17th International *Symposium on* Aquatic Plants - Back to the Future of Aquatic Plants and the Way Forward

Lisbon 2025

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INSTITUTO SUPERIOR DE AGRONOMIA

cef Centro de Estudos Florestais

TERRA
Laboratório para a sustentabilidade do uso da terra e dos serviços dos ecossistemas

INTERNATIONAL AQUATIC PLANTS GROUP

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Francisca C. Aguiar (Chair) & Sofia F. Santos

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Cover
Ranunculus peltatus Schrank (pond water-crowfoot), a freshwater hydrophyte species observed in lentic waters of Portugal, South-Western Europe; Francisca C. Aguiar.

Sponsors

Logistics

Layout

Preface

The 17th International Aquatic Plants Group (IAPG) conference is held from 15 to 19 September 2025 in Lisbon, Portugal. Since 1964, the IAPG has organized a conference every two to three years to share scientific advances, exchange ideas, and deepen collective knowledge of aquatic plants and their ecosystems. The event also serves as a valuable networking platform, fostering collaborations that drive impactful research across all areas of aquatic plant science, including botany, genetics, ecology, ecophysiology, conservation, weed control and management. The last IAPG Symposium hosted in Lisbon took place in 1998 and addressed the theme 'Aquatic Weeds: Towards Integrated Aquatic Plant Management'. Since then, the importance of aquatic plants has expanded across multiple fields, such as invasive ecology, aquatic plant-based bioassessment, biotic interactions, ecological stoichiometry, nutrient cycling, and fundamental aquatic plant science. These developments have been influenced by global challenges, such as climate change, water pollution, dam construction, and land-use changes impacting rivers, lakes, wetlands, riverine and coastal ecosystems. At the same time, there has been a significant increase in research on the role of aquatic plants in nature-based solutions, including in both constructed and natural wetlands, in the restoration of freshwater ecosystems, and more recently, in exploring new perspectives enabled by technological advancements and AI-driven innovations.

Lisbon edition's theme, '*Back to the Future of Aquatic Plants and the Way Forward*', seeks to unite knowledge of aquatic plant sciences from past achievements to current challenges to leverage innovation for a sustainable future of aquatic plant ecosystems.

It brings together over 140 participants from 30 countries across 6 continents, sharing 141 communications organized into 10 thematic sessions. The sessions start with addressing new tools and approaches for monitoring aquatic plant ecosystems, move through topics such as ecophysiology, genetics, biotic interactions, invasive species and global change, and conclude with nature-based solutions, conservation, and aquatic plant management. The symposium features two keynote sessions designed to reflect on the past, present, and future of aquatic plant science. The first keynote is delivered by two long-standing and distinguished contributors to aquatic plant sciences who will trace the evolution of this field over the past five decades, highlighting how our understanding and approaches have shifted in response to new scientific insights and environmental challenges. Looking ahead, they will offer their perspective on how aquatic plant science can redefine its role; for example, by questioning whether the emphasis on macrophytes as indicators under frameworks like the European Water Framework Directive may have diverted attention from foundational ecological research. Complementing this retrospective view, the second keynote brings together four enthusiastic early career researchers (ECRs) to share fresh perspectives rooted in new technologies, interdisciplinary methods, and computational advances, all anchored in ecological principles and the historical development

of the field. They present ideas for theoretical, technological, and methodological advancement, while discussing the value of networking to support collaboration, knowledge exchange, and the continued growth of aquatic plant science. The “voice of aquatic plants” will be heard giving awareness for the cultural values of aquatic plants in a short talk and a workshop that links science and art through music.

A sincere acknowledgement goes to the Scientific Committee, Local Organization, IAPG members and the ECRs for their valuable contributions in making this event possible. Together with IAPG members and the Scientific Committee, on behalf of the Local Organisation, I warmly welcome you and wish you a productive and engaging symposium. We hope you enjoy the event and take part in shaping the future of aquatic plant science.

Francisca C. Aguiar
(Chair of the Organizing Committee)

Program 2025

Program 2025 - Oral presentations

17th International *Symposium on* Aquatic Plants - Back to the Future of Aquatic Plants and the Way Forward

- Location: LNEC, National Laboratory of Civil Engineering, Avenida do Brasil, 101, 1700-066 Lisboa, Portugal
- Poster presentations are shown during Coffee & Tea Breaks
- Welcome Reception: Museu da Água (Water Museum), Barbadinhos Steam Pumping Station; Rua do Alviela nº 12, Lisboa
- Conference Dinner: Restaurante Zambeze, Calçada Marquês de Tancos - Edifício EMEL Mercado Chão do Loureiro, São Cristovão, Lisboa

15/09 Monday (Auditorium)

08:30 Desk opening/registration

09:00 **Official opening**

09:30 **Keynote Lecture** Jan E. Vermaat & Elisabeth M. Gross

10:30 Coffee & Tea Break

11:00 **Session 1A|** New tools and approaches for the monitoring of aquatic plant ecosystems

12:30 Lunch

13:30 **Session 1B|** New tools and approaches for the monitoring of aquatic plant ecosystems

15:30 Coffee & Tea Break

16:00 **Session 2|** Biotic interactions

19:30 Welcome Reception: Water Museum Barbadinhos Elevatory Station

16/09 Tuesday (Auditorium)

09:00 Desk opening/registration

09:00 **Session 3A|** Invasiveness and control

10:45 Coffee & Tea Break

11:15 **Session 4A|** Riparian and aquatic plant dynamics and succession

12:30 Lunch

13:30 Keynote Lecture Anne Lewerentz, Antonella Petruzzella, Lindsay Trottier, Michał Brzozowski.

14:30 **Session 4B|** Riparian and aquatic plant dynamics and succession

15:45 Coffee & Tea Break

16:15 **Session 3B|** Invasiveness and control

17/09 Wednesday

Mid-Symposium excursions: 09:00 - 17:30

18/09 Thursday

09:00 Desk opening

Auditorium

9:00 **Short Talk Between Science & Art|** The Voice of Aquatic Plants

09:15 **Session 5|** Aquatic plant collaborations: insights from emerging projects and growing networks

10:45 Coffee & Tea Break

11:15 **Auditorium Session 6A|** Macrophytes and global change

Room *Nymphaea* Session 8| Ecophysiology of aquatic plants

12:45 Lunch

13:45 **Auditorium Session 7A|** Nature-based solutions, conservation and management

Room *Nymphaea* Session 8 (cont.) | Ecophysiology of aquatic plants

Room *Nymphaea* Session 9| Aquatic plant genetic diversity and evolution

15:15 Coffee & Tea Break

15:45 **Auditorium Session 6B|** Macrophytes and global change

Room *Nymphaea* Session 10| Pollutants and the use of aquatic plants in water treatment

19:30 **Conference Dinner: Welcome Reception**

20:00 **Conference Dinner: Seated Dinner**

19/09 Friday (Auditorium)

09:00 **Session 7B|** Nature-based solutions, conservation and management

10:30 Coffee & Tea Break

11:00 **Session 7B|** (cont.)

11:30 **Awards & Closing Session**

12:00 *Meeting of the IAPG Scientific Committee (by invitation only)*

12:00 Boxed lunch

Full program

15/09 Monday (Auditorium)

8:30 Desk opening/registration

9:00 **Official opening**

9:30 **Keynote Lecture** Jan E. Vermaat & Elisabeth M. Gross
Will the crystal ball tell us something about the future of aquatic plant research? - A dialogue

10:30 Coffee & Tea Break

Session 1A New tools and approaches for the monitoring of aquatic plant ecosystems

11:00 **Silvia Huber** Combining satellite remote sensing and deep learning for large-scale monitoring of shallow marine plant ecosystems - use cases from Scandinavia

11:15 **Paolo Villa** Linking spectral, phylogenetic and functional diversity of wetland plant communities

11:30 **Robert Richardson** Incorporating drones into US aquatic plant management and monitoring

11:45 **Rui Zhou** Monitoring and analyzing the dynamics of Zizania floating mats with PlanetScope imagery and Google Earth Engine

12:00 **Kara Foley** Technology development and advancement in aquatic plant management

12:15 **Raymond Newman** Use of a multi-value assessment approach to assess macrophyte response to lake management

12:30 Lunch

Session 1B New tools and approaches for the monitoring of aquatic plant ecosystems

13:30 **Aleksandra Marković** Developing eDNA-based methods for exploring charophyte algae diversity in lakes

13:45 **Michelle T. Casanova** Using water plant functional groups to understand and manage wetlands

14:00 **Roel Lammerant** The underestimated role of intra-specific trait variability in aquatic plant trait-based studies

14:15 **Seppo Hellsten** Developing distribution models of lake macrophytes, a case study from Nordic countries

14:30 **Konstantinos Stefanidis** Patterns of ecological uniqueness in rivers of Greece - analyzing local and species contributions to beta diversity within the framework of the Water Framework Directive (WFD)

14:45 **Lukas Petrulaitis** Enhancing macrophyte monitoring in Lithuanian rivers: unveiling the best assessment indices

15:00 **Paweł Tomczyk** Macrophyte Index for Rivers as a tool for evaluating the impact of hydropower on Bóbr River ecosystems in Poland

15:15 **Chad Keates** Using genetics to 'Root Out' non-native *Vallisneria* in Florida

Session 2 Biotic interactions

16:00 **Afonso Petronilho** Contrasting flower biology and reproductive patterns of two threatened *Utricularia* L. species in Portuguese ponds

16:15 **Sándor Szabó** High pH is an inhibiting mechanism of submerged plants against free-floating competitors

16:30 **Haowu Cheng** Interactions between submerged macrophytes and plant-associated toxic cyanobacteria

16:45 **Arie Vonk** Unravelling plant-microbe interactions: the role of endophytes in macrophytes

17:00 **Sebastian Palmieri** Pollinators of Florida wetlands

17:15 **Preben Clausen** A century of changes in submerged aquatic vegetation and associated waterbirds in a coastal lagoon, Ringkøbing Fjord in Denmark.

17:30 **Todd Sink** From blooms to balance: humic acid as a solution for pond eutrophication

19:30 Welcome Reception: Water Museum Barbadinhos Elevatory Station

16/09 Tuesday (Auditorium)

08:30 Desk opening/registration

Session 3A Invasiveness and control

09:00 **Samuel Schmid** Drivers of plant community invasion for small lakes in the Southern United States.

09:15 **Corentin Gaudichet** For decision-making support in order to better manage *Crassula helmsii* in France

09:30 **Elisabeth Gross** Beyond limits and control – Variable-leaved milfoil extending its ecological niche in small-gauge channels in North-Eastern France?

09:45 **Jesse Beyer** *Myriophyllum rubricaule* (Haloragaceae) revisited, a search for the origin of an invasive species

10:00 **Megan Reid** Managing a beautiful monster: efforts to improve management of waterhyacinth *(Pontederia crassipes)* in South Florida, USA.

