeds. Second, high turbidity and nitrate levels corresponded to high presence of tall emergent species. Native charophytes were almost exclusively present in less impacted streams. Our results thus suggests that while agricultural land use is the primary factor driving community changes, the outcome of the intraspecific competition can vary with different types of stressors, and this could help managers target specific nuisance species or species-groups.

Susanne Schneider, Julie A. Coetzee, Sarah Faye Harpenslager, Bart Immerzeel, Jan Köhler, Benjamin Misteli, Andre Padial, Gabrielle Thiébaut, Kirstine Thiemer, Jan Vermaat

Norwegian Institute for Water Research, **Økernveien** 94, 0579 Oslo, Norway
Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, P.O. Box 5003, 1432 **Ås**, Norway
Centre for Biological Control, Rhodes University, PO Box 94, Grahamstown 610, South Africa
Departamento de Botânica, Universidade Federal do Paraná. PoBox 19031, Curitiba, Paraná, Brazil
Dept. of Community and Ecosystem Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 301, 12587, Berlin, Germany
B-Ware Research Centre, Postbus 6558, 6503 GB, Nijmegen, The Netherlands
Norwegian Institute for Nature Research, Sognsveien 68, 0855 Oslo
Université de Rennes 1, Campus Beaulieu, bat 14A, UMR CNRS 6553 ECOBIO, 263 Avenue du Général, 35042 Rennes, France

susi.schneider@niva.no

Mass development of aquatic macrophytes - causes and consequences of macrophyte removal for ecosystem structure, function, and services - Oral presentation

In the project “Mass development of aquatic macrophytes - causes and consequences of macrophyte removal for ecosystem structure, function, and services (MadMacs)”, we studied six sites in rivers and lakes with mass development of macrophytes. The sites were in Norway, Germany, France, South Africa, and Brazil, and the macrophytes were perceived as problematic by water managers and residents. At each site, we mechanically removed the macrophytes from areas ranging from 550 m^2 to 70,000 m^2, reflecting

current management practices. We quantified the short-term consequences of macrophyte removal on biogeochemistry and biodiversity, comparing each macrophyte removal site with a nearby site in which the macrophytes were left standing. We distributed questionnaires, in which we asked residents and tourists how they perceive the aquatic vegetation. We also quantified ecosystem services and compared the current situation with management regimes where the macrophytes were fully removed, as well as with a "do-nothing" scenario, i.e., where the macrophytes were left standing.

Overall, we learned the following lessons:

- Mass developments of macrophytes often occur in ecosystems which (unintentionally) were turned into a «perfect habitat» for aquatic plants
- Reduced ecosystem disturbance can cause macrophyte mass developments even if nutrient concentrations are low
- Macrophyte removal treats the symptom rather than the cause
- Targeted removal of non-native macrophytes may lead to nuisance growth of other macrophytes
- The effect of macrophyte removal on ecosystem carbon emissions is site-specific
- The consequences of partial macrophyte removal on the biodiversity of other aquatic organism groups are variable but generally small
- Dense stands of macrophytes raise the water level of streams and adjacent groundwater
- Nobody likes macrophyte mass developments, but visitors tend to regard them as less of a nuisance than residents do
- Aquatic plant management often does not affect overall societal value of the ecosystem much

Liesbeth Bakker, Casper van Leeuwen, Hui Jin, Ralph Temmink

Netherlands Institute of Ecology
Radboud University
Utrecht University

l.bakker@nioo.knaw.nl

Top-down and bottom-up effects on the establishment of aquatic plants in ecosystem restoration project Marker Wadden, The Netherlands - Oral presentation

Land-water transitions play an important role in the functioning of both aquatic and terrestrial ecosystems, but are increasingly modified by anthropogenic activities, inducing loss and degradation of littoral habitats. Therefore, restoration of land-water transition zones to lake systems is needed. Here, we studied the ecosystem restoration project Marker Wadden, a newly created archipelago in Lake Markermeer, The Netherlands, which has a surface area of 680 km^2 among the largest shallow lakes in Western Europe. The lake has suffered from ecological degradation, including a decline in number of birds and fish over the last decades and lost most of its natural shorelines by the construction of basalt dikes around the lake. The large-scale ecosystem restoration project-Marker Wadden was initiated in 2016 and aimed to enhance the habitat complexity and heterogeneity by adding sheltered land-water transitions through the construction of a 700-ha archipelago of five islands in Lake Markermeer. We present the results of our 5-year study of the top-down and bottom-up effects on the establishment of submerged and emergent aquatic plants, and the role of the aquatic plants in the restoration of this shallow lake ecosystem.

Ken Schoutens, Maike Heuner, Patrick Meire, Stijn Temmerman

University of Antwerp, Ecosystem Management Research Group, Antwerp, Belgium;
Bundesanstalt für Gewässerkunde, Koblenz, Germany

ken.schoutens@uantwerpen.be

Plant-wave interactions in pioneer tidal marshes - poster presentation

Nature-based mitigation is increasingly proposed as a strategy to cope with global change and related risks for coastal flooding and erosion. Tidal marshes are known to provide shoreline protection by attenuating waves. Since the wave attenuation capacity of tidal marsh vegetation is plant trait dependent, the aim of this study was to quantify how effectively wave attenuation rates are sustained throughout seasons in pioneer tidal marshes in the Elbe estuary (Germany). Changes in hydrodynamics were measured during 17 months along three sea-to-land transects of 50 m length. Simultaneously, changes in biomass of typical brackish marsh pioneer species (*Bolboschoenus maritimus* and *Schoenoplectus tabernaemontani*) were measured monthly.

This study shows that wave and flow attenuation rates positively correlate with seasonal variations in aboveground biomass, that is: in summer, aboveground biomass and associated wave and flow attenuation rates are highest; while aboveground biomass is washed away during the first storms in autumn or winter, resulting in low wave and flow attenuation rates. Contrastingly, maximum incoming wave heights and flow velocities occur during winter, indicating that wave and flow attenuation is most needed then. Using tidal marshes as nature-based adaption for shoreline protection should take into account these seasonal changes.

and confirm the potential of well-developed tidal marshes as a valuable extra natural barrier reducing flood discharges towards the hinterland, following a dike breach. These outcomes promote the consideration to implement tidal marshes as part of the overall flood defense and to rethink dike strengthening in the future.

Atilola Abidemi-Iromini

The Federal University of Technology, Akure, Nigeria

attytej@gmail.com

Anti-microbial Activities of Some Aquatic Macrophytes on *Proteus vulgaris* and *Staphylococcus aureus* - Poster presentation

Aquatic macrophyte were collected from three (Awoya, Ilebirin and Obanla) streams within the environment of The Federal University of Technology, Akure, Nigeria. The abundance and antimicrobial activities of the plants on *Proteus vulgaris* and *Staphylococcus aureus* bacteria flora were determined. A total of six species of macrophytes: *Ludwigia abyssinica*, *Struchium sparganophora*, *Heterotis rotundifolia*, *Pistia stratiotes*, *Sacciolepis africana* and *Pteridium aquilinium* were collected from streams using quadrant sampling method. The frequency of occurrence, abundance and anti-microbial activities of the plant samples were determined on *P. vulgaris* and *S. aureus*. Aqueous extract of the plant samples was tested on the bacteria flora in replicates at two subjection levels: 0.5 ml and 0.75 ml respectively over 24 hours on litmus paper in petri-dishes. The layers of inhibitions of the plant samples seen on the litmus papers indicated *S. africana* anti-microbial activities against *P. vulgaris* and *S. aureus* bacteria flora was highest with mean ranged {(1.5 ± 0.20 and 2.0 ± 0.13) cm} inhibition levels, followed by *P. aquilinium* macrophytes {(1.0 ± 0.04 and 0.8 ± 0.02) cm} inhibition levels respectively. The inhibition zones ranked highest from *S. africana* > *P. aquilinium* > *S. sparganophora* > *L. abyssinica* > *H. rotundifolia* and *P. stratiotes* which had no inhibition zone against the bacterial flora. Hence, there were anti-bacteriological effects of some of the macrophytes on the bacteria flora. And this revealed alternative ecosystem services of aquatic macrophytes for sustainable ecosystem management.