10:15 **Deborah Hofstra** Native macrophyte response to invasive weed removal

10:30 **Susanne Schneider** *Juncus bulbosus* mass development: towards sustainable solutions for Norway's waterways

10:45 Coffee & Tea Break

Session 4A Riparian and aquatic plant dynamics and succession

11:15 **Emanuele Pelella** Vegetation resurvey using adjusted sampling methodology highlights the dynamism of aquatic plant communities in a Mediterranean river over a decade

11:30 **Francisca Aguiar** Going down and across the river: how aquatic and riparian plants cope with regulated flows

11:45 **Claudia Irene Ortiz-Arrona** Riparian ecological status in the El Cangrejo-Jalocote watershed, Jalisco, Mexico

12:00 **Jacqueline Hoppenreijs** Not fewer, but different species: the effects of flow regulation on riparian vegetation

12:15 **Sofia Santos** Unveiling riparian vegetation dynamics using aerial, UAV high-resolution imagery and LiDAR

12:30 Lunch

13:30 **Keynote Lecture** Anne Lewerentz, Antonella Petruzzella, Lindsay Trottier, Michał Brzozowski. Rooted in the future: an ECR perspective of aquatic plant research

Session 4B Riparian and aquatic plant dynamics and succession

14:30 **Sabine Hilt** Frequency, causes and consequences of boom-bust dynamics: lessons from invasive and native aquatic plant dynamics

14:45 **Sara Puijalon** Anchoring of aquatic plants: role of architectural and biomechanical root traits

15:00 **Ewan Shilland** 30 years of aquatic plant surveys in the UK upland waters monitoring network

15:15 **Enhua Li** Evolution and ecological restoration of Honghu Lake

15:30 **Kerstin Bouma** Multi-year water level drawdown and grazing drive wetland vegetation succession

15:45 Coffee & Tea Break

Session 3B Invasiveness and control

16:15 **Brittany Chesser** Investigating herbicidal susceptibility of bladderwort *(Utricularia radiata)*

16:30 **Gray Turnage** Integrating chemical and biological control of alligatorweed *(Alternanthera philoxeroides):* submersed herbicides and thrips

16:45 **Maria Rita Minciardi** Fight against *Myriophyllum aquaticum* and *Elodea nuttallii* in Po River (Italy).

17:00 **Maxwell Gebhart** Using machine learning techniques to predict the spread of invasive species: *Cyperus blepharoleptos* as a case study.

17:15 **Jonathan Newman** Using the adjuvant TopFilm to improve herbicide control of Invasive Aquatic Plants

17:30 **Madison Self** Comparative analysis of light response of *Pontederia crassipes* and its *congener P. cordata* in invaded regions

17/09 Wednesday

Mid-Symposium Excursions

18/09 Thursday (Auditorium)

09:00 Desk opening

09:00 **Short Talk Between Science & Art**
David De La Haye The Voice of Aquatic Plants

Session 5 Aquatic plant collaborations: insights from emerging projects and growing networks

09:15 **Udo Schwarzer** The IUCN SSC Freshwater Plant Specialist Group update on activities

09:30 **Anne Lewerentz** Tracking aquatic plant phenology across Europe: first insights from the EUPHORIA Project

09:45 **Janne Alahuhta** Introducing research project on historical and contemporary environmental changes of macrophytes in Europe and North America

10:00 **Lindsay Louise Trottier** The Macroecology of Aquatic Plant Functions (MAP) Project: exploring the functional and environmental trait space of macrophytes

10:15 **Gray Turnage** Understanding phenology of invasive aquatic plants to inform management initiatives in the United States

10:30 **Rossano Bolpagni** iMAD: updating ecological and functional knowledge on macrophytes in Italy

10:45 Coffee & Tea Break

Session 6A Macrophytes and global change

11:15 **Angelo Troia** Biodiversity in Italian rice fields: a test with aquatic macrophytes

11:30 **Jael Palhas** Updates to the Portuguese aquatic flora

11:45 **Esperança Gacia** Macrophyte community responses to environmental change in alpine Pyrenean high mountain lakes

12:00 **Mariusz Pełechaty** Biomass production and $CaCO_3$ precipitation by charophytes: environmental implications and carbon sequestration

12:15 **Mateja Germ** Long-term research of the distribution of macrophytes in Alpine Lake Bohinj (Slovenia)

12:30 **Jose Luis Moreno** Macrophyte communities in the reference network of Spanish rivers: river types and indicator species

12:45 Lunch

Session 7A Nature-based solutions, conservation and management

13:45 **Astrid Biddle** Nature-based measures increase freshwater biodiversity in agricultural catchments

14:00 **Daniel Larkin** Quantifying aquatic plant species' commonness and coexistence to guide conservation and management

14:15 **Jennifer Bishop** Illinois pondweed common nursery and reciprocal planting research

14:30 **Krzysztof Szoszkiewicz** Environmental drivers of macrophyte communities in urban aquatic nature-based solutions across Europe

14:45 **Fei Ma** The effect of trait-based diversity on productivity in macrophyte communities

15:00 **Ioannis Bazos** Interpretation of the Greek Natural Capital: exploring the diversity of freshwater plants and habitats

15:15 Coffee & Tea Break

Session 6B Macrophytes and global change (Auditorium)

15:45 **Paulo Lemos** The effects of industrial agriculture on residual populations of rare aquatic macrophytes in Western Portugal.

16:00 **Daniel Gebler** Influence of environmental factors on macroalgae development in lowland rivers

16:15 **Vincent Bertrin** Effects of lakeshore hydromorphological alterations on isoetids and invasive species in two Lobelia lakes in South-Western France

16:30 **Michał Brzozowski** Experimental testing of the effects of warming on periphyton, submerged vascular plants and charophytes in heated temperate lakes

16:45 **Cristina Ribaudo** Carbon fluxes under the littoral wet-dry continuum of natural shallow lakes

17:00 **Manuela Ramírez Valle** Macrophyte communities of Mediterranean Spanish rivers: diversity and indicator species

17:15 **Alice Dalla Vecchia** Using functional biogeography to study global plant invasions in freshwater systems

Session 8 Ecophysiology of aquatic plants (Room *Nymphaea*)

11:15 **Giulia Lodi** Spatiotemporal variation in C:N:Si stoichiometry of *Cyperus papyrus*: insights from herbaria and field studies

11:30 **Michał Rybak** Al- Inclusive: an unintentional journey of aluminum through a food chain during lake restoration

11:45 **Takashi Asaeda** The characteristics of H_2O_2 generation in submerged plants under a flowing environment and its mechanism

12:00 **Mégane Jeanmougin** Anthropogenic pressure of aquatic ecosystems: isolated and combined effect of night-time light pollution and temperature on the ecophysiology of aquatic plant species

12:15 **Yang Liu** Divergent stomatal strategies in heterophyllous aquatic plants: Reduced hydraulic investment in floating leaves and enhanced gas exchange in emergent leaves

12:30 **Amine Mohamed Mahdjoub** Physiological response of submerged freshwater macrophytes to multiple stressors: current knowledge and future research directions

12:45 Lunch

13:45 **Suting Zhao** Studies on germination characteristics and mechanisms of vitality maintenance in aquatic plant seeds

Session 9 Aquatic plant genetic diversity and evolution (Room *Nymphaea*)

14:00 **Elisa Denis** The intraspecific diversity of macrophytes in European pondscapes

14:15 **Maria Adelaide Iannelli** Reticulate evolution at the origin of duckweed diversity and shapes its evolution

14:30 **Vojtech Dolejsek** First molecular insight into Pannonian *Batrachium:* revealing high diversity and distant origins

14:45 **Yu Ito** Cryptic diversity of *Monochoria* (Pontederiaceae) with description of two new species

15:00 **Yuri Lee** Hybridity of mainly asexually propagating duckweeds of genus *Lemna* - dead end or breakthrough?

15:15 Coffee & Tea Break

Session 10 Pollutants and the use of aquatic plants in water treatment (Room *Nymphaea*)

15:45 **Udo Schwarzer** Aquatic plants for maintaining recreational water quality

16:00 **Gergo Koleszar** Biofiltration potential and toxicity assessment of ionic gadolinium using free-floating aquatic plants: *Lemna gibba* and *Pistia stratiotes*

16:15 **Viktor Oláh** Duckweed turions can be used as reference biomass in monitoring water pollution

16:30 **Manli Xia** Impacts of rosette and canopy macrophyte communities on water quality and aquatic plant reproduction in shallow lakes

16:45 **Xiumei Zhang** The effects of downward transportation of lanthanum-modified bentonite on phosphorus inactivation and submerged macrophyte growth

17:00 **Xiaolin Zhang** Ecological functions of submerged macrophytes diversity and a case study of restoration in eutrophic plateau shallow lake

17:00 **Luke Huffman** Using the asterisk survey method to examine effects on macrophyte and macroinvertebrate biodiversity in Wisconsin lakes

19:30 **Conference Dinner: Welcome Reception**

20:00 **Conference Dinner: Seated Dinner**

19/09 Friday (Auditorium)

Session 7B Nature-based solutions, conservation and management

09:00 **Silvia Cannucci** Diversity and conservation value of farmland ponds: identifying key sites and drivers

09:15 **Thomas Abeli** First systematic assessment of germination requirements in the endemic quillwort *Isoëtes malinverniana*

09:30 **Lindsay L. Trottier** Aquatic macrophytes as nature-based solutions: challenges and opportunities across inland and marine waters

09:45 **Krister Karttunen** Aquatic bryophytes in deteriorating rivers

10:00 **Tafara Frank Bute** Does heavy metal pollution from acid mine drainage undermine the biological control of water hyacinth, Pontederia crassipes in invaded East Rand wetland systems in South Africa?

10:15 **Antonella Petruzzella** Critical light and nutrient conditions for shifts between charophytes and vascular aquatic plants: Implications for charophyte restoration in hardwater lakes

10:30 Coffee & Tea Break

11:00 **Fred Lubnow** The management of submerged aquatic vegetation to prevent the development of harmful algal blooms

11:15 **João Neiva** Endangered aquatic halophytes in a cultural landscape: importance and habitat partition in man-made habitats

12:00 **Meeting of the IAPG Scientific Committee** *(by invitation only)*

12:00 Boxed Lunch

Poster Sessions

Session 1 New tools and approaches for the monitoring of aquatic plant ecosystems

Dagoberto Martins Immersed aquatic plant movement inside the 'Jupiá' hydroelectric reservoir in the 'Paraná' River, Brazil

Liucija Kamaitytė-Bukelskienė Use of seed bank to assess the status of protected aquatic plants in Lithuania

Alexander Plakias Large-scale monitoring of *Azolla filiculoides* in river systems using Sentinel 2 imagery and random forest classification in the Google Earth Engine

Rodrigo Felipe Bedim Godoy Remote sensing of submerged aquatic vegetation in an optically complex fluvial lake using Sentinel-2 and Google Earth Engine

Sara Puijalon Monitoring of large stands of riverine submerged aquatic plants using Planet satellite imagery

Angelo Troia Not only birds: the essential role of vegetation in wetland conservation

Session 2 Biotic interactions

Angelo Antonio Agostinho Association between fish abundance and macrophytes: exploring the importance of functional traits

Janne Alahuhta The signature of biotic interactions on lake macrophytes differs among seven metacommunities of three continents

Sarkhan Ibrahimov Seasonal biomass dynamics and interactions of *Nitellopsis obtusa* with other macrophytes in charophyte- versus angiosperm-dominated lakes: implications for biodiversity and invasion ecology

Session 3 Invasiveness and control

Andrea Bertol Short- and medium-term effects of jute benthic barriers on the control of Eurasian watermilfoil (*Myriophyllum spicatum*)

Beatrice Fois Genomic and functional approaches to explore the role of environment in the adaptation and diversification of invasive aquatic plants

Dan Larkin Does relatedness between invasive and congeneric native macrophyte species influence invader success in lakes and rivers worldwide?

Kara Foley Addressing the challenge of submersed aquatic weed management in flowing systems in the United States

Samuel Schmid Alligatorweed thrips is a better climate match for the host than conventional agent

Paolo Villa Investigating phenological characteristics of two invasive macrophytes across gradients using satellite data time series

Session 4 Riparian and aquatic plant dynamics and succession

Justyna Hachoł Macrophyte elements in near-nature river regulation – hydraulic research

Justyna Hachoł Long-term changes in aquatic macrophyte communities after river regulation - analysis of succession and ecosystem dynamics

Laura Grīnberga Growing distribution of *Hydrilla verticillata* in Latvia and Lithuania – good news?

Eva Papastergiadou Riparian landscape dynamics, ecological integrity, and ecosystem services in east Mediterranean rivers

Session 5 Aquatic plant collaborations: insights from emerging projects and growing networks

Giulia Lodi The charm(s) of Duckweed 2.0: breathing new life into the duckweed knowledge hub website

Lindsay Louise Trottier The New Macrophyte Researchers Group: a network for students and early-career researchers

Session 6 Macrophytes and global change

Christian Chauvin Ecological traits for improving macrophyte-based Indicators

Donatas Naugžemys Aquatic plant communities: what can we expect as temperatures change?

Małgorzata Gałczyńska Condition of lobelian lakes in the Nature 2000 area. The case analysis of Bobolice lobelian lakes, PLH320001

Maria Rita Minciardi A repertory of aquatic macrophytes and herbaceous species most frequent and widespread in the river corridor and wetland in Italy

Cristina Ribaudo Carbon and nitrogen stock and sequestration in oligotrophic temporary ponds of South-West of France

Session 7 Nature-based solutions, conservation and management

Ana Caperta Long-term cultivation of salt marsh sea lavenders under high saline conditions affects plant physiological status and growth performance

Antonio Camargo Spatial variation in biomass, richness and species pool of aquatic macrophytes in subtropical and tropical estuaries

An Leyssen Abiotic characteristics and local conservation status of protected freshwater habitats in Flanders (Northern Belgium)

Konstantinos Stefanidis Filling the Wallacean shortfall of the aquatic quillworts in Greece

Maxwell Gebhart Phenological and morphological trends of *Vallisneria* in North America

Maria Sarika Aquatic plant communities rarely occurring in freshwater habitats of Greece

Eli Russell Evaluating abrasive weeding as a potential method for controlling floating aquatic plants

Abha Panda To revegetate or not: a meta-analysis of aquatic plant community outcomes with and without active revegetation

Manuela Ramírez Valle The reference network of Spanish rivers: defining bryophyte communities of national river types

Łukasz Łucza The use of edible aquatic and emergent plants in Eastern Europe

Session 8 Ecophysiology of Aquatic Plants

Cibele Chalita Martins Breaking dormancy of *Ceratophyllum demersum* seeds

Katharina Wilfert Defining the spatial variation of plant responses to hydrodynamic flow in a submerged macrophyte patch

Session 9 Aquatic plant genetic diversity and evolution

Boissezon Aurélie Conservation genetics of *Chara strigosa* A. Braun and its ecologically and morphologically related species in Switzerland

Duarte Frade Cryptic diversity and conservation of euryhaline seagrasses, *Ruppia*

Jose Luis Moreno Alcaraz *Fluvioralfsia iberica* gen. et sp. nov., Fluvioralfsiaceae fam. nov.: the first freshwater member of the Ralfsiales (Phaeophyceae), collected from streams in Spain

Petr Koutecký Origin of *Ranunculus fluitans*: from vernal pools to permanent rivers and from the south to the north?

Sidinei Magela Thomaz Asexual reproduction of aquatic macrophytes via stem fragments: A review on determinants of plant fragmentation and propagule dispersal

Session 10 Pollutants and the use of aquatic plants in water treatment

Małgorzata Gałczyńska Multiple stress effects of static magnetic field and heavy metals on the growth of *Ceratophyllum demersum*

Keynote speakers

Will the crystal ball tell us something about the future of aquatic plant research? - A dialogue

Jan E. Vermaat[a] & Elisabeth M. Gross[b]

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We have shared editorial responsibility for the journal Aquatic Botany for quite some years and collected invited reviews in a special issue to celebrate its 40-year anniversary under the title 'Aquatic botany since 1975: have our views changed?' We concluded in 2016 that 'our conceptual thinking has matured and our method has become more rigorous', but modestly argued that this is an 'on-going process', and we concluded that we would not 'speculate where and how the research fronts have developed'. During this conference, we take the opportunity to explore several research fronts that we personally find challenging, promising, due for revision, sadly neglected, or very new and refreshing. We decided to choose the dialogue as a more constructive format then a classical conference monologue and we will engage the audience in an attempt to lift our reflections beyond our personal and possibly subjective views. Specifically, but not exclusively, we will discuss the following topics: (a) is it time to get out of the shadows of terrestrial botany? (b) has the use of aquatic macrophytes as indicators for water quality monitoring, as for the European Water Framework Directive, channelled away our attention from in-depth ecological research? . (c) molecular genetics versus the classical morphological species delineation in herbaria: who will win? (d) will the increasing use of e-DNA as well as big data crunching cause an increasing distance between researcher and what really happens ecologically in streams and lakes? (e) the focus on functional traits needs underpinning in the evolutionary significance for our long-lived and often highly clonal plants. (f) the focus on macrophytes, and notably seagrasses, as producers of blue carbon is wonderful as justification of our work, but ignores the rapid decay of this carbon. (g) whereas eutrophication issues have steered our work for decades, we may have to adjust our focus on other drivers and pressures (h) what happened to allelopathy – was it too difficult an issue to resolve? This year is the 50th anniversary of "Aquatic Botany" and we are curious to discuss with you if and how our views have evolved in the past 10, 20, … 50 years and more.

Jan E. Vermaat
Research Dean

Elisabeth M. Gross
Professor

Rooted in the future: an ECR perspective of aquatic plant research

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Aquatic ecosystems face complex and interconnected challenges - from climate change and unprecedented biodiversity loss to pressing management questions. Now, more than ever, we must take a diversified approach and incorporate fresh perspectives to tackle these challenges. Fresh perspectives can emerge from the development of new technologies and methods, interdisciplinary approaches, and growing computational power, while remaining deeply rooted in overarching ecological principles, rigorous science, and the historical development of the field. This keynote panel explores how early career researchers (ECRs) in the aquatic plant community see the future of macrophyte research. Based on a recent survey of ECRs, the discussion highlights priority areas where the field can expand, innovate, and respond to global ecological demands. Based on this, the panellists present potential theoretical, technological, and methodological advances, weaving in their own perspectives and offering unique reflections based on their field and laboratory experiences. Finally, the panel discusses the importance of networking as an ECR, and opportunities for ECRs to develop professional and social networks that facilitate engagement, information exchange, knowledge generation, and foster lasting collaborations to advance aquatic plant science. Through this talk, we reflect on how ECRs are building a macrophyte science that critically engages with the past, while extending its roots into the future. Strategic collaboration with, and among, the next generation will be key to effectively addressing environmental challenges.

This keynote panel is comprised of:

Anne Lewerentz

a postdoctoral researcher at the Karlsruhe Institute of Technology (Germany). She addresses key questions on patterns, drivers and trends in the distribution, species richness, and phenological traits of aquatic plants.

Lindsay Trottier

a PhD Candidate at McGill University (Canada). Her research focuses on the functional ecology of aquatic plants across scales, and explores how macrophyte functional traits vary in response to environmental conditions and spatial drivers.

Antonella Petruzzella

a postdoctoral researcher from the Global South at the Leibniz Institute of Freshwater Ecology and Inland Fisheries (Germany). Her research explores freshwater biodiversity, ecosystem structure, function and services recovery after anthropogenic stressors, focusing on improving management and restoration actions to promote the recovery of aquatic plants.

Michał Brzozowski

a Principal Investigator at the University of Life Sciences in Poznań (Poland). He is researching ecological interactions among microscopic and macroscopic algae (Characeae), macrophytes, and vascular plants, with a focus on the fish–periphyton–charophyte system and plant competition dynamics in freshwater ecosystems.

Short Talk

Short Talk Between Science & Art| The Voice of Aquatic Plants

David de la Haye (United Kingdom)[1]

[1] School of Arts and Cultures, University of Newcastle

Listening to the underwater sounds of freshwater ponds reveals a complex soundscape that has existed for millennia yet remains a mystery to most, even now. A key voice in these habitats belongs to the aquatic plants. The process of oxygenation creates rapid streams of bubbles which is experimentally used to measure plant stress. But the exquisite rhythms and timbres that they produce also provide the impetus for musical response, establishing an interspecies dialogue with plants and encouraging a deeper relationship to freshwater ecologies. Sensitive hydrophones serve as a timely reminder that in an age of technological innovation nature's beauty continues to inspire. David de la Haye's creative practice investigates the use of sonic arts to raise the cultural value of freshwater. His album With Ears Underwater was nominated for a coveted Ivor Novello Composer Award in 2022, for the track 'Plant Based Patterns'. Instead of holding nature with reverence in a picturesque rural landscape, it seeks to explore the interconnectedness of our acoustic landscape through a making-with approach to music. The spontaneous sound-making of aquatic plants is echoed in the responses of three freely improvising musicians tasked with creating instrumental repertoire based on underwater recordings. Many of the location recordings were made during Sonic Pond Dipping workshops, a creative methodology for engaging with ecoacoustics and more-than-human listening in freshwater habitats. As an art-science curator, David has found his way onto the programmes of international conferences such as INTECOL2022, SEFS13, and World Biodiversity Forum, but he is especially pleased to be able to sound the voice of aquatic plants at the IAPG Symposium.

David de la Haye is a PhD Researcher in Music: 'The Art of Freshwater Soundscapes in the Age of Remote Monitoring';
www.daviddelahaye.co.uk

Abstracts

New tools and approaches for the monitoring of aquatic plant ecosystems

Chairs:

Session 1A: Michelle T. Casanova (Federation University, Ballarat, Australia) & **Seppo Hellsten** (Finnish Environment Institute-SYKE, Finland)

Session 1B: Susanne Claudia Schneider (Norwegian Institute for Water Research – NIVA, Norway) & **Raymond Newman** (Fisheries, Wildlife, and Conservation Biology, University of Minnesota, USA)

Setting the tone for the days ahead, the opening session paves the way for the symposium by exploring the transformative role of innovation in measuring ecosystem health, monitoring and managing aquatic plant ecosystems. Presenters present the advancements in technology, software, and methodologies that enhance our ability to conduct biodiversity assessments and biomonitoring, and increase our knowledge in the field of environmental biology. Through case studies spanning marine and freshwater environments, the session highlights large-scale assessments and ecosystem management efforts, but also the assessment of rare and cryptic aquatic plant species. Topics include spectral and functional diversity, vegetation dynamics, ecological modelling, and the evaluation of management outcomes using both remote sensing tools, such as satellite time-series data and drone imagery, and field-based methods. Other emerging areas are tackled, in particular eDNA and molecular ecology. The session underscored the value of integrating emerging techniques with established practices to develop more effective, data-driven conservation and monitoring strategies.