Kati Vierikko, Dagmar Haase, Dörthe Tetzlaff, Krzysztof Szoszkiewicz, Jan Staes, Jonas Schoelynck, Pedro Pinho

Finnish Environment Institute (SYKE)
Humboldt University Berlin, IGB Berlin
Poznań University of Life Sciences (PULS), Poland
University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium
University of Lisbon
kati.vierikko@syke.fi

Bringing nature back – biodiversity-friendly nature-based solutions in cities (BiNatUr 2022-2025) - Poster presentation

The water cycle is expected to be drastically influenced by climate change across Europe, with critical changes to water quantity, water quality, and seasonal distribution. Urban areas will be subject to reduced water quantity and quality, flash flooding, and soil erosion, among other risks. Nature-based solutions (NBS) are expected to enhance climate and water resilience and provide multiple benefits for society. In many European cities, the implementation of NBS in aquatic ecosystems ("aquaNBS") through the restoration or construction of small water bodies has become an important policy goal. While it is assumed that aquaNBS such as wetlands, stormwater ponds and streams provide multiple ES and enhance local biodiversity, our knowledge of the biodiversity of urban aquaNBS and its linkages with ES provision in cities is limited. The project 'Bringing nature back – biodiversity-friendly nature-based solutions in cities (BiNatUr)' analyses the role of biodiversity and its linkages with ES in urban aquaNBSs, and in the planning, building, restoration, and management of aquaNBS, supporting the transformation to climate-smart, biodiversity-friendly, and sustainable cities. We employ a SETS (social, ecological, and technological systems) framework, a holistic approach for the study of complex and strongly interactive systems, to analyze the complex SET interactions of aquaNBS at three spatial scales in five European cities. Our analyses of 60 aquaticNBS in five cities encompass the European climatic gradient from Mediterranean to boreal regions. BiNatUr focuses on four main research questions: (1) How are biodiversity and ES of aquaNBS mediated by social, ecological, and technological factors, (2) How do factors vary among cities and regions? (3) How does biodiversity influence regulating-ES provided by aquaNBS? BiNatUr produces practical guidelines and recommendations on how urban planning can effectively co-design, monitor, and enhance the biodiversity and ES of aquatic NBS.

Krzysztof Szoszkiewicz, Krister Karttunen, Niko Lehti, Pedro Pinho, Ana-Júlia Pereira, Vladimira Dekanová, Dagmar Haase, Thilo Wellmann, Jan Staes, Jonas Schoelynck, Robrecht Debbaut, Silvia Martin Muñoz, Michael T. Monaghan, Maria Warter, Daniel Gebler, Szymon Jusik, Krzysztof Achtenberg, Tomasz Kałuża, Mariusz Sojka, Kati Vierikko

Department of Ecology and Environmental Protection, Poznan University of Life Sciences, Poland
Finnish Environment Institute (SYKE), Latokartanonkaari 11, 00790 Helsinki, Finland
Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de Lisboa, Portugal
Institute of Geography, Humboldt University of Berlin and Helmholtz Centre for Environmental Research – UFZ, Department of Computational Landscape Ecology, Germany
University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium
Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin – Institut für Biologie, Freie Universität Berlin, Germany

Diversification of macrophytes in urban Aquatic Nature-Based Solutions across the European geographical gradient - poster presentation

The BiNatUr project, conducted from 2022 to 2025, aims to take a comprehensive approach in examining the interactions among social, ecological, and technological factors related to aquatic Nature-Based Solutions (aquaNBS) across three different scales in five European cities: Antwerp, Berlin, Helsinki, Lisbon, and Poznań. The selection of sampling sites was carried out by categorizing aquaNBS types (ponds and streams) and considering water availability throughout the year (temporary and permanent). Consequently, each city had a minimum of 12 sites, each surveyed twice – once in its most altered state and once in its natural condition. The BiNatUr macrophyte database comprises a total of 122 surveyed sites.

The analysis encompassed plants rooted in the water, encompassing emergent, submerged, and floating plants. The survey methodology employed 10-meter quadrats, with about half of each section dedicated to the aquatic zone. Species abundance was quantified

using a 9-level cover scale, and macrophytes were identified at the species level. Field surveys were conducted during the summer season in 2023, spanning from July to early September.

A total of 106 aquatic plants were identified during the survey, including 23 submerged and floating-leaved plants, and 83 emerged helophytes. Among these, 43 were dicotyledons, 58 were monocotyledons, and 4 were pteridophyte species. Most of these species are ecologically linked to specific trophic conditions, but only a few of them can be regarded as indicators of extreme degradation. Additionally, 10 taxa could be considered as mesotrophy indicators, while high-quality indicators were entirely absent.

On average, each site hosted a low number of macrophytes, with only 5.01 per site and six taxa (ranging from 0 to 15). Six sites were entirely devoid of aquatic species. The mean number of submerged and floating-leaved species was less than one (only 0.76 taxa), while emerged taxa averaged 4.2 (ranging from 0 to a maximum of 5 and 13, respectively). Significant differences in macrophyte richness were observed between the cities ($p<0.001$). Helsinki displayed the highest average number of taxa (7.20) and the greatest variability (SD=4.20). The mean richness in other cities was as follows: Poznań (5.69, SD=3.69), Lisbon (4.91, SD=2.30), Antwerp (3.88, SD=2.07), and Berlin (3.33, SD=2.28). Although no significant differences were found in macrophyte richness between modified and natural sections, or between brooks and ponds at the project scale, also such variations were detected in some of the project cities.

Macrophyte monitoring (Biomonitoring based on macrophytes/Environmental monitoring based on macrophytes)

Session 8

Chair: Krzysztof Szoszkiewicz (Poznań University of Life Sciences, Poland).

By monitoring the diversity and abundance of macrophytes, we can obtain valuable information about the ecological condition of the water body. Aquatic plants are sensitive to environmental changes, mainly related to nutrient enrichment, sedimentation, and hydrological as well as morphological alterations. In that context, aquatic plants can be used to assess the water quality and the ecological health of aquatic ecosystems. Moreover aquatic plants are efficiently used to detect the level of various stressors in rivers and lakes. We encourage presenters to share their latest research findings, as well as innovative methodologies, techniques, and tools that can advance the field of aquatic plant ecology and biomonitoring. This session will include presentations on:

- Water quality biomonitoring systems using aquatic plants
- EU Water Framework Directive in rivers and lakes – experiences, recent changes
- Plant-based monitoring in aquatic ecosystem management and conservation
- Biotic and abiotic stressors that can be efficiently detected by macrophytes
- Ecotoxicology and aquatic plant toxicity testing
- Novel techniques for aquatic plant-based monitoring
- Ecosystem functioning and services of aquatic plants

Amritha Nair, Fleur Visser, Jonas Schoelynck, Ian Maddock

University of Worcester

University of Antwerp, Department of Biology, ECOSPHERE Research Group, Wilrijk, Belgium

nairamritha18@gmail.com

Mapping stress in submerged aquatic vegetation using multispectral imagery and Structure from Motion (SfM) photogrammetry

Oral presentation

Inland waters such as streams sustain a rich variety of species and are essentially hotspots for biodiversity. Submerged aquatic vegetation, also known as SAV, forms an important part of ecologically healthy river systems. Direct and indirect human influences, such as climate change are putting stress on aquatic plant communities, ranging from the invasion of non-native species and grazing, to changes in the river flow conditions and temperature. There is a need to monitor SAV, because they are in a state of deterioration and their disappearance will greatly impact river ecosystems. Like terrestrial plants, SAV can show visible signs of stress. However, the techniques used to map terrestrial vegetation from its spectral reflectance, are not easily transferable to a submerged environment. The effect of the overlying water column in the form of refraction, attenuation of visible and NIR bands in water, as well as highly moving targets, are key challenges that arise when remotely mapping SAV. This study looks into the possibility of mapping the changes in spectral signatures from SAV and their response to certain stresses. Optical remote sensing techniques are employed to detect the stress from remotely sensed images through multispectral imagery and Structure from Motion photogrammetry. In my proposed presentation, I will be discussing the methods used to detect stress in SAV and share the results obtained so far from the analysis.

Takashi Asaeda, Mizanur Rahman, Fumiko Imamura, Akio Nohara, Masaomi Matsubayashi

Saitama University

asaeda@mail.saitama-u.ac.jp

The application of hydrogen peroxide concentration to elucidate the submerged macrophyte distribution in a lake - Oral presentation

The feasible or infeasible condition for submerged macrophyte growth is hard to understand as many environmental factors contribute to establishing macrophyte distribution with different intensities. Subjected to biotic or abiotic stresses, reactive oxygen species (ROS) is generated in organelles of their cells and deteriorate tissues. Among various kinds of ROS, hydrogen peroxide (H_2O_2) is relatively stable and can be measured accurately. The tissue H_2O_2 concentration may have a high possibility to elucidate the distribution of submerged macrophytes in a lake. Laboratory experiments were conducted for four weeks with *P. anguillans* and *P. pussilus*, dominant species in brackish water lake, Lake Shinji, using different light intensities (PAR) and salinity concentrations, and tissue H_2O_2 and Chlorophyll-*a* (Chl-*a*) concentrations and antioxidant activities were analyzed. The homeostasis was maintained by antioxidant activities to reduce H_2O_2, which increased with increasing H_2O_2 concentration. If H_2O_2 exceeded a threshold value attributed to too intensive stress, the homeostasis collapsed, causing the lethal condition and declining H_2O_2 significantly. Chl-*a* concentration changed, associated with an altering H_2O_2 concentration, following a unique negative relationship between stress intensity and H_2O_2 concentration. In the first two week, a stable level of H_2O_2 was maintained up to about 200µmol/¬m^2/¬s of PAR, followed by an increase as PAR increased, while, after 2 weeks, the H_2O_2 concentration became low even with low PAR, likely it was close to the lethal condition. This indicates the tolerance level decreased in a long period of exposure of the same stress intensity. The H_2O_2 concentration increased with higher salinity with *P. anguillans*, while declined at 15 psu. With *P. pussilus*, on the other hand, H_2O_2 concentration was nearly constant regardless of salinity concentration until 15 psu, while H_2O_2 increased with higher PAR. These results indicate the higher tolerance of *P. pussilus* for salinity, while similar trend with *P. anguillans* for PAR. In the lake, for both species, the biomass was largest around 1.3 m deep, and *P. pussilus* had high biomass in deeper site, although PAR was low and salinity level was high, while biomass of both species was eliminated at shallower than 0.3 m deep, where solar radiation was high. The comparison of laboratory experiment and field observation samples suggested that high PAR rather than salinity affected the colonization of both species and determined the distribution of each species' colony in the lake.

Paolo Villa, Andrea Berton, Rossano Bolpagni, Michele Caccia, Maria Beatrice Castellani, Andrea Coppi, Alice Dalla Vecchia, Francesca Gallivanone, Lorenzo Lastrucci, Erika Piaser

IREA-CNR
IGG-CNR
University of Parma
IBFM-CNR
NBFC
University of Florence
Natural History Museum
Politecnico di Milano

villa.p@irea.cnr.it

Assessing Spectral Metrics to Estimate Aquatic Plant Diversity from Hyperspectral Imaging: Preliminary Results

Oral presentation

For their morpho-physiological peculiarities and wide phenotypic plasticity, aquatic plants occupy the extremes of the global spectrum of vegetation forms; such heterogeneity results in them displaying contrasting patterns of diversity along ecological and geographical gradients. In the last decade, remote sensing has opened new ways of measuring biodiversity; in particular, high-throughput imaging spectroscopy is a feasible, efficient option for assessing plant diversity based on spectral proxies directly related to morphological and biochemical traits, which we define as spectro-functional traits. Linking spectral features to plant species diversity to characterize plant communities can further advance

this topic. In this study, we explored the use of spectral features extracted from centimetric resolution hyperspectral images collected from a drone to estimate taxonomic diversity via generalized additive models (GAMs) within communities of floating hydrophytes and helophytes sampled across a trophic gradient. Hyperspectral images were acquired during drone flights over target aquatic plant communities during the summer of 2021 in five wetland sites in Italy, using a Nano-Hyperspec® (Headwall Photonics) sensor (400-1000 nm), with a nominal spatial resolution around 3 cm pixel size. Spectral diversity features were derived from hyperspectral data cubes as spectro-functional traits (SFTs) and spectral Principal Components (sPCs). Four SFTs were computed: three normalized difference proxies of aquatic plant leaf biochemical parameters and the Water Adjusted Vegetation Index (WAVI), a spectral index specifically developed for its sensitivity to aquatic vegetation greenness. As additional spectral diversity features, the first five components (PC1-5) were computed from all hyperspectral bands over green material pixels. As a last step, mean, standard deviation and distance from the multidimensional centroid were calculated over all green pixels falling within a circular area of 4 m radius centered on in situ surveyed plant communities. Alongside drone flights, in situ data were collected from boat-based surveys, covering species abundance and coverage across 89 target plant communities, where diversity was calculated as effective number of species (2D) and species evenness (J'). After the exclusion of mutually correlated ones within each group (SFTs and SPCs), spectral metrics were used as input to GAMs for predicting species diversity across all 89 target communities, as 2D or J' (log-transformed for reducing distribution skewness), without considering interactions and using site information as random effect. Our results show that spectral features better predict 2D (R2 up to 0.75) than J' (R2 up to 0.55), especially when SFTs are employed.

Teresa Ferreira, Daniel Gebler, Francisca Aguiar

School of Agronomy, University of Lisbon
Department of Botany, Poznan University of Life Sciences

terferreira@isa.ulisboa.pt

Assemblage-based monitoring of freshwater ecosystem using similar macrophyte indices: how difficult can it get

Oral presentation

In Europe, the European Framework Directive has fostered in the 2000 decade, common indices to biomonitor aquatic ecological quality. The IBMR aquatic plant indice was one of those. Of French origin, it was adapted in many Southern European countries and intercalibrated in 2016. Albeit its elegant theoretical conceptualization frame, three decades of application have showed that field application has many challenges, namely for creating homogenous water regions, finding true reference conditions and long-enough disturbance gradients, setting the quality classes, combining results from other biological elements or comparing results across states. One further challenge is cross border and transborder river systems, where river types, reference conditions, ways to measure disturbance and biological skills are different. We surveyed and applied IBMR along all rivers and waterbodies of the border of Spain and Portugal and found strong inconsistencies justifying different results. In this study we show them and indicate solutions. However, the final challenge is achieving a common management of biomonitoring between the two countries.

Morgan Botrel, Roxane Maranger

Université de Montréal, Département de Sciences Biologiques

morganbotrel@gmail.com

Changing submerged aquatic vegetation in inland waters: new tools for high frequency monitoring at broad spatial scales

Oral presentation

Submerged aquatic vegetation (SAV) are essential components of inland water ecosystems and provide many ecosystem services, such as supplying food and habitat for fauna and promoting a clear water state. These ecosystem services are threatened by the rapid changes in SAV quantities associated with various drivers, where the predominant decline in recent decades is due to eutrophication. However, this information comes from biased time series primarily located in temperate zones, measured through single recurrent annual inventories. Therefore, our understanding of both SAV ecology and their response to human activities is hampered by the lack of observations in the many lake-rich regions of the world and the limited description of the timing in SAV seasonal development. To improve knowledge on SAV geographic distribution and temporal evolution, we present an overview of methodological developments that we have conducted in recent years. We first show an intercalibration of three methods, quadrat, rake and echosounding, to facilitate the monitoring of SAV biomass at large spatial and temporal scale. We then discuss the use of the slope of water surface elevation as an indicator of biomass and how it allowed for the detection of detailed seasonal growth and phenological changes.

Maarten De Jonge, Frank Lavens, Bram Haspeslagh, Martin Verdievel, Wim Gabriels

Flanders Environment Agency (VMM)

m.dejonge@vmm.be

Macrophyte monitoring by the Flanders Environment Agency (VMM): Status, trends and relations with environmental variables

Oral presentation

The macrophyte monitoring network of the Flanders Environment Agency (VMM) was developed to meet the requirements of the European Water Framework Directive (WFD). The network includes information on more than 4000 sampling events, associated with 140 Flemish waterbodies. To date the monitoring network resulted in more than 40 thousand occurrences of inland water macrophytes in Flanders (Belgium), sampled from 2006 onwards. This large and unique dataset can be used to determine 1) the current status regarding the biological water quality based on macrophytes in Flanders, 2) reveal both spatial and temporal trends in biological water quality and 3) relate macrophyte community composition to environmental variables such as physicochemical water quality, hydromorphology and land use. Currently only 26% of Flemish waterbodies achieve good biological status based on macrophytes, which is an increase with a factor 3 compared to the first monitoring cycle 2007-2009 (when only 8% of the waterbodies achieved good biological status). A strong spatial gradient exists, since in general a better macrophyte community composition is recorded in the eastern Flemish river basins (e.g. river basins of Nete, Demer and Meuse). The rather poor quality in macrophyte community composition in Flemish surface waters is due to the still high levels of nutrients such as nitrogen and phosphorus. Also poor hydromorphology is an important explanation, since a lot of Flemish water bodies are straightened and contain only few suitable habitats for submerged aquatic plants. In general land use seems to play only a minor role. The results of the macrophyte monitoring network are used to direct the water policy in Flanders, in order to generally improve water and habitat quality. The latter focuses on expanding and improving the remediation of domestic wastewater, preventing loss of nutrients from agriculture, and restoring river hydromorphology.

Krzysztof Szoszkiewicz, Anna Budka, Karol Pietruczuk

Poznan University of Life Sciences

krzysztof.szoszkiewicz@up.poznan.pl

How to estimate efficient sampling effort and the accuracy of river macrophyte monitoring

Oral presentation

The accuracy of environmental assessment based on aquatic species may often be affected by insufficient survey and the completeness of taxa identified should be controlled. The use of Hill numbers and Chao estimators can evaluate completeness of the sampling effort. The aim of this work was to present macrophyte groups, associated with various species traits, which are rich in species, as well as those whose detection is particularly difficult as it requires an exceptional sampling effort (sources of dark diversity). It was shown that the field identification of all estimated macrophytes is particularly difficult for low trophy indicators and generally submerged plants, as well as for small-leaved species. Field studies of rivers have shown that the full diversity of macrophytes can be mostly detected for free-floating plants and large-leaved macrophytes, as well as species with high trophic tolerance. The study proved that ecological assessment of rivers based on a small number of sampling units may lead to incorrect diversity estimates. Conversely, the estimation of diversity patterns at the level of the Shannon and Simpson indices does not require extensive sampling, and the extrapolation approach is not needed.