Silvia Huber, Lisbeth Tangaa Nielsen, Nicklas Simonsen, Preben Clausen, Claus Lunde Pedersen, Mikkel Hoeegh Bojesen

DHI Denmark
Department of Ecoscience, Aarhus University, Denmark

Combining satellite remote sensing and deep learning for large-scale monitoring of shallow marine plant ecosystems – use cases from Scandinavia - Oral presentation

Coastal waters are highly productive and diverse ecosystems, particularly if dominated by belts of submerged aquatic vegetation (SAV). SAV, including diverse macroalgae and seagrasses, thrives below the water surface in coastal and estuarine areas. The presence, type, and abundance of SAV are key indicators of the ecological status and environmental state of these waters. Aquatic vegetation, particularly seagrass, provides critical ecosystem services, including habitats and spawning grounds for many different marine species and feeding areas for a variety of waterbirds. Due to the essential ecosystem functions coastal plant ecosystems provide, up-to-date knowledge about their abundance and growth dynamics is essential for assessing the impacts of management and conservation efforts and monitoring overall marine health. However, the highly fragmented nature of SAV, with patches of diverse communities, makes monitoring and mapping challenging. Traditional methods, such as field-based observations through diving or acoustic technologies, and newer methods like aerial and underwater drones, provide very valuable and detailed information, yet with some limitations: they often cover only small areas, making them unsuitable for large-scale assessments, and are labor-intensive, often hindering consistent, repeatable mapping. This limits our ability to comprehensively understand the abundance and dynamics of these underwater coastal communities on a large scale. Yet, accurate and timely information about the status and trends of shallow marine habitats is essential for effective management and conservation. At a large scale, analyzing free satellite imagery is the only cost-efficient method that can facilitate operational and consistent monitoring of SAV. All year-round and systematic satellites can cover large areas quickly and repeatedly, allowing the assessment of different vegetation stages during the growing season in shallow waters that are sufficiently clear and under cloud-free conditions. In our presentation, we demonstrate the potential of free Copernicus satellite imagery for SAV monitoring in different use cases from Denmark and Sweden, for example, how satellite imagery is integrated into national operational monitoring systems to support requirements of the EU WFD, the MSFD, the HD and the EU Nature Restoration Law. An example from Denmark demonstrates how satellite-derived time-series of SAV are converted into biomass estimates, how herbivorous waterbirds respond numerically to variations in these estimates, and how these satellite-derived data potentially can assist in evaluating to which extent Special Bird Protection Areas designated for this species-cluster can be evaluated as being in high, good, moderate, poor or bad ecological status.

Paolo Villa

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

Linking spectral, phylogenetic and functional diversity of wetland plant communities - Oral presentation

Given the global threats to freshwater ecosystems, the conservation of aquatic plant diversity has emerged as a priority area of concern. In the last decade, remote sensing has facilitated the measurement of biodiversity, particularly in terrestrial biomes. The combination of spectral features with additional information derived from community phylogeny can further advance the accurate characterisation of plant functional diversity across scales. In this study, we investigated the potential of using spectral features extracted from centimetre resolution hyperspectral imagery collected by a drone, in conjunction with phylogenetic features derived from a fully resolved supertree, to estimate functional diversity (richness, divergence and evenness) in floating hydrophyte and helophyte communities sampled from different sites. We used non-linear parametric and machine learning models. The results show that all three functional diversity metrics can be estimated from spectral features using machine learning models (random forest regression; R^2 = 0.90-0.92), whereas parametric models show inferior performance (generalised additive models; R^2 = 0.40-0.79), especially for the estimation of community evenness. The integration of phylogenetic and spectral features improves the predictive ability of machine learning models for functional richness and divergence (R^2 = 0.95-0.96), although this benefit is significant only for the estimation of community evenness when parametric models are employed. The combination of imaging spectroscopy and phylogenetic analysis provides a quantitative means of capturing the diversity observed in plant communities across scales and gradients, which is valuable to ecologists involved in the study and monitoring of biodiversity and related processes.

Robert Richardson, Andrew Howell

North Carolina State University, United States of America

Incorporating drones into US aquatic plant management and monitoring - Oral presentation

Unmanned aerial systems (UAS, 'drones') are being readily utilized by aquatic plant managers in the United States. Aerial imaging technology has shown the ability to enhance mapping and monitoring of dynamic field sites while increasing survey efficiency for aquatic weed populations. Additionally, specialized drone equipment [unoccupied aerial application systems (UAAS)] can also dispense herbicides, reducing applicator exposure risk and limiting physical in situ disturbance. Initial case studies with aquatic plant management drones in the United States include applications in large reservoir systems, small ponds, remote wetland spaces, and major rivers, among others. To date, limited data are available which directly compare application strategies between UAAS and boat-based treatments in aquatics. We evaluated UAAS against standard operations for managing giant salvinia (*Salvinia molesta*) in Lake Moultrie, South Carolina and variable-leaf watermilfoil (*Myriophyllum heterophyllum*) control in remote North Carolina ponds. Results from the giant salvinia study showed plant control was similar between UAAS and boat-based systems; however, the UAAS decreased spray loss to the water column and increased spray efficiency by 2.6 times. For variable-leaf watermilfoil, results indicated some variation in control based upon the UAAS treatment pattern utilized, with grid-point application techniques providing analogous control and dissipation patterns as the standard operation tested. Discussion will include the importance of selecting the most appropriate UAAS delivery method of herbicide to achieve foliar and in-water aquatic plant control. Overall, these case studies documented the first comparisons of how drones can enhance standard management operations by increasing the efficiency and efficacy of both submersed and free-floating invasive aquatic plants.

Rui Zhou, Chao Yang, Enhua Li, Xiaobin Cai, Suting Zhao, Yingying Zhang, Shiyan Liu

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Changjiang Basin Ecology and Environment Monitoring and Scientific Research Center, Changjiang Basin Ecology and Environment Administration, Ministry of Ecology and Environment, China
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Hubei Key Laboratory of Big Data in Science and Technology, Wuhan Library, Chinese Academy of Sciences, China
Zhengzhou Normal University, China

Monitoring and analyzing the dynamics of *Zizania* floating mats with PlanetScope imagery and Google Earth Engine - Oral presentation

Zizania latifolia, a dominant emergent macrophyte in Honghu National Wetland Nature Reserve, has been observed to form floating mats due to water level fluctuations and wind-waves, leading to significant detrimental impacts on both water quality and biodiversity. The key to controlling and monitoring the spread and movement of *Zizania* floating is the early detection of outbreaks and the clarification of its formation mechanisms in response to water levels and wind actions. This study develops a timely and accurate monitoring method for *Zizania* floating by calculating the Normalized Difference Vegetation Index (NDVI) from high spatiotemporal resolution PlanetScope (PS) imagery and building a decision tree on the Google Earth Engine (GEE) platform. We extracted the continuous movement trajectories of *Zizania* floating from May to September 2019 in Honghu Wetland. Subsequently, we analyzed the interrelationship between the formation of *Zizania* floating and hydrometeorological factors. We then investigated the effects of *Zizania* floating on water quality and biodiversity. The results show that: (1) The integration of PS imagery and the GEE platform holds the potential to simplify the workload of remote sensing data processing. Due to the relatively large patch size of the *Zizania* floating mats and the high spatial resolution of PS imagery, the boundary between water bodies and floating mats could be clearly identified through visual interpretation. Based on manual interpretation, the dynamic expansion and reduction areas of the *Zizania* floating were successfully extracted by setting the threshold at 0.3, enabling timely and accurate tracking. (2) Abrupt fluctuations in water levels during brief time intervals serve as the primary trigger for *Zizania* floating. Additionally, wind speed during the same timeframe acts as a catalyst for the emergence of *Zizania* floating, with wind direction influencing its movement. (3) The outbreak of *Zizania* floating significantly elevates the concentrations of total nitrogen (TN), total phosphorus (TP), chemical oxygen demand (CODmn), and total ammonia nitrogen (TAN), while concurrently reducing the dissolved oxygen (DO) concentration in water bodies. (4) Based on field investigations, the movement of *Zizania* floating mats was found to cause physical damage to aquatic vegetation along their paths. Combined with associated water quality deterioration, these factors contribute to biodiversity loss by inhibiting growth and altering habitat conditions. Prompt, accurate, and cost-effective detection strategies for *Zizania* floating mats are essential to mitigate their ecological impacts.

Andrew Howell, Kara Foley, Robert Richardson

North Carolina State University, United States of America

Technology development and advancement in aquatic plant management

Oral presentation

Effective management of water resources is inherently challenging due to the complex nature of aquatic ecosystems. Limited site access often restricts management and monitoring opportunities, and these activities generally require labor-intensive techniques that confine the overall scale and feasibility. Traditional practices for monitoring and controlling invasive aquatic plants also demand considerable expertise and time. However, technological development and advancement in the last 25 years have shown great promise for modernizing and enhancing these efforts. Innovations in GPS, satellites, hydroacoustic (sonar), smart devices, and remotely piloted systems (drones) have significantly improved our ability to more accurately assess plant dynamics and direct management activities. These technologies offer further benefits, including faster and more detailed plant surveys and enhanced environmental and human safety during monitoring and management events. Yet, questions remain: Are these technologies as reliable as conventional methods? Can they replace many established plant evaluation and control practices? This presentation will explore the latest technological developments, discuss regulatory and practical considerations, and examine their potential to reshape the future of aquatics. Perspectives from use cases in the United States will help highlight and inform reasons why or why not to implement technology into aquatic plant management. We compare findings of point-intercept, sonar, and aerial image capture survey methods to understand the varying degrees of time, expertise, and precision each provides. Results from annual surveys conducted at Chautauqua Lake, New York, largely suggest that technology offers unique opportunities to meet the demands of aquatic weed management. While each survey method provides value independently, the most effective approach occurred when these technologies were deployed either synchronously or sequentially. However, there remains a clear need to develop programs in aquatics that improve technology usage and fill application gaps based upon present technical expertise in this field of study.

Raymond Newman, Maija Weaver

Fisheries, Wildlife, and Conservation Biology, University of Minnesota, United States of America
FWCB, University of Minnesota, United States of America

Use of a multi-value assessment approach to assess macrophyte response to lake management - Oral presentation

Numerous approaches have been used to assess aquatic macrophyte response to management. including macrophyte occurrence or cover, relative abundance, biomass, species richness, floristic quality and multi-metric indices. Researchers often use one or more of these approaches with formal statistical analyses to compare responses to management, but managers like criteria to assess the status of their lake or as a goal for management or restoration outcomes. We explored the ability of a new multi-value index approach developed by Weaver to assess the response of aquatic macrophytes to various management actions (carp removal, alum treatment, herbicide treatments and combinations thereof). The approach included an index of macrophyte community health (Beck's IBI, B-IBI), a new Invasive Species Index (ISI) and a new Single-species Dominance Index (SDI). The IBI reflects the health and diversity of the plant community independent of invasive species, the ISI reflects the coverage and relative abundance of invasive species (curly-leaf pondweed and Eurasian watermilfoil in these lakes) and the SDI reflects the coverage and relative abundance of the most common plant taxon in the survey. The response to each value can be assessed independently. We evaluated the responses of Twin Cities Metro lakes to management (before and after) using the three indices. For mean response to alum treatment in 7 lakes (2011-2023) before ($n = 43$) and after ($n = 23$) alum treatment, B-IBI increased (t-test, $p<0.05$), but there was no change in ISI or SSD ($p>0.14$). Similar results were seen from a single lake analysis of Lake Riley, but a subsequent herbicide treatment to control Eurasian watermilfoil resulted in a decrease in ISI (t-test, $p<0.05$), but no change in B-IBI or SSD. Carp removal in Staring Lake resulted in a significant increase in B-IBI and an increase in SSD (coontail), but no change in ISI. A subsequent whole-lake herbicide treatment resulted in decreases in all three indices; the invasives and dominant coontail were controlled, but the native plant community was degraded. Alum treatments and carp removal improved the plant community (B-IBI), whereas herbicide treatments controlled the invasives but had variable effects on IBI and SSD. Plant response varied with management, showing expected benefits but also revealing unexpected non-target effects. The multi-value index approach allows assessment of plant community health (largely native species) separately from invasive response and the response of the most common (and often nuisance) taxon, each of which addresses different management aims.

Aleksandra Marković, Susanne C. Schneider, Danijela Vidaković, Miloš Ćirić, Vladimir Petrović, Željka Milovanović, Andreas Ballot

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Norwegian Institute for Water Research – NIVA, Økernveien 94, 0579 Oslo, Norway

Developing eDNA-based methods for exploring charophyte algae diversity in lakes - Oral presentation

Over the last two decades, eDNA metabarcoding has rapidly evolved into a cost-effective and time-efficient methodology, widely used in areas such as biodiversity assessment, biomonitoring, invasive species control, and the discovery of rare, cryptic and unknown species. This has boosted a great number of new studies and the development of new methods. Still, eDNA studies on aquatic plants lag behind those on animals, as it is much more difficult to find suitable eDNA markers, but a considerable number have recently emerged. Yet, an important group of aquatic plants, the charophytes, remains neglected. Charophyte algae play a vital role in aquatic ecosystems and contribute to a better ecological status of the ecosystems. Due to their sensitivity to water quality, they have long been used for ecological status assessment of lakes. However, their diversity is often underestimated as they have great morphological plasticity and sometimes short life cycles. Within the BIOLAWEB project, we investigated charophyte algae diversity in lakes using both eDNA metabarcoding and a traditional morphological approach. Samples were collected in two saline and two freshwater lakes in Serbia, in three seasons. rbcL gene marker was used for metabarcoding and Oxford Nanopore technology for sequencing. Bioinformatic analyses were conducted using the cloud-based metagenomic platform CZID, using NCBI as a database. The aligned sequences were checked manually and the consensus sequences were then aligned with confirmed sequences from the Boldv4 database. The morphological approach revealed the presence of charophytes in three out of four lakes. Two lakes had only one charophyte species, both belonging to the genus *Chara*, while the third lake had six species belonging to three genera, *Chara*, *Nitella* and *Nitellopsis*. The eDNA metabarcoding approach detected the presence of charophytes in all four lakes, all belonging to the genus *Chara*. However, due to the high similarity of the selected rbcL barcode, the *Chara* sequences could only be assigned to two broad charophyte species-complexes (*Chara hispida* and *Chara vulgaris* complex). This study is the first time eDNA metabarcoding has been successfully used to detect charophytes in lakes. To provide species-level identification and identify representatives of all genera, further fine-tuning of the method is required, particularly in generating primers that better discriminate charophyte diversity.

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Michelle T. Casanova, David Deane

Federation University, Ballarat, Australia

Latrobe University, Australia

Using water plant functional groups to understand and manage wetlands - Oral presentation

Water plants germinate, establish, grow and reproduce according to the water regime. In Australia, we aimed to develop a hierarchical classification of water plant species into groups in relation to their response not just to water level, but water level fluctuations (depth, duration, frequency and season of inundation). Our initial objective was to determine if there were groups of species that responded to water level variation in a similar way, because it is often not possible to compare wetland species representation due to non-overlapping species distribution in different wetlands. In the initial study, traits of sixty water plant species (germination, establishment requirements, growth and reproduction related to water regimes) were analysed using cluster analysis (PATN: Belbin 1991) and three major groups were distinguished. These primary categories were Terrestrial (plants that can tolerate the minimum of waterlogging and depth, but do not tolerate long-term flooding), Amphibious (plants that require inundation for either germination, establishment or growth, but reproduce in the air) and Submerged (species that can reproduce under water). The Terrestrial group was further subdivided into Tdr (species found in terrestrial situations throughout the landscape but colonise wetlands when they are dry) and Tda (species that only colonise dry wetland areas). The Amphibious group has been further divided into ATw (species that are emergent and woody and often have aerial seed banks, serotiny); ATl (low-growing species that can germinate and persist in flooded conditions but need wetlands to dry to reproduce); ATe (emergent species that can tolerate dry conditions for long periods); ARp (herbaceous emergent species that respond to water-level fluctuations during their life-time by having morphological flexibility (e.g. heterophylly) and ARf (species with floating leaves that can tolerate drying). The Submerged group is divided into Se (species that require access to saturated soil all year round), Sr (short-lived species that require submerged conditions for their entire life) and Sk (long-lived species that require submerged conditions for more than one year). The resulting groups initially allowed the comparison of wetlands and their habitat values. However, since it was developed, the classification has been expanded to c. 2000 different species and used to 1) predict water plant occurrence, 2) predict water regime, 3) understand ecosystem responses to variation in water regime and delivery of water for the environment, and 4) predict plant assemblage change in relation to climate change.

We will provide examples of how the use of WPFGs can assist in understanding and managing ecosystems dominated by water plants.

Roel Lammerant, Jenna Hölttä, Janina Pykäri, Nishant Nishant, Anna Villnäs, Sofia Wikström, Alf Norkko, Camilla Gustafsson

Tvärminne Zoological Station, University of Helsinki , Finaland

Baltic Sea Centre, Stockholm University, Sweden

The underestimated role of intra-specific trait variability in aquatic plant trait-based studies - Oral presentation

Functional traits can be used to better understand patterns of species succession and associated ecosystem processes. To date, many trait-based studies have mainly used a single species-specific value for each trait, assuming that species turnover (i.e., change in species composition) is the main driver of trait variation. However, ecosystems like aquatic plant meadows, characterized by low species richness and high microenvironmental heterogeneity, typically exhibit higher variation within traits of a species (intraspecific trait variation; ITV) at local scales, which may even surpass interspecific trait variation. With few studies having assessed how functional traits and environmental context shape the extent of ITV in aquatic plant communities, we sought to explore (i) the extent of ITV across multiple plant organs, (ii) the influence of ITV on inference of trait-environment patterns and (iii) how environmental stress shapes the amount of ITV in functional traits. We conducted a field survey during peak biomass season in the Baltic Sea, Finland, where we sampled 20 soft-bottom communities dominated by aquatic vascular plants spanning an exposure-salinity gradient and measured four traits (maximum height, specific leaf area, maximum rooting depth, root to shoot ratio) that capture the key variation in plant life-history strategies. We found high levels of ITV across aquatic plant organs, and that ITV can have a substantial impact on the inferences of trait-environment relationships. Our results further suggest that the amount of ITV is correlated with environmental stress; however, a discrepancy exists between the response of singular traits and whole-plant functional strategies. Our results indicate that certain foundations of trait-based ecology, like the assumption that species turnover is the main driver of trait variation, may not hold true for aquatic plant communities. Furthermore, we shed light on the considerable influence of ITV on the inference of CWM shifts and on the fact that this is a recurrent phenomenon across traits.

Seppo Hellsten, Benoit Demars, Marit Mjelde, Benno Dillinger, Juha Riihimäki, Minna Kuoppala, Jens Folster, Richard Johnson

SYKE, Sweden
NIVA, Norway
SLU, Sweden

Developing distribution models of lake macrophytes, a case study from Nordic countries - Oral presentation

The implementation of the European Water Framework Directive has created an intercalibrated biology-based classification of water bodies. Classification and monitoring focus on lakes larger than 0.5 km², which means that the status of smaller lakes and ponds is unknown. In our study, we utilized national monitoring data of aquatic macrophytes and water quality with climate data from Norway, Sweden and Finland. Lake-specific data covered more than 2000 lakes and was utilized to develop species distribution models (GAM, GLM, Ensemble) for Isoetes lacustris and Potamogeton lucens, which are two key species for siliceous and calcareous lakes, respectively. Further, we utilized northern European lake survey data of water quality for over 5000 lakes larger than 0.04 km² to fill the spatial biodiversity gap. The distribution model showed that Isoetes lacustris prefers low alkalinity, clear water lakes with relatively low phosphorus content, whereas Potamogenton lucens preference was dominated by higher alkalinity and warmer climate. A model based on these habitat preferences, combined with a larger spatial water quality dataset, created distribution probability maps. Such probability maps can be utilized when estimating reference conditions of biological communities and in biodiversity mapping. These tools are useful in prioritizing restoration targets and the most valuable lakes for the protection of species. Our study is part of the EuropaBON project (Europa Biodiversity Observation Network: integrating data streams to support policy).

Konstantinos Stefanidis, Georgios Dimitrellos, Dionisis Tsoukalas, Ioanna Xynogala, Eva Papastergiadou

Department of Biology, University of Patras, GR 26500 Patras, Greece

Patterns of ecological uniqueness in rivers of Greece – analyzing local and species contributions to beta diversity within the framework of the Water Framework Directive (WFD) - Oral presentation

Beta diversity is a critical concept of conservation science, as it provides a framework for understanding spatial and temporal variations in biological communities, which are essential for effective conservation planning. Macrophytes (vascular plants, bryophytes, macroalgae, ferns, etc.) are an important component of freshwater and play a crucial role in river functioning. In Mediterranean-type rivers. macrophytes form dynamic assemblages adapted to the high seasonal and annual variability of the hydrological regime. This study investigates the ecological uniqueness of macrophyte assemblages in rivers across Greece by analyzing local and species contributions to beta diversity (LCBD and SCBD). LCBD represents the ecological uniqueness of a site, while SCBD reflects the relative influence of each species on beta diversity patterns. Using Hellinger-transformed presence-absence data from over 100 river reaches on the Greek mainland, we calculated LCBD and SCBD for each site using the beta.div function from the adespatial package in R. Beta regression was then employed to examine the influence of environmental factors on LCBD and to identify the species and life forms contributing most to beta diversity. Additionally, we used the Kruskal-Wallis test to assess significant differences in ecological uniqueness among sites with varying ecological status. We hypothesized that river reaches meeting the Water Framework Directive (WFD) targets would exhibit higher ecological uniqueness in macrophyte assemblages compared to sites failing to meet these standards. Our findings show that LCBD is primarily driven by hydromorphological changes and habitat features, while emergent species were identified as the most significant contributors to SCBD. Furthermore, sites with “Bad” and “Poor” ecological status were found to be more homogenized than those with “Good” or “High” status. The responses of macrophyte assemblages to environmental stressors reflect the overall ecological degradation of rivers and consequent loss of numerous invaluable functions. The preliminary results of the current research highlight the importance of identifying sites with high ecological value and offer useful insights for prioritizing management actions to maintain or improve the ecological status of river ecosystems.