Todd Sink, Brittany Chesser

Texas A&M AgriLife Extension Service

Todd.Sink@tamu.edu

AquaPlant: A Success Story of an Extension Tool for Aquatic Vegetation Identification and Management - Poster presentation

Satellite survey data shows Texas contains over 1.3 million ponds, making up approximately 22% of privately owned waters in the United States by surface area. This amount of water comes with both water quality and security issues, which is further exacerbated by nuisance aquatic vegetation and seasonal water scarcity issues in the state. With more than 600 species of aquatic and obligate wetland species of vegetation in Texas, management issues are abundant and varied, complicating management for private water owners. There are no state or federal agencies tasked with management of aquatic vegetation issues other than the Texas A&M AgriLife Extension Service. The AquaPlant website, developed in 1996 and subsequently undergoing multiple rounds of revisions and updates, has become a true success story in assisting private water owners with management of aquatic vegetation issues. AquaPlant is utilized by more than 200,000 users annually from more than 217 countries and territories worldwide for aquatic vegetation identification, management options, and restoration or habitat efforts. This presentation will cover the history of AquaPlant, user demographics, information that can be obtained from the website, as well as analytic data we can glean from the website that may be useful as aquatic plant managers.

Tinotenda Mangadze, Krzysztof Szoszkiewicz

Poznań University of Life Sciences

The Use of Macrophyte Biomonitoring Tools Beyond Their Country of Origin: A Case of Southern Africa

Poster presentation

The utilization of macrophyte-based biological tools in various regions of the world is notably limited, resulting in the widespread adoption of tools originally developed in Europe. However, the suitability of these foreign tools to unique regional contexts remains uncertain. This necessitates a comprehensive assessment of the applicability of these adopted tools within the new system. Therefore, the aim of this study was to evaluate the applicability of implementing the European macrophyte-based monitoring system for rivers in watercourses of southern Africa. The study compiled the list of aquatic plants for southern Africa using a variety of databases and sources. A set of potential macrophyte indicators for southern Africa was selected based on the list of indicative species which is utilized for European rivers. Four of the most widely used methodological approaches, the European Macrophyte Index for Rivers (MIR), Macrophyte Biological Index for Rivers (IBMR), River Macrophyte Nutrient Index (RMNI) and the British method Mean Trophic Rank (MTR) were applied to evaluate their suitability for biomonitoring of rivers in southern Africa. Together, these indices provided a comprehensive evaluation of various ecological aspects, including habitat quality, ecosystem functioning and trophic status. The results also indicated a notable differentiation in the distribution and abundance patterns of macrophytes species in southern Africa when compared to the European context. The observed variations highlighted the unique ecological characteristics and biodiversity of southern African watercourses. Therefore, we concluded that although macrophyte indices developed in Europe are useful, a macrophyte index unique to southern Africa including endemic species will have to be formulated.

Fleur Visser, Amritha Nair

NERC Field Spectroscopy Facility

f.visser@worc.ac.uk

Spectral detection of epiphytic algae on macrophytes in the River Lugg - Poster presentation

Macrophyte and epiphytic algae interactions in streams are not well understood. More extensive data on the spatial and temporal distribution of epiphytic periphyton could help improve this understanding and its possible links with stream pollution incidents. This poster shows the first results of a study in the River Lugg, UK, investigating spectral signatures of algae cover on submerged macrophytes with the aim to identify distinct reflectance properties that can be used to distinguish covered and uncovered macrophytes from drone and possibly satellite image data.

Management of macrophytes

Session 9

Chair: Deborah Hofstra (National Institute of Water and Atmospheric Research, New Zealand),
Iris Stiers (Vrije Universiteit Brussel, Belgium).

Aquatic plants play a substantial role in the functioning of aquatic ecosystems, but some macrophytes, mostly alien species, are invasive and have significant ecological and economic impacts. Alien invasive species are considered second only to habitat loss as the drivers of biodiversity decline in freshwaters globally. Their impacts are additional to other stressors on the aquatic environment, often operating independently from them and escalating over time in the absence of management. The selection of an appropriate management option that will decrease negative effects of invasive macrophytes is largely dependent on the species (its ecology and impacts), the invasion pathways and size of the invaded area, and the outcome sought. The outcomes sought by management agencies may be driven by legislative requirements, the need to protect biodiversity, rare or threatened species habitat, and are increasingly related to the risks as perceived and accepted by the public. To successfully manage the threats and mitigate the impacts of invasive aquatic weeds, science is challenged to develop tools and approaches that can be implemented within a complex range of aquatic environments (including a changing climate), and that will provide predictable outcomes within appropriate timeframes and at scale. This session welcomes papers on all aspects of macrophyte management, from invasion ecology to pathway and vector interception of invasive species, and the restoration of desirable species. We also welcome papers on public perception or communication and outreach.

Jeffrey Hutchinson, Angela Maroti

Texas Parks and Wildlife Department

jeffrey.hutchinson@utsa.edu

Evaluating the suppression of *Hydrilla verticillata* by manual removal and planting native aquatic plants - Oral presentation

Hydrilla verticillata (hydrilla) is an invasive species found throughout the San Marcos River in central Texas and every continent, except Antarctica, colonizing rivers and lakes. Hydrilla management options are limited in the San Marcos River due to the presence of seven federally protected flora and fauna species. In this river study, we examine the ability of the native species [*Zizania texana* (federally endangered) and *Heteranthera dubia*] to suppress or outcompete hydrilla. Three sites were selected in the upper section of the San Marcos River. At each site, eight plots (0.25 m2) with different percentages (0, 25, 50, 75, and 100%) of hydrilla were removed and five *H. dubia* and *Z. texana* were randomly planted. The coverage of each plant within the plot was measured monthly and harvested at six months for biomass. In the field study there was significantly greater *Z. texana* biomass ($P < 0.05$) compared to hydrilla and *H. dubia,* and less hydrilla cover when ≥ 50% was removed and *Z. texana* was planted. However, the overall survival rate of *Z. texana* was 50%. The results of the field study suggest that *Z. texana* can suppress hydrilla if ≥ 50% of hydrilla is removed and *Z. texana* is planted. The field study results indicate morphological differences with hydrilla allocating greater biomass into its shoots while Texas rice allocates equal amounts of biomass into its shoots and roots. The results of this study agree with management practice in the river to restore *Z. texana* in which complete areas of hydrilla are removed and planting high densities of *Z. texana*.

Colin Burke, Luke Carpenter-Bundhoo, David Roberts, Hannah Franklin, Mark Kennard

Australian Rivers Institute
Seqwater

colin.burke@griffithuni.edu.au

Unravelling the consequences of extreme floods and dam-induced river fragmentation on macrophyte populations: A case study of the Mid-Brisbane River, Australia

Oral presentation

Extreme flood events, as well as river fragmentation and flow alteration caused by dams and weirs, are major drivers of reductions in macrophyte populations. Reduced connectivity can inhibit hydrochory (dispersal by water), the primary process of downstream propagule dispersal, likely impeding the recovery of macrophyte populations after large disturbances, such as floods. The Brisbane River in coastal eastern Australia, is impounded by a very large dam and has a long history of flooding events that have shaped the physical and ecological characteristics of the system. Historically, aquatic macrophytes were abundant throughout the main channel and major tributaries prior to 2021, however an extreme flood has reduced macrophyte abundance, particularly downstream of the dam. We conducted annual quantitative surveys in the Brisbane River from 2020 – 2023 of two sites upstream and seven sites downstream of the dam, to assess changes in macrophyte habitat, species distribution, abundance, and impacts of catastrophic floods in early 2022. Macrophyte propagules were collected monthly using drift nets in 2022/2023 at three sites upstream and two downstream of the dam to quantify temporal variation in propagule dispersal rates at base flow conditions and assess the impact of the dam on dispersal. Six species of macrophytes were observed during the annual surveys at the nine study sites, with all species occupying shallow to moderate depths (0.1 – 0.6m) and low water velocities ($<0.2 m*s^{-1}$) within a broad range of substrate types (mud, gravel, and cobbles). *Vallisneria nana* and *Ottelia alismoides* were the most widespread and abundant species sampled. Following the 2022 floods there was limited macrophyte cover upstream, and no macrophytes were observed downstream of the dam. Aquatic macrophyte propagules were only collected in drift nets at the three upstream sites, with no vegetation collected downstream of the dam. Propagules consisted primarily of macrophyte leaves

and fragments from two species (*V. nana* and *Potamogeton crispus*), with very few reproductive structures or crowns collected. Collectively, our findings strongly suggest that the barrier effect of the dam is impeding recovery of macrophyte populations downstream of the dam following large floods, reducing both hydrochory and connectivity by blocking propagule dispersal. Consequently, post-flood disturbance recovery is hampered. Our study highlights the profound impacts of extreme floods and river fragmentation, on macrophyte populations in the Mid-Brisbane River. Understanding these effects is crucial for the conservation and management of both macrophytes and the species that depend on them.