Lukas Petrulaitis, Diana Osadčaja, Nathan Jay Baker

Nature Research Centre, Akademijos Str. 2, Vilnius, Lithuania

Enhancing macrophyte monitoring in Lithuanian rivers: unveiling the best assessment indices - Oral presentation

All Lithuanian rivers are lowland and calcareous, classified into five types (1–5) based on catchment size and slope. Although the Water Framework Directive (WFD) recommends type-specific bioassessment methods, current macrophyte monitoring in Lithuania likely does not adequately capture variations among reference communities in rivers that differ in their hydromorphological, physico-chemical, and biological characteristics. Moreover, macrophyte monitoring is conducted periodically (once every 6 years), rather than annually. While long-term periodic studies reduce randomness and year-to-year variability, annual monitoring can capture significant year-dependent fluctuations, albeit at the cost of financial and human resources. Within the new national project "Modernizing and Optimizing Biomonitoring of Lithuania Rivers", we started collecting macrophyte data for the creation of an updated river-type-specific macrophyte index for Lithuanian rivers. From July to September 2024, macrophyte data were collected from 28 sites throughout Lithuania. We assessed river types 1–5; Type 1 has a catchment area <100 km², while types 2 and 3 range from 100 to 1000 km², with slopes <0.7 m/km and >0.7 m/km, respectively. Types 4 and 5 rivers have catchment areas >1000 km², with slopes <0.3 m/km and >0.3 m/km, respectively, following the Lithuanian Environmental Protection Agency (LEPA) monitoring methodology. Additionally, we analysed macrophyte data from LEPA collected from previous years. On average, LEPA identified 12.00 ± 7.04 species per site, whereas our assessment in 2024 recorded 18.75 ± 5.44 macrophyte species per site at the same locations. Further, we found a discrepancy between the species identified by LEPA and those identified in our study. our study. There was an overlap of 31 species, while we recorded 40 unique species not listed by LEPA and we did not observe 5 species that LEPA had identified. Biodiversity quantification is not the primary focus of national monitoring programs, as the data are primarily used to assess ecological quality under the WFD. However, discrepancies between species counts have the potential to impact measures of the ecological status of the site (e.g., Ecological Quality Ratios). Moreover, the omission of certain rare macrophyte species (e.g., Ranunculus sect. Batrachium, Stuckenia × fennica) may impact their conservation status and contribute to their further decline. Our project aims to enhance ecological monitoring schemes and conservation plans for aquatic plants in Lithuanian rivers.

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Paweł Tomczyk, Justyna Hachoł, Mirosław Wiatkowski

Institute of Environmental Engineering, Wrocław University of Environmental and Life Sciences, Poland
Department of Environmental Protection and Development, Wrocław University of Environmental and Life Sciences, Poland

Macrophyte Index for Rivers as a tool for evaluating the impact of hydropower on Bóbr river ecosystems in Poland - Oral presentation

The paper presents the temporal and spatial changes of macrophyte communities on the Bóbr River in southwestern Poland, which has been used for hydropower since the 13th century. Based on the obtained results of indicator taxa, the Macrophyte Index for Rivers (MIR) was calculated, which is the reference method for assessing this biological element in Poland (the assessment of indicator taxa in selected 100-meter sections of watercourses). The study included sections upstream and downstream of six hydropower plants on the Bóbr River (Ciechanowice, Janowice Wielkie, Jelenia Góra, Pilchowice, Kraszewice, Olszna) and reference sections for the upper, middle and lower reaches, stretching for a length of about 125 km. A total of 15 research sites were designated, each 100 meters long. The MIR values ranged from 0.172 to 0.570, which corresponds to the ecological potential from bad to moderate. Based on the estimated values, it is not possible to clearly determine the impact of hydropower plants, because in three cases these values decreased in the ratio downstream-upstream hydropower facilities (from 13.35% to 84.22%), while in the remaining three - they increased (from 9.71% to 52.38%), which means a worse and better ecological potential, respectively. In comparison to the reference sections, the average MIR was lower upstream and downstream hydropower plants (respectively: 0.432, 0.373 and 0.370) - on a wider spatial scale, hydropower plants rather negatively affect macrophyte communities (in 8 out of 12 cases), while on a local scale (within facilities) these changes are not significant (average number of taxa upstream and downstream these objects unchanged). The number of identified indicator taxa taken into account in the MIR ranged from 2 to 8 (average: 5.67), upstream hydropower plants - from 4 to 7 (average: 5.60), downstream hydropower plants - from 2 to 14 (average: 5.60), so the results in these groups are comparable. The described studies are consistent with the goals of sustainable development and also concern issues important from the point of view of the Water Framework Directive, one of the assumptions of which is to achieve at least good water status in water bodies by the end of a given planning cycle. The work may also be useful for investors and officials in the context of assessing the impact of hydropower structures on the aquatic environment, e.g., as one of the elements of environmental impact assessments or water management instructions. The research was carried out within the framework of the project 2021/41/N/ST10/01450.

Chad Keates, Lyn Gettys

University of Florida, United States of America

Using genetics to 'Root Out' non-native *Vallisneria* in Florida - Oral presentation

Vallisneria, or eelgrass, is a genus of freshwater macrophytes that can be found in tropical and sub-tropical regions throughout the world. Within South and Central Florida there is one naturally occurring species, *Vallisneria* neotropicalis, which is a critical component of many aquatic ecosystems throughout its range. These plants serve as a source of food and habitat for a wide variety of vertebrates and invertebrates, and they render invaluable ecosystem services critical to the health of wetlands, lakes and rivers throughout Florida. Despite this, habitat fragmentation, the proliferation of non-natives and human-induced habitat alteration have resulted in the decline of native eelgrass throughout the state. To combat this, large-scale restoration programs have been implemented to cultivate and translocate cultured and/or wild stocks back into the wild. While this is an incredibly important initiative, it is important to note that *Vallisneria* neotropicalis is not the only species of eelgrass found in Florida. There are several non-natives, with the most notable being the hybrid of the *V. spiralis* (eelweed) and *V. denseserrulata* (Eurasian eelgrass), which have been found throughout Florida, in both freshwater ecosystems and in nurseries. These species, and their hybrids, are morphologically conserved, have similar ecologies, and can often be found in sympatry with V. neotropicalis. This makes identification very challenging even for seasoned taxonomists, which hampers restoration attempts. This is evidenced by the erroneous use of hybrids in restoration projects in the past, something which this project seeks to address with genetic analysis. The combination of Sanger sequencing and fragment analysis has emerged as a highly effective tool when confirming the species status of *Vallisneria* populations. To ensure that the eelgrass used in restoration and habitat enhancement projects in Florida is native, the Florida Fish and Wildlife Conservation (FWC) has funded the establishment of a genetics platform at the Aquatic and Wetland Plant Science Program at the University of Florida's Fort Lauderdale Research Centre. The presentation will describe the collection, sampling, and submission protocols that will be used for transplanting projects, nursery out-planting projects, and hybrid detection in existing nursery stocks. In this presentation, we will also discuss the specific extraction, amplification and sequencing techniques, which are being used to produce high-throughput and high-quality genetic results, which will be used to efficiently and confidently identify populations of *Vallisneria* throughout Florida.

Dagoberto Martins, Sidenei Roberto De Marchi, Neumarcio Vilanova Da Costa

Universidade Estadual Paulista/UNESP, Brazil
Universidade Federal do Mato Grosso/UFMT, Brazil
Universidade Estadual do Oeste do Paraná/UNIOESTE, Brazil

Immersed aquatic plant movement inside the 'Jupiá' hydroelectric reservoir in the 'Paraná' river, Brazil - Poster presentation

The purpose of this research was to develop a methodology to determine reproduction sites and their respective importance on the dissemination of *Egeria densa*, *Egeria najas* and *Ceratophyllum demersum* that are found in 'Jupiá' reservoir, in 'Paraná' River, Brazil, regarding their arrival at hydroelectric turbines. It was monitored by ten sites with a high incidence of these aquatic plants. Two sites were located at Paraná River called "horseshoe" and "mosquito" ponds; and the others eight sites were located at 'Tietê' River on marginal ponds called "witness", "muddy", "comma", "Florida", and on channel river points called "above of Bridge", "bellow of Bridge", "bay besides bridge" and "in front of Itapura beach". A plastic box with a volume of 0,14 m3 was used as a measure to place the aquatic plants taken from the river and tie them to identification buoys, this agglomeration of plants being called "plant blocks". Ten plant blocks were released by month and monitored at each study site for a year. The plant blocks were georeferenced, and the movements were evaluated every 15 days using GPS equipment, twice a month for a year. In one year,1080 plant blocks were released into the reservoir and 621 were recovered, 57.5% of the total. The sites "comma", "witness" and "muddy" ponds showed outstanding number of plant blocks (30, 20 e 19 blocks, respectively) that moved for distances higher than 500m and, consequently, left their respective sites of reproduction, these sites being the most important and responsible for problems found in the hydroelectric plant's turbines. Most of the plant blocks remained in the "Flórida" pond and only 12 block plants left the place and reached the channel of the 'Tietê' River, of 37 plant blocks that moved more than 500m away. The site "above of bridge" supplied 18 plant blocks, while the sites "below of bridge" and "bay beside Bridge" supplied 15 and 14 plant blocks on 'Tietê' river, respectively. The reproduction sites located at 'Paraná' River also contributed to supplying of immersed plant on 'Jupiá' reservoir, being observed nine plant blocks from the "mosquito" pond showing movement higher than 500m. However, "muddy" and "Horseshoe" ponds were the most important reproduction sites that contributed to the arrival of immersed plants at the hydroelectric plant. Once it was collected, six and four plant blocks came from these dispersing sites, respectively. The methodology used proved to be efficient in evaluating the movement of immersed aquatic plants inside 'Jupiá' reservoir.

Liucija Kamaitytė-Bukelskienė, Zofija Sinkevičienė

Nature Research Centre, Lithuania

Use of seed bank to assess the status of protected aquatic plants in Lithuania - Poster presentation

The evaluation of the population status of small-sized plant species in aquatic environments is often challenging. Plant surveys from boats can be inaccurate in the case of plant growth at greater depths or even when using diving in the case of soft-bottomed lakes where the vegetation is subject to mud cover in the later stages of the growing season. A potential solution to this issue is the analysis of the seed bank. In our study, we used a method of seed separation from the bottom sediments to estimate rare species composition and distribution in lakes throughout a depth gradient. Sediments were sampled at known growth sites of target species (*Najas minor, N. flexilis*) to assess the seed bank in a depth gradient and address the problem of patchiness in seed distribution. Samples were collected before the vegetation period. A series of bottom sediment samples were taken at 0.5 metres of depth intervals from the shore to the maximum depth of plant growth in a transect perpendicular to the shore. At each depth point, 1× 1 m frames were placed, and sediment samples were collected from each corner of the square using 5 cm long and 7.5 cm diameter PVC tubes. A total of four sediment samples were collected at each depth point. The samples were washed through different diameter mesh sieves, and diaspores and plant parts were sorted manually using a stereomicroscope. Seeds of all species were evaluated from the samples. For the target species Najas minor and *N. flexilis* the seed density (number per square metre) was estimated and the seeds' distribution throughout the depth gradient was evaluated. The results demonstrated that seeds were found distributed throughout the investigated areas, concentrating in depths where the highest densities of plant cover were found during the vegetation period. Most abundant in the samples were oospores of Chara species. Seeds of N. minor and *N. flexilis* were found in most of the samples, together with other species such as *Ceratophyllum demersum* and *Schoenoplectus lacustris*. The highest ratio of intact seeds to seed shells was found at a depth of 2.5 metres for N. minor and 3 metres for *N. flexilis*, comprising almost half of all seeds counted. The findings of this study suggest that populations of both species are stable and viable, since most of the samples contained broken pieces showing previously germinated seeds and potentially viable and capable of germinating intact seeds.

Alexander Plakias, Mateusz Draga

Technical University Berlin, Urban Ecosystem Science, Germany
Adam Mickiewicz University in Poznań | UAM · Institute of Environmental Biology, Poland

Large-scale monitoring of *Azolla filiculoides* in river systems using Sentinel 2 imagery and random forest classification in the Google Earth Engine - Poster presentation

The proliferation of *Azolla filiculoides*, a fast-growing invasive aquatic fern, poses a significant threat to freshwater ecosystems worldwide by degrading water quality and outcompeting native species. Its distribution is constrained by minimum winter temperatures, making its spread increasingly relevant in the context of climate change and for the development of predictive ecological models. Furthermore, the EU prescribes prevention and monitoring of invasive species, and even though *A. filiculoides* is listed in multiple countries as invasive, monitoring, especially large-scale, has not been conducted for most alien aquatic plants, nor *A. filiculoides*. This study introduces a rapid, globally scalable method for large-scale detection of *A. filiculoides* using satellite imagery and machine learning classification within the Google Earth Engine (GEE) cloud-computing platform. To capture the unique reflectance characteristics of *A. filiculoides*, we utilized spectral imagery from Sentinel-2 due to its multi-spectral capabilities, 10 m spatial resolution, and nearly a decade of data availability. Machine learning classifiers generally outperform traditional water mapping methods; Random Forests, in particular, offer a balance between computational efficiency and robust classification performance compared to more resource-intensive deep learning approaches. Accordingly, two Random Forest classifiers were trained; one for water detection based on the JRC Global Surface Water Occurrence dataset, and a second using around 1000 expert-annotated labels of *A. filiculoides* presence across 10 Sentinel-2 scenes covering multiple years and seasons. The classifiers were trained over 100 km of the Spanish Tagus River and tested on more than 850 Sentinel-2 scenes spanning eight years. It achieved high water classification accuracy (94.42%) and perfect *A. filiculoides* detection accuracy in classified water (100%), outperforming comparable methods, which report detection rates of around 70%. The primary objective is to develop a scalable and user-friendly GEE application that enables near real-time monitoring of *A. filiculoides* in global river systems. By providing high-resolution, large-scale species distribution data, the tool advances biogeographical research of aquatic plants and supports modelling of invasive spread under changing climate conditions. Additionally, it supports environmental managers and policymakers through early detection capabilities and informed decision-making for targeted management interventions. By enabling satellite-based monitoring through expert-validated training data and machine learning, our approach is a robust, cost-effective solution to address the global challenge of invasive aquatic plant spread.

Rodrigo Felipe Bedim Godoy, Christophe Kinnard, Arthur De Grandpré, Martin Laporte, Rémy Pouliot, Jean Morin, Patrice Fortin, Andrea Bertolo

Université du Québec à Trois-Rivières, Canada
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Environnement et Changement Climatique Canada, Canada

Remote sensing of submerged aquatic vegetation in an optically complex fluvial lake using Sentinel-2 and Google Earth Engine - Poster presentation

Submerged aquatic vegetation (SAV) meadows are crucial components of aquatic environments, playing several roles in ecosystem functioning. Therefore, a cost-effective monitoring of these key habitats is essential to understand the impacts of increasing environmental stressors (related to both anthropogenic actions and climate change) and also propose mitigation plans in case of their degradation. Advances in the application of Earth observation technologies, such as optical satellite remote sensing, create vast opportunities for the monitoring of spatial and temporal trends in aquatic vegetation across all types of aquatic ecosystems. In this study, we propose to apply a pre-existing classification method to a scalable cloud environment, using applied Sentinel-2 in an optically complex ecosystem. Sentinel-2, launched between 2016 and 2017, is often used to classify aquatic vegetation and detect changes over time. However, there are some limitations and challenges in using optical remote sensing for the investigation of SAV. The presence of suspended sediments and dynamic water levels are important challenges in the identification of SAV in aquatic systems. We used Google Earth Engine to collect and process Sentinel-2 level 2A images during two periods (2019 and 2022) in Lake Saint-Pierre (LSP), the largest fluvial lake in the St. Laurent River (Québec, Canada). The lake contains up to eight highly contrasted water masses with different optical and physico-chemical water properties, hindering aquatic vegetation detection. We used a method recommended for turbid waters and validated with observations in the field to identify areas of SAV and floating and emergent vegetation (FEAV) in LSP. For 2019, we obtained a preliminary global accuracy of 54%, with the worst performances found in highly turbid, deep waters. For 2022, the classification improved to 60%, probably because of the lower water level. However, in the 2022 image, some areas of high turbidity in the northern part of the system were wrongly classified as SAV. Based on those results, we conclude that there is potential in the use of satellite remote sensing in SAV identification in dynamic environments such as LSP, but prior knowledge and validation are necessary to exclude potentially large classification errors.

Léo Rasse, Julien Godfroy, Géraldine Nogaro, Florian Cordier, Danaë Feldis, Sara Puijalon, Hervé Piégay

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Monitoring of large stands of riverine submerged aquatic plants using Planet satellite imagery - Poster presentation

The high temporal resolution of satellite images has considerably accelerated the monitoring of vegetation worldwide. However, these data remain underexploited for riverine submerged aquatic vegetation due to the small size of stands of submerged aquatic plants compared to the spatial resolution of images and the scattering, reflectance and absorption of light induced by water. This study aims to overpass these limitations by testing if nanosatellites, such as Planet (planet.com), with a high spatial and temporal resolution (3m, daily acquisition), can be used to assess changes of large aquatic plant stands. For this purpose, we selected three aquatic plant stands located on the Rhône River, France, that were identified from very high spatial resolution images (15cm–25cm) acquired annually in the summers of 2017, 2018, 2019 and 2023. These images were used as validation or reference and compared with all cloud-free Planet images acquired within ± 8 days of each of them to classify submerged aquatic vegetation and water. For each Planet image, a vegetation index based on the reflectance in the green and near-infrared spectra, the GNDVI, was calculated to test whether submerged aquatic vegetation and water observed on reference images could be differentiated spectrally. As the GNDVI of aquatic vegetation and water varied greatly from one image to another, the GNDVI of Planet images was first centred on the mean to improve the consistency between images and enable classification by thresholding. For each stand, the GNDVI threshold for classifying all Planet images was determined using a Generalized Linear Model based on the GNDVI of Planet images acquired in 2018, a year marked by fairly sparse vegetation compared to other years. To minimise noise from environmental conditions (e.g., water height), the frequency of pixels classified as vegetation was calculated for each 16-day period and pixels with a frequency ≥ 0.85 were retained as aquatic vegetation, with the remaining pixels classified as water. Our results showed that aquatic vegetation and water were spectrally distinct. Moreover, the model was effective in detecting submerged aquatic vegetation without referring to high-resolution airborne data. Specifically, the model accurately classified aquatic vegetation for all years and stands, except in areas where the vegetation was sparse and did not reach the water surface. These results suggest that the model could be applied to other Planet images for similar stands, providing a valuable tool for monitoring and understanding changes in aquatic plant stands over time and supporting decision-making.

Angelo Troia, Adriana Arnal, Karl-Georg Bernhardt, Pablo García-Murillo, Riccardo Guarino, Vincenzo Ilardi, María. A. Rodrigo, Dario Salemi, Barbara Turner, Johanna Weitzel, Hendrik Schubert

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University of Sevilla, Dep. Plant Biology and Ecology, Faculty of Pharmacy, Spain
University of Rostock, Institute for Biosciences, Chair Aquatic Ecology, Germany

Not only birds: the essential role of vegetation in wetland conservation - Poster presentation

Wetlands are ecosystems of extraordinary ecological importance, often highlighted for their key role in bird conservation. They serve as crucial stopovers and nesting sites for numerous migratory and resident species, drawing attention from scientists, conservationists, and the public. However, a bird-centred focus is reductive and risks overlooking the complexity of these ecosystems and the crucial role played by other components of wetlands, particularly vegetation. Despite its critical functions, wetland vegetation receives significantly less media and scientific attention than birdlife. Most conservation and management initiatives prioritize avian species (or other animals), neglecting the fact that bird populations strongly depend on the health of aquatic vegetation. This fragmented approach risks compromising wetlands conservation, underscoring the need for a more integrated perspective that acknowledges vegetation as a key element of ecosystem integrity, functionality and resilience. Among wetland macrophytes, the alga *Chara canescens* (Charophyceae, Charales) stands out as the only known charophyte that can reproduce parthenogenetically and form oospores in the absence of male gametangia. It occurs in brackish waters, but while its parthenogenetic populations are widespread across Europe and the African Mediterranean coast, its sexually reproducing populations are exceptionally rare, with only a handful documented across Europe. Due to its ecological significance and peculiarity, *C. canescens* has become the target of the European project ProPartS (Biodiversa+) (https://proparts.unipa.it), started in April 2023; it aims to develop effective transnational conservation and restoration strategies for the species, based on targeted research carried out on the ecology, distribution and genetic of the European populations. In Fall 2024, an online meeting marked the foundation of a transnational network among the sites hosting sexual populations of *C. canescens*, including representatives from Austria, Italy, Serbia, and Spain. This preliminary goal was achieved by contacting environmental managers, policymakers, and conservation groups, directly talking in person with them and, if possible, visiting the sites with

them, establishing the basis for subsequent exchange of knowledge, best practices, and resources. Beyond protecting *C. canescens*, the project contributes to broader sustainability goals and serves as a model for future conservation efforts. It highlights the importance of stakeholder engagement and collaborative networks, and the need to integrate macrophytes and vegetation into wetlands management, ensuring these ecosystems are preserved not just as bird habitats but as complex, interdependent systems.

Biotic interactions

Session 2

Chairs:

Sabine Hilt (Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany) & **Daniel Larkin** (University of Minnesota, USA)

Aquatic plants are keystone components of freshwater ecosystems, shaping physical habitat and supporting biodiversity through a wide range of ecological functions. Their role extends beyond primary production, influencing the integrity and dynamics of aquatic environments through interactions with other organisms, including other plants, algae, fish, birds, invertebrates, and periphyton. Research on aquatic biotic relationships is still scarce, and this session presents an opportunity to highlight the multifaceted nature of these biotic relationships, emphasizing the importance of species linkages in sustaining ecosystem structure and function. By examining these interactions across spatial and temporal scales, we deepen our understanding of the ecological significance of aquatic plants and reinforce the need for a multi-biological perspective in aquatic science.