Roelf Pot

HarkboatNL BV, Roden
Waterboard Vechtstromen, Almelo
Sport Fisheries Groningen Drenthe

roelfpot@wxs.nl

Removing nuisance aquatic macrophytes with a rakeboat

Oral presentation

Some nuisance species are not satisfactorily controlled with the usual cutting methods. This is especially the case with the alien invasive species *Cabomba caroliniana* and *Myriophyllum heterophyllum*. These species have in common that they have firm roots from which they regrow very fast after being cut. Therefore, the hypothesis is that the key for controlling these species is in removing the roots with the plants. The rakeboat stirs up the soil with a large rake, loosening the whole plants, including their roots. The plants then start floating and can be collected. Fragmentation is minimized in comparison to cutting. The paper presents results of five years of application under various circumstances. The role of soil type, water depth, water body profile, water transparency, timing, and handling of plant fragments is discussed based on experiences so far. In all cases the density of the plants was reduced more than yearly regeneration could compensate for. In some cases, the plant density remained low for more than one year after treatment, in others 2 or 3 successive yearly treatments were needed. The method proved to be successful in reducing nuisance of these rooted plants, and now is applied as well to other rooted macrophytes such as *Vallisneria gigantea, Nuphar lutea.* There was no improvement, in comparison to usual cutting methods, when applied to species with less firm root systems, such as *Elodea nuttallii.* The machine is not intended nor advised for regular yearly application because the environmental impact can be bigger than with the usual cutting methods. It can however initiate system change for dense monospecific stands of rooted aquatic plants.

Hélène Groffier, Théo Solfato, Simon Devin, Elisabeth Maria Gross

Université de Lorraine, CNRS, LIEC - Metz (France)
LTSER-Zone Atelier Moselle - Metz (France)

helene.groffier@univ-lorraine.fr

Alkalinity and nitrogen: drivers of Myriophyllum heterophyllum invasion success? - Oral presentation

The aquatic invasive species *Myriophyllum heterophyllum* has been spreading in France for at least 12 years, especially in the northern and north-eastern parts. It has expanded mainly in small-gauge channels, where it usually forms monospecific dense stands that may emerge during late spring. These mats impair navigation and maintenance of the waterway infrastructure and may displace other species of macrophytes as well as fauna. Sometimes it is present with native vegetation and one common co-occurring species is *Myriophyllum spicatum*. We assume it is either arriving in sites where submerged native macrophytes already are or that its establishment leads to clear water allowing native plants to grow. Based on environmental conditions found in invaded areas outside France, this species seems to prefer low mineralised, low alkalinity waters. Compared to similar systems in eastern Germany, plants in France occur in higher alkalinity waters rich in nitrogen, reflected also by much higher nitrogen content in the plants. We consider that this might explain its high competitiveness compared to native species such as *M. spicatum*, whereas several studies have shown that the native *M. spicatum* would normally be more efficient growing under high alkalinity. We thus hypothesised that *M. heterophyllum* has adapted to these two factors. Based on our chemical water analyses, alkalinity ranges from 0.9 up to 3 mM and nitrogen (mostly as nitrate) varies between 0.3 and 5.9 mg.l-1 N. Thus, in order to get further clarification, we designed a full-factorial laboratory experiment using two alkalinity (high – low) and two inorganic nitrogen levels (high – low) with both *M. spicatum* and *M. heterophyllum* in single and mixed culture. The objective was to understand which species performs best under a given condition. The experiment has just ended, and analyses are ongoing. We compared the RGR, stoichiometry and pigment contents of the two species. Results will be presented during the IAPG congress. With our field monitoring and experimental work, we aim to get a better understanding of the plant's ecology and physiology. This should allow us to identify which habitats are suitable for the plant's establishment and growth since, given its fast expansion, it is important to predict and manage future spread.

Iris Stiers, Pieter Meert, Gianmarco Minuti, Sven De Boeck

Multidisciplinary Institute of Teacher Education, Science and Technology (MILO), Vrije Universiteit Brussel, Brussels, Belgium
Department of Biology, Ecology & Biodiversity, Vrije Universiteit Brussel, Belgium
Science Outreach Office, Vrije Universiteit Brussel, Brussels, Belgium.

istiers@vub.be

Bugs 2 the Rescue: a citizen science project - Oral presentation

Citizen science, the intentional engagement of the public in scientific research to increase knowledge around a scientific endeavor, plays an important role in collecting environmental data. Citizen science has already a rich tradition in the inventory of invasive alien species (IAS). At the same time, it can improve communication with the public in ways that can bring about changes in participants' knowledge, skills, and attitudes. This is especially needed with regards to classical biological control (CBC) as a management method for invasive weeds. CBC has been practiced worldwide for over 100 years in several regions of the world with a high success rate and cost-benefit ratio, but the EU is an exception. The prime reason for this reluctance towards CBC is to be attributed to a general lack of knowledge about it, combined with a high risk-aversion amongst policy makers, the general public and advisors in conservation. The topic of biological invasions has only recently caught the attention of environmental educators. To support the inclusion of IAS in education, we need to develop and implement novel, user-friendly educational materials. In that view, we developed the Bugs 2 the Rescue (B2R) project (www.bugs2therescue.be). B2R is a citizen science project that unites researchers, pond owners, the local nature and water sector and schools. B2R focuses on three goals: (1) it creates awareness about aquatic invasive plants and biological control, (2) it enables innovative data collection on invasive weeds and insect damage on them and (3) it links schools with citizen science. For the project we developed a Do-It-Yourself kit with field material (for both teachers and pond owners) and a complete lesson package, but all the free material is adaptable to the user's own needs or interests. Further it also uses gamification elements and smartphone apps, which have been highlighted to be effective tools for environmental education. To date 5 schools and 4 youth movements, with a focus on nature, participated in the full project, 50 biology student-teachers were trained in the field techniques, the lesson package was downloaded > 120 times, and the website has 3500 unique visitors. B2R was also present at different science events and had a broad media coverage by which we reached more than 50.000 citizens.

Olga Delange, Iris Stiers

Laboratoire d'Ecologie végétale et Biogéochimie, Université Libre de Bruxelles
Ecology and Biodiversity, Vrije Universiteit Brussel
Multidisciplinary Institute for Teacher Education, Science & Technology

olga.delange@ulb.be

Towards assessing post-management recovery of native flora by comparing seed banks composition in *Ludwigia* spp. – invaded; – managed and non – invaded ponds in Belgium - Oral presentation

Invasive Alien Aquatic Plants (IAAPs) are recognized as one of the major threats to aquatic biodiversity globally. Because of their high growth rate and ability to form dense mats, these plants strongly impact biodiversity and conservation status of aquatic ecosystems. In Belgium, the invasive water primroses *Ludwigia* spp. are listed on the Invasive Alien Species blacklist, and conventional management actions (manual or mechanical removal) have been carried out, but successful control stories are rare. As soil seed banks represent a source of propagules for both native and alien species, its composition could trigger re-invasion or suppress recovery of native species, hindering restoration efforts. We explore these questions by using germination experiments and seed bank emergence assays from invaded, managed and near-pristine ecosystems in Belgium. We collected seeds from 14 populations and checked their germination abilities by growing them in petri dishes under a 12|12h light regime and 14|24°C temperature regime in growth chambers. Results on germination show that 11 out of 14 *Ludwigia* populations in Belgium did produce viable seeds, with final germination percentages ranging from 0 to 77% at the end of the experiment. Mean time to germination (i.e., to reach 50% of total germination) ranged between 12 and 23 days. Preliminary seed bank emergence assays were set up in 2022, while the full experiment is ongoing (2023). Core sediments were taken in the selected ponds, sieved, and spread on a layer of sand under two hydrologic regimes to allow germination of submerged, floating and emergent species from the seed banks. Preliminary results on seed bank composition point towards a negative effect of *Ludwigia* germination on the persistence of native flora, highlighting the fact that producing viable seeds could affect the growth of native species. Our point of focus is especially on managed ponds, where the presence of *Ludwigia* seeds could hinder the recovery of native species after management of the vegetative parts of these invasives. Our results thus underline the need for a more integrated management that considers seed bank dynamics for a targeted, efficient approach.

Nguyen Nguyen, Tobias Bickel, Christine Perrett, Steve Adkins

School of Agriculture and Food Sciences, The University of Queensland, Brisbane, Australia
Queensland Department of Agriculture and Fisheries (QDAF), Brisbane, Australia

hoang.t.nguyen@uqconnect.edu.au

Regeneration of macrophytes from a lake propagule bank after removal of the invasive *Cabomba caroliniana* using herbicide and manual control - Oral presentation

Cabomba caroliniana A.Gray (cabomba) is an alien invasive species worldwide and is well established across Australia. Regarded as one of Australia's worst environmental weeds, cabomba is controlled with herbicides or by mechanical removal. While the effectiveness of different control methods is well established in the literature, little is known about the effects of those control methods on the regeneration of native and exotic plant species after removing the invasive plant. The increase in light penetration after weed removal is expected to trigger germination of other macrophytes. The propagule bank is thus an important source for the regeneration of a macrophyte community after management actions. We established experimental plots in the shallow littoral zone of a reservoir to compare the regeneration of aquatic plants from the propagule bank after removing cabomba with the herbicide flumioxazin or by hand. The aquatic vegetation in the local area was surveyed to compare the standing vegetation to that emerging from the plot propagule bank. We also collected substrate samples that were cultured in outdoor mesocosms to observe emergence seedling rate, then to determine species richness, seedling abundance and density. We found that native and exotic macrophytes regenerated more rapidly in the manual control plots as compared to herbicide plots, possibly because manual removal resulted in an instant opening of the water column and rapid light penetration triggering earlier seed germination. However, cabomba regrowth was observed after 40 days because manual control failed to remove all cabomba fragments, and repeated manual maintenance was required to maintain a clear water column in those plots. Contrary to this, the herbicide slowly cleared cabomba from the plots over 2 weeks, therefore, regeneration of macrophytes was delayed. The species emerging from substrate samples in the mesocosms, were like those of the local standing vegetation. Nymphaeae species and *Nymphoides indica* (L.) Kuntze dominated the macrophyte community emerging from the lake seedbank. The herbicide and manual removal of cabomba facilitated the emergence of native and non-invasive macrophytes. While seed germination was more rapid in manually cleared plots, the herbicide treatment needed less maintenance in the long term and will be more economical to restore native vegetation after removal of the invasive cabomba.

Eva Rekkers, Antonella Petruzzella, Samuel Motitsoe, Hlumel Mantshi, Julie A. Coetzee, Martin Hill, Emily Strange

Leiden University, The Netherlands
Centre for Biological Control (CBC), Rhodes University, South Africa

evarekkers@gmail.com

Early phytoplankton responses to invasive floating plant control in subtropical freshwater systems - Oral presentation

Invasive free-floating macrophytes cover freshwater systems with dense mats, reducing light and oxygen levels, lowering pH, and disrupting nutrient cycling. This can have detrimental impacts on biodiversity, and ecosystem function and services. These environmental changes affect not only native macrophyte communities but can impact multiple trophic levels including macroinvertebrates and primary producers such as phytoplankton. It is often assumed that controlling invasive alien aquatic plants (IAAP's) is enough to restore systems to their previous condition and re-establish biodiversity. However, post-monitoring efforts usually focus on the target plant, while the impacts on other aquatic communities remain relatively unknown. There is a lack of studies assessing the responses of other aquatic communities after invasive plant control, even more so in subtropical systems despite their long history with invasive species. It's vital to establish recovery mechanisms in order to rebuild stable resilient systems which can provide optimal and intrinsic ecosystem services. Phytoplankton is a suitable indicator for environmental conditions and overall biodiversity. It rapidly adapts to changing conditions, which makes it a fitting tool for evaluating the recovery capabilities of a system. Post-invasion phytoplankton communities have yet to be thoroughly assessed. This study aims to evaluate the taxonomic and functional diversity of phytoplankton communities before and after Salvinia molesta control. Also, to determine what key environmental and biotic factors i.e., submerged macrophyte regrowth drive the responses of phytoplankton communities. To address this, a field study was conducted across five *S. molesta*-invaded freshwater bodies in South Africa, in which we collected phytoplankton, phytoplankton and submerged plant biomass, and environmental variables before (summer 2021-2022) and after (summer 2022-2023) plant invasion control. Preliminary results indicate an overall increase in phytoplankton taxonomic diversity after *S. molesta* control. Our results are an important step towards understanding complex aquatic community responses of recovering systems.

Tressia Chikodza, Martin Hill, Julie Coetzee

Center For Biological Control (CBC)
Water Research Commission (WRC)
Rhodes University
DFFE
Leiden University

tressiachikodza9@gmail.com

The effect of biological control on the population dynamics of Pontederia crassipes (C. Mart) Solms (Pontederiaceae) and Salvinia minima Baker (Salviniaceae)

Oral presentation

Pontederia crassipes is widely regarded as the most damaging floating aquatic weed in terms of its invasive potential, and its impact on aquatic ecosystems. Biological control using host-specific natural enemies is widely used for its control, with the most recent agent released being a planthopper, *Megamelus scutellaris*, in South Africa and the USA. Inundative releases of *M. scutellaris* has been shown to control the weed even at eutrophic, and high elevation cold sites, such as Hartbeespoort Dam, the arguably Africa's most hypertrophic impoundment. However, subsequent to the control of *P. crassipes* on Hartbeespoort Dam, in 2021, the water surface was covered by Salvinia minima, in what is termed an invasion cascade. *Salvinia minima* is only known from a handful of sites near Hartbeespoort and there is currently no approved biocontrol agent for it. This study investigated the combination of competition and herbivory between P. crassipes and S. minima to understand the dynamics of these two highly invasive species. The impact of the planthopper was evaluated using an additive series analysis of competition between P. crassipes and S. minima. Competitive abilities of P. crassipes and S. minima were determined using an inverse linear model with plant weight as the yield variable. In the absence of herbivory, P. crassipes was 4 times more competitive than S. minima, but as competitive when exposed to *M. scutellaris* feeding. *Salvinia minima* was 1.2 times as aggressive as P. crassipes that was free of herbivory, but 2.6 times as competitive when *M. scutellaris* was established on *P. crassipes*. In the presence of herbivory on P. crassipes, interspecific competition coefficients from P. crassipes on S. minima were no longer statistically significant. These results indicate that the competitive ability of P. crassipes is reduced through herbivory when grown with *S. minima*, explaining the temporal dominance between the two species at Hartbeespoort Dam. Biological control options of S. minima are under consideration in South Africa, but in the absence of nutrient control, the system is likely to be taken over by yet another invader.

Darren Reidy, Justin Cepas, Simon Harrison, Marcel Jansen

National Botanic Gardens of Ireland, Office of Public Works
School of Biological, Earth & Environmental Sciences, University College Cork

darren.reidy@opw.ie

Does *Myriophyllum aquaticum*, a freshwater invasive species, have capacity to invade brackish waters in Ireland? - Oral presentation

The distributions of plants in transitional or brackish water habitats (e.g., estuaries, lagoons, salt marshes & tidal rivers) are controlled by a complex suite of abiotic factors such as substrate, salinity, and tidal regime. Freshwater macrophytes are not typically capable of tolerating salt stress in the same way halophytes do and it has been hypothesised that stressful environments may represent a barrier to invasion by non-native species. *Myriophyllum aquaticum* (Vell.) Verdc. is a heterophyllus aquatic plant species native to S. America and an invader of freshwater habitats globally. In order to determine if *M. aquaticum* has the potential to become a successful invader of transitional wetland habitats in Ireland this study drew comparisons with *Myriophyllum spicatum*, a native congeneric species and known invader of brackish and freshwaters globally. Using a combination of in-situ field and ex-situ lab-based experiments, this study investigated the response of both species to salinity treatments at the various life stages of the plants (i.e., clonal propagules and established plants). Under laboratory conditions vegetative propagules of *M. aquaticum* and *M. spicatum* were capable of overcoming salt stress with varying success. *M. aquaticum* propagules remained fully viable, maintained normal growth rates and successfully produced roots and shoots in salinities of up to 8 ppt. Propagules of *M. spicatum* were tolerant of higher salinities of up to 11 ppt, but also exhibited enhanced growth rate at salinities of 3-8 ppt when compared to the control. Plants of both species grown in low to moderately saline field conditions displayed enhanced performance in terms of relative growth rate, shoot biomass and number of branches. Deleterious effects of high salinity environments on plant survival, growth rate and morphology were observed for both species. *M. aquaticum*, exhibited morphological plasticity, adjusting its emergent to submerged biomass ratio in response to salinity, allowing it to reduce evapotranspiration and maintain normal growth rates under moderately saline field conditions. *M. aquaticum*, like M. spicatum, is capable of invading brackish water environments in Ireland. Propagules of both species are capable of surviving and regenerating under brackish conditions and plants grown in moderately saline environments perform as well as plants grown in freshwater. *M. aquaticum*'s apparent phenotypic plasticity in brackish conditions combined with its capacity to tolerate other related stressors such as drought and fluctuating water levels makes it a competitive invader of transitional brackish water habitats in Ireland.

Gabrielle Thiébaut

Université de Rennes/ ECOBIO, France

gabrielle.thiebaut@univ-rennes.fr

Is removal a solution for management of the alien aquatic plant species *Egeria densa*? A mesocosm approach - Oral presentation

Invasive Aquatic Plant species (IAP) are considered as a threat to native biodiversity and for the ecosystem functioning. Mass development of IAP incur economic costs because they deleteriously affect recreational activities (boating, fishing, swimming, and other water sports), clogging hydropower stations and increasing the risk of flood in alluvial valley. They also have ecological impacts by limiting light therefore oxygen depletion, by altering biological communities, resulting in food web changes. Once a mass development occurs, management is widely used to preserve the ecosystem services provided by the aquatic environment. Various control measures are employed by managers to reduce the impact of the mass developments, including removal, herbicide application, biological control, or a combination of these. The Brazilian waterweed *Egeria densa* Planchon (Hydrocharitaceae) has been widely distributed around the world. The successful management of this IAP requires comprehensive knowledge on the biology of *E. densa* and its ability for regrowth after a disturbance such as cutting. To evaluate the impact of the period of cutting and the frequency of harvesting on *E. densa* biomass and precisely investigate the process of regrowth and the ability of propagule release to regenerate and colonize new sites, an approach based on measurements of morphological traits in experimental outdoor mesocosms was used. The date of the harvest (May or July) had no significant effect on the biomass of *E. densa*. However, two harvests significantly reduced the plant biomass by comparison with one harvest and with no harvest. Fragments produced in May by harvest were able to better colonize and had a higher regeneration ability (anchorage rate, fresh biomass, production of lateral branches and roots) than fragments produced in July by the management. Each fragment containing a double node has the potential to develop into a new plant. When a shoot sinks to the bottom, a new root crown may develop at one or several double nodes along the new shoot. *Egeria densa*, has a relatively high rate of growth, as well as the ability to propagate vegetatively. Removal could favour the fragmentation, dispersal, and the development of new masses of *E. densa*.

Brittany Chesser, Todd Sink

Texas A&M AgriLife Extension Service
Texas A&M University

Brittany.chesser@tamu.edu

Information and Education: Texas A&M AgriLife Extension Service Models Used to Combat Aquatic Vegetation Issues

Oral presentation

Satellite survey data shows Texas contains over 1.3 million ponds, which are growing in number each year, making up almost 25% of privately owned waters in the United States. This amount of water comes with both water quality and security issues, which is further exacerbated by nuisance aquatic vegetation. With more than 600 species of aquatic and obligate wetland species of vegetation in Texas, management issues are abundant and varied. There are no state or federal agencies tasked with management of aquatic vegetation issues other than the Texas A&M AgriLife Extension Service. Throughout the past two decades, Texas A&M has developed strong extension models to support Texans, residents of the greater United States, and international communities with aquatic vegetation control and restoration. This presentation will cover Extension and education models developed at Texas A&M to assist owners of private waters with aquatic vegetation identification, management, restoration, as well as classroom efforts to train the next generation of aquatic plant management professionals. These efforts include the AquaPlant website, professional development programs, online training modules, Extension programs, professional relicensing efforts, publications and fact sheets, identification booklets, and funding for education.

Stijn Van Onsem, Xavier Vermeersch, Niels Schild, Sonia Vanderhoeven, Vincent Golabek, Jérémie Guyon, Dido Gosse, Bram D'hondt, Etienne Branquart, Arnaud Monty

Vlaamse Milieumaatschappij
Brussels Environment
Agentschap voor Natuur en Bos
Belgian Biodiversity Platform
Contrat Rivière Dendre asbl
Contrat de Rivière Dyle-Gette asbl
Contrat de Rivière Senne asbl
Research Institute for Nature and Forest (INBO)
Service Public de Wallonie
Université de Liège - Gembloux Agro-Bio Tech

s.vanonsem@vmm.be

The LIFE RIPARIAS project: Reaching Integrated and Prompt Action in Response to Invasive Alien Species - Poster presentation

Tackling Invasive Alien Species (IAS) requires a coherent approach across administrative boundaries, especially so in continuous aquatic habitats. LIFE RIPARIAS targets a selection of invasive aquatic and riparian plants, including species of the following genera from the EU list: *Hydrocotyle*, *Lagarosiphon*, *Ludwigia*, *Myriophyllum*, *Heracleum*, *Impatiens* and *Lysichiton*. Its goal is to optimize the management of these IAS at river basin scale within a multiregional pilot area in Belgium (Dyle, Senne, and Marcq river basins). LIFE RIPARIAS provides 1) early warning and management reporting; 2) decision support for prioritizing management actions; 3) river basin management strategies adopted by all stakeholders; 4) prioritized IAS field management; 5) monitoring of management actions; 6) the sharing of expertise and best management practices. A novel evidence-based workflow for decision making on IAS management at the river basin scale has been developed, maximizing cost effectiveness. The decision support tool will be made available to IAS managers across EU Member States. Active participation and cooperation between decision makers, field managers and the public are essential. The ten project partners include public bodies, public research institutes, academia, and associations. Additionally, species identification sheets, booklets and best practice management guides will aid identification and management in the field. Information and training sessions will spread knowledge as widely as possible. This innovative project (2021-2026) is co-funded by the LIFE programme of the European Union and the three Belgian regions for a total budget of about 7 million euros (LIFE19 NAT/BE/000953).

Gianmarco Minuti, Michael Sean Staniszewski, Singh Kanika, Iris Stiers

Department of Biology, Ecology & Biodiversity, Vrije Universiteit Brussel, Brussels, Belgium
Multidisciplinary Institute for Teacher Education, Science and Technology (MILO), Vrije Universiteit Brussel, Brussels, Belgium

gianmarco.minuti@vub.be

Assessing the recovery of aquatic ecosystems after the biological control of the invasive water fern *Azolla filiculoides* – A case study from Belgium - Poster presentation

Azolla filiculoides Lam. is a floating water fern native to warm temperate and tropical regions of the Americas, considered invasive in several regions of Europe, Africa, and Asia. Dense mats of this weed can reduce light penetration and oxygen levels throughout the water column, causing die-off of submerged macrophytes and having serious impacts on aquatic fauna. Standard control methods, consisting of manual and mechanical removal, seldom result in the complete eradication of the weed, raising the need for recurrent management and the relative costs associated with it. In South Africa, the biocontrol agent *Stenopelmus rufinasus* (Coleoptera: Curculionidae) was released to control water fern in 1997. Within 10 years the weevil brought the Azolla invasion under complete control, to the point where the plant was redefined as non-invasive in the country. The azolla weevil is already present in Belgium, probably introduced accidentally together with the plant. In the UK, inundative releases and translocations of this insect have been employed and led to a substantial level of control. However, this method is not yet considered in other European countries. The effectiveness of various management strategies, including weed biological control, is often evaluated based on the ability to reduce plant biomass. However, due to a lack of long-term monitoring, the recovery of natural ecosystems is often left unexplored. In this study, we combined the results of field observations with a mesocosm experiment to evaluate i) the effect of *A. filiculoides* invasion; ii) the ability of *S. rufinasus* to control *A. filiculoides*; and iii) the recovery of aquatic ecosystems after effective biological control. Invaded and closely-located uninvaded systems were sampled at different moments in time to compare their ecological state before and during water fern invasion, and after the weed was controlled by the insect. Our results highlighted a change in water parameters, zooplankton, and macroinvertebrates assemblages in both invaded and uninvaded ecosystems over time. Largest differences were recorded for macro-invertebrate diversity and community composition, which showed a decline during the invasion stage, but quickly recovered upon biological control.

Johan Van Valkenburg, Edu Boer, Laurens Piet

NVWA / National Instute for Vectors, Invasive plants and Plant health

j.l.c.h.vanvalkenburg@nvwa.nl

Tools to support pathway interception of invasive plants

Poster presentation

With the adoption of the EU regulation on Invasive Alien Species (EU regulation 1143/2014), National Governments are obliged to fulfill the requirement of prevention, early detection, eradication, and control of species on the List of Union concern. For plants, this inspection and surveillance work is supported by a knowledge infrastructure, consisting of a range of identification tools and online databases. For aquatic plants, tailormade tools for the trade pathway have been developed which differ from similar tools for field surveyors and inspectors overseeing management and/or control activities. Similar tools are available for seed as contaminants in animal feed, weeds of potted plants and invasive terrestrial plants.
https://q-bankplants.eu/
https://qbank.eppo.int/plants/

Luke Huffman

University of Wisconsin-Madison, United States

lchuffman2@wisc.edu

How are People Searching about Aquatic Plant Management Online

Poster presentation

Most people in the U.S. use search engines like Google to find online information related to questions they have, including information about aquatic plant management (APM). How people 'search' about APM, what keywords they use, and what websites they click on is critical information to professionals focused on best practices in APM since this can inform their educational programming and outreach. Analyzing the search engine results page (SERP) for various keywords can help managers understand what information people are seeing when searching for APM information. Using a search engine analysis software this study examined 113 popular search keywords pertaining to aquatic plants, algae, cyanobacteria, and their management. 1130 websites were categorized into either institutional/governmental, commercial, or mixed/other, which was further broken down into subcategories (e.g., blogs, encyclopedias, etc.). The number of websites and their position in the SERP were documented for each keyword. The commercial category had the most websites in the collective SERPs and the highest rankings overall. People using keywords that were scientific or about specific species were more likely to click on institutional/governmental category websites. This was also true with keywords related to invasive species. However, the commercial category performed better for keywords that were vernacular terms, negatively framed, and management related. Mixed/other websites were much less prevalent overall. Many keywords were highly polarized, wherein representation from one category dominated the SERP. Considering many institutional and government aquatic plant management webpages are educationally motivated with an emphasis on science, many people looking for APM information may not find their website due to the nature of the search queries used. The results of the study indicate that more outreach materials should include language that matches how target audiences search for information related to APM. This includes using more vernacular terms and discussing management techniques. The results also provide information which might be useful in the creation of outreach and promotional strategies for APM that anyone can use to help people learn more about aquatic plant management.

Excursion

Excursion **2023**

16/11 Thursday

Today we take you to a couple of the nicest places in Belgium, which will be a mix between research, nature and culture. It is a very packed day, so buckle up and here we go!
You will still receive an email with further excursion day details during the conference.

Departure

We meet in the morning at **07h45 in front of the conference building**: University of Antwerp (Stadscampus), Hof van Liere, Prinsstraat 13, 2000 Antwerp, to hop on the bus.
Please make sure to be in time for the bus! We will leave at 08h00 sharp!

First stop: KBR CFA

The Kruibeke Bazel Rupelmonde (KBR) Controlled Flood Area (CFA) is a key component of the Belgian Sigma Plan for the Scheldt Estuary. The Sigma Plan is an integrated flood protection plan that combines dikes, seawalls and flood areas to protect approximately 20,000 hectares of land from flooding. Within the Sigma Plan, the KBR site is the most important Controlled Flood Area, which is projected to reduce flood risks along the Scheldt Estuary by five times.
To create the KBR area, works were carried out to open three contiguous polders (areas of reclaimed land) – the Kruibeke, Bazel

and Rupelmonde polders – to controlled tidal action. The re-opened polders do not provide only a defence system from Scheldt river flooding but are a wide natural and attractive space, where forest and creek habitats were restored, fish stocks were managed and recreational opportunities were provided. The system has already proved its efficacy, counteracting the effects of storm surge events. Currently the KBR is one of the most frequented sites of the Sigma Plan's area of intervention, with increasing attractiveness for touristic activities.

Second stop: Mesodrome

AnaEE-Belgium is the national branch of the European infrastructure AnaEE (Analysis and Experimentation on Ecosystems). It focuses on the ecological and agronomical challenges posed by environmental change, and conducts experiments that offer us a look into the future. AnaEE-Belgium manages five state-of-the-art experimental platforms that enable such forward-looking research.

One of these platforms is the Mesodrome, focusing on aquatic ecosystems, where environmental problems co-occur such as eutrophication, pollution, and flooding. It is a glasshouse infrastructure (operational since 2017), which features 16 Experimental Ponds and 4 smaller Experimental Rivers or Raceways. Here, interactive effects of pollution and

future-climate hydrology on linked biotic (fish, invertebrates, vegetation, crayfish) and abiotic (sediment, water) ecosystem parts are examined. The Mesodrome also has a 20 m long, 2 m wide Experimental River (operational since 2020), allowing manipulation of hydrology, water quality (pollutant loads), sediment characteristics and vegetation, to assess interactive effects of future changes in these drivers on river ecosystem functioning.
During our time at the Mesodrome, lunch will be available.

Third stop: Meise Botanic Garden

The history of the Botanic Garden goes back to 1797. For centuries we have been collecting, studying and caring for plants, passed on from generation to generation. The story of the Botanic Garden starts in Brussels, first in the estate of the Nassau Palace and later in what is still the Brussels Botanic Garden. In that period, our botanic garden collected as many plants as possible; novelties brought back by the explorers. We studied plants with the aim of growing, perfecting, and selling them. They were exhibited to the clientele in impressive gardens.
Botanical research became more important after the Belgian State took over the Botanic Garden in 1870. An important task was to study plants from outside Europe: Brazil, Mexico, and Central Africa; this last region became more important during the colonial period. Ornamental plants continued to be cultivated and the Botanic Garden was the main supplier for all public buildings. This is where an important part of our ornamental plant collection originated. In the 19th century, the herbarium began to be expanded.
In 1938 the Botanic Garden moved to its present location in Meise. The estate owes its formation to the fusion of two mediaeval castle estates. King Leopold II bought both estates for his sister, 'Empress' Charlotte, widow of Maximilian of Austria (briefly Emperor of Mexico) and sister-in-law of the famous Sissi. The former lords of the castle had each transformed their estate into an English-style landscape park at the beginning of the 19th century. Both were also plant collectors. And so two stories come together...

The move to Meise was the start of an impressive investment programme. The 'Plant Palace' was built (1947-1965): a series of thirteen impressive greenhouses. The Balat Greenhouse moved to Meise: it is the preliminary study by court architect Alphonse Balat for the Royal Greenhouses of Laeken, and one of the oldest (1854) greenhouses of drawn glass and wrought iron in Belgium. The Herbarium building (1959-1962), representative of post-war modernism, houses the library and the world-famous herbarium. The plant collection was substantially expanded. The Botanic Garden was protected as a landscape in 1967.

Over the course of the 20th century, cooperation between botanical gardens grew. Plants were exchanged and knowledge shared. Today these networks form an important link in the preservation of biodiversity on our planet, which is threatened by climate change and human activities. Botanic gardens fulfil an important role as protectors of the plant world.

Since 2014, the Flemish government has managed the Botanic Garden as the Agency Botanic Garden Meise.

Fourth stop: Back in Antwerp

The bus will now stop around 17h00 – 17h30 (depending on traffic) in front of the KMSKA museum of Fine Arts in Antwerp for those of you who will be joining us for our final stop. There is now (limited) time foreseen for you to go relax and find dinner on your own in the "Zuid Quarter" (nice and vibrant place of the city of Antwerp). Nevertheless, please do not linger around too long at the restaurant for dinner, because we will start our museum visit to the KMSKA museum of Fine Arts (hence why we dropped everyone of here) at 19h30 sharp!

For those of you who will not be joining the museum visit, please note that the bus will make a second stop to drop the remaining participants of at the closest possible location to the conference building.

Fifth stop: KMSKA

Seven centuries of art: from Flemish Primitives to Expressionists. World-famous masters. The largest and most important collections of James Ensor and Rik Wouters. Yet the Royal Museum of Fine Arts Antwerp is much more than even this internationally renowned collection of art. The KMSKA is the only Flemish museum with high-level scientific status.

Not only are we responsible for conserving, managing and expanding our collection, we also carry out scholarly research into the works, the techniques used, colour, visual language and more

besides. In doing so, we challenge received wisdom. We share our newly acquired interpretations with the public, enriching the knowledge of art lovers. The KMSKA operates according to the charter of ICOM, the International Council of Museums.

The Finest Museum: Ten Reasons Why

1. The KMSKA is home to countless Flemish masters: many of the art works on show were 'Made in Flanders'.
2. No fewer than 111 works in the collection are on the Flemish Government's official Masterpiece List.
3. Top international names like Fouquet, Titian, Alechinsky, Modigliani, Rodin and Chagall, to name just a few, have a global appeal.
4. The world's largest collections of work by James Ensor and Rik Wouters put the KMSKA on the map as the home of modern art pioneers and of revolutionary art.
5. With its thrilling symbiosis between the powerful new volume and the historic galleries, the new museum building is an architectural gem.
6. The KMSKA is one of the few Flemish museums with a conservation studio of its own.
7. The KMSKA is an internationally renowned research institution too.
8. With our Artists in Residence programme and cross-overs with the wider cultural sector, the KMSKA has emerged as a breeding ground for outstanding new talent.
9. The Museum Garden is a gallery in its own right: a green oasis, which brings local people together and offers a tranquil haven in this lively district.
10. The Finest Feeling shines through in everything we organize, do and represent: a positive emotion that truly affects people.

List of the speakers

List of speakers