Afonso Petronilho, Silvia Castro

FLOWer Lab, Centre for Functional Ecology – Science for People & the Planet,
Department of Life Sciences, University of Coimbra, Portugal

Contrasting flower biology and reproductive patterns of two threatened *Utricularia* L. species in Portuguese ponds - Oral presentation

Under ongoing global change and dramatic biodiversity loss, conservation plays a crucial role in protecting nature. However, effective conservation relies on a deep understanding of species' biology and ecology. The genus *Utricularia* L. comprises a widespread and diverse group of mostly aquatic carnivorous plants, many of which are threatened or endemic. Their reproductive strategies remain poorly understood due to the rarity of flowering events and the challenges of studying them in their often extreme habitats. These factors, combined with the restricted distribution of many species, increase the importance of sexual reproduction for their persistence (both short and long-term) and adaptability, and make understanding their reproductive patterns even more critical. In Portugal, two free-floating, vulnerable species – *Utricularia* gibba L. and *Utricularia* × *neglecta* Lemn. – coexist in isolated, acidic, oligotrophic ponds. Despite sharing habitats, they differ significantly in size, with *U.* × *neglecta* producing notably larger flowers. This study examines their floral biology, reproductive strategies, and biotic interactions, assessing how these traits vary across populations and influence species persistence and population dynamics. We analysed floral morphology and physiology, reproductive systems, and the role of animal visits, pollen origin and pollen availability in sexual reproductive fitness, comparing both species. Additionally, we characterized species distributions and the sampling site's ecology to explore correlations between reproductive strategies and success, dispersal, and adaptability. Our results reveal striking reproductive differences: U. × neglecta, despite its heavy investment in floral attractiveness, was found to be sterile, whereas *U. gibba*, with lower resource investment, remains sexually fertile. We also found indirect evidence of insect visitation in *U. gibba*, with an associated pollen transfer and improvement in sexual fitness, despite no direct observations of said visits. Interestingly, *U.* × *neglecta* exhibits broader ecological tolerance compared to *U. gibba*. These findings provide key insights into the evolutionary and reproductive strategies of *Utricularia* species and highlight the need for species-specific conservation approaches. Understanding how reproductive traits influence population dynamics is crucial for developing conservation strategies for these threatened aquatic plants.

Sándor Szabó, Noemi Fedor, Gergő Koleszár, Mihály Braun, János Korponai, Aleksandra Kočić, Sabine Hilt, Viktor Oláh

University of Nyiregyhaza, Department of Biology, Hungary
Hun-Ren, Institute for Nuclear Research, Hungary
National University of Public Service, Department of Water Supply and Sewerage, Hungary
University of Osijek, Department of Biology, Croatia
Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Community and Ecosystem Ecology, Germany
University of Debrecen Department of Biology, Hungary

High pH is an inhibiting mechanism of submerged plants against free-floating competitors - Oral presentation

Submerged and free-floating macrophytes represent two dominant vegetation types that can alternate in controlling small, shallow water bodies such as ponds and ditches. While submerged macrophytes offer more ecosystem services and pose lower risks of anoxia and greenhouse gas emission, they are less competitive when it comes to light acquisition compared to free-floating plants. Elevated pH has been suggested as a mechanism favoring submerged plant dominance, but the specific pH thresholds at which floating plant growth is inhibited remained unclear so far. In this study, we conducted laboratory experiments to evaluate whether submerged plants (*Ceratophyllum demersum*) can suppress the growth of free-floating competitors (Lemna gibba) above a threshold pH. Additionally, field data were analyzed to determine if and when such pH levels occur under natural conditions in dense submerged macrophyte stands. Our findings indicate that L. gibba's biomass- and chlorophyll-based growth decreased by 50% at pH values of 9.6 and 9.8, respectively, and nearly stopped above pH 10.0. The photochemical efficiency of photosystem II and the chlorophyll content of *L. gibba* declined rapidly above pH 9.0 and 9.5, respectively. Similarly, nitrogen and phosphorus content decreased strongly while dry matter content increased significantly in *L. gibba* fronds above pH 9.5. These results suggest a critical threshold for *L. gibba* growth around pH 9.5. Our mesocosm and field data revealed that this critical pH threshold for *L. gibba* was frequently surpassed within dense stands of bicarbonate-utilizing submerged macrophytes in lentic ecosystems. Such elevated pH conditions are commonly observed in the upper water layer during summer daylight hours, lasting up to 12 hours per day. Existing literature confirms that many duckweed species (and other common free-floating plants) in temperate and tropical water bodies experience growth inhibition above pH 8. This suggests that high pH by submerged macrophytes through photosynthesis-related utilization of bicarbonate plays a crucial role in maintaining dominance over free-floating competitors in densely vegetated, eutrophic water bodies. We propose that alternative stable states exist between submerged and free-floating macrophytes along the pH gradient. This study was supported by the Scientific Board of the University of Nyíregyháza.

Haowu Cheng, Sven Meißner, Jutta Fastner, Charlotte Schampera, Timo Niedermeyer, Sabine Hilt

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Interactions between submerged macrophytes and plant-associated toxic cyanobacteria - Oral presentation

In recent years, increasing concerns have been raised regarding the global proliferation of toxic cyanobacteria that adhere to submerged surfaces, posing significant health risks to both animals and humans. These cyanobacteria have been observed in various aquatic ecosystems, where they can colonize submerged macrophytes, forming complex plant-cyanobacteria associations. Such associations are of considerable ecological and societal concern, as they serve as potential pathways for toxin transfer within food webs. Herbivorous organisms feeding on these cyanobacteria-associated macrophytes may introduce harmful toxins into higher trophic levels, while detached cyanobacterial colonies and plant fragments can accumulate in beach areas, further increasing human exposure risks. Despite these concerns, the interactions between submerged macrophytes and cyanobacteria, particularly regarding their growth dynamics and toxin production, remain poorly understood. To address this knowledge gap, we conducted a series of controlled laboratory experiments as part of the larger DIVATOX project in Germany. Our study focused on the common aquatic moss *Fontinalis antipyretica* and various strains of *Microcoleus* species, both collected from Lake Tegel, Germany. Since 2017, recurring incidents of toxic cyanobacteria producing potent anatoxins have been documented in this lake, with reports of fatal intoxications in dogs that consumed cyanobacteria-laden moss washed ashore. To investigate the mechanisms underlying these plant-cyanobacteria interactions, we developed a novel method for cultivating *F. antipyretica* alongside motile *Microcoleus* strains on agar-based substrates. We then examined the growth responses of both organisms under single and co-culture conditions across different environmental scenarios. Additionally, we analyzed the effects of plant-derived leachates and extracts on the proliferation and toxin production of Microcoleus. Our preliminary findings indicate that different *Microcoleus* strains exhibit significant variations in their responses to the presence of *F. antipyretica*, suggesting that plant-microbe interactions may influence cyanobacterial toxicity and ecological distribution in freshwater ecosystems. Further research is needed to elucidate the underlying biochemical and ecological mechanisms driving these interactions and their potential implications for aquatic ecosystem health and public safety.

Arie Vonk, Jan Van Straaten, Hans Breeuwer

Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Netherlands

Unravelling plant-microbe interactions: the role of endophytes in macrophytes- Oral presentation

The microbiome of multicellular organisms, including plants, performs essential functions and enables these organisms to flourish. The importance of the microbiomes in the rhizosphere of plants and their epiphytic communities has been shown extensively, for example, related to resource uptake, disease resilience, and climate change. The importance of the endophytic microbial community, ie, microbes living within the plant tissue, has been recognized for terrestrial plants, but has received much less attention in aquatic plants. Macrophytes are host to a wide range of endophytes, including bacteria, fungi, and potentially archaea, that influence their growth and resilience. In this presentation, we will first summarize current knowledge on the diversity, interactions, and functional roles of endophytes associated with macrophytes. Secondly, the main knowledge gaps will be discussed based on comparisons to endophytes in terrestrial plants. The dominant bacteria occurring as endophytes in aquatic plants belong to the genera *Bacillus, Rhizobium*, and *Acinetobacter.* The diversity of bacterial endophytic communities varies across macrophyte species and plant compartments, with roots harboring the most diverse and abundant bacterial endophytic communities. Bacterial endophytes stimulate macrophyte growth by facilitating nutrient acquisition, producing phytohormones, and can also promote macrophyte resilience by mitigating abiotic stresses (e.g., heavy metal toxicity) and biotic stresses (e.g., pathogenic infections). Fungal endophyte diversity in aquatic plants is dominated by the phyla Ascomycota and Basidiomycota. These fungi stimulate macrophyte growth through nutrient solubilization, production of bioactive compounds, and promote macrophyte resilience through increased pathogen resistance. Mechanisms employed by aquatic fungal endophytes to stimulate plant growth and resilience are identical to those employed by terrestrial endophytic fungi. However, studies on functions that are more specific to the aquatic environment are lacking. Emerging evidence from terrestrial systems on the role of archaeal endophytes in osmotic stress regulation and tolerance to abiotic stress suggests a key role for Archaea in macrophytes, but their presence as endophytes in macrophytes remains underexplored. By stimulating macrophyte growth and resilience, endophytes are crucial for macrophyte fitness. We highlight a need for metagenomic studies assessing endophyte diversity of macrophytes. The specific role of endophytes could be assessed by combining inoculation and transplantation experiments examining their functional roles. This would advance our understanding of plant-microbe interactions. We discuss endophytes as potential solutions for restoring degraded aquatic ecosystems and combating environmental challenges such as pollution and pathogen-induced stress.

Sebastian Palmieri, Megan Reid, Lyn Gettys

University of Florida, United States of America

Pollinators of Florida wetlands - Oral presentation

Pollinators are keystone species within most ecosystems across the world because of the crucial role they play in the reproduction of flowering plants. Although pollinator ecology has been the focus of much entomological research, the discipline is largely focused on terrestrial plant taxa. Less is known about pollinator ecology in the context of aquatic or semi-aquatic plants. Florida is known for its vast network of water bodies and wetland systems, which support a high biodiversity of aquatic flowering plants, providing an opportunity to research pollinator-plant relationships in these ecosystems. Hence, this project aims to investigate pollinator diversity on aquatic plants within Florida, USA, through targeted surveys at selected wetlands, including supplementation with assessments of iNaturalist records through a desktop assessment. Insect collection alongside additional data from verified online records can allow us to gain a further understanding of the relationships that support our aquatic plants. By enhancing knowledge of the pollinator species associated with different aquatic plants, we can obtain an improved understanding of the role wetlands play in supporting insect diversity. This improved understanding can be used to further push for the conservation of wetland ecosystems, as well as the vast amount of other ecosystems that rely on the health of our wetlands.

Preben Clausen, Claus Lunde Pedersen, Birgit Olesen,
Lisbeth Tangaa Nielsen, Silvia Huber, Nicklas Simonsen, M.S. Vissing, A.D. Fox

Department of Ecoscience, Aarhus University, Denmark
Danish Hydraulic Institute, Hørsholm, Denmark
Department of Biology - Aquatic Biology, Aarhus University, Denmark

A century of changes in submerged aquatic vegetation and associated waterbirds in a coastal lagoon, Ringkøbing Fjord in Denmark. - Oral presentation

Monitoring of waterbird populations began in 1928 in the Tipperne Reserve, located in the southern part of Ringkøbing Fjord, a coastal lagoon situated on the west coast of Denmark. A few years later, the first, in fact very thorough, mapping of aquatic vegetation, i.e., species and their distribution in the lagoon, was carried out. Ringkøbing Fjord used to have a natural opening to the North Sea, but since 1931, water flow between the sea and the lagoon has been regulated by a lock in Hvide Sande Harbour. The lagoon is today designated as a Ramsar Site and protected as a Special Protection Area for Birds under the EU Birds Directive and as a Special Conservation Area for a variety of species and habitats under the EU Habitats Directive. In the following almost 100 years since monitoring of biota began, the lagoon has been subject to many changes in nutrient and salinity conditions, where a combination of an increasing load of nutrients from a large agricultural catchment and from human settlement discharges via rivers and streams around 1980 caused a collapse in the occurrence of water plants and associated water birds. Since then, many measures have been taken to reduce the nutrient load, but lock practice has also been changed repeatedly, both before and after 1980. The most recent major change was in late 1995, when the salinity was raised to the hitherto highest level, inducing a new collapse in the distribution of water plants, associated water birds, and induced a regime shift in the marine biology in the lagoon. In this presentation, we show how these multiple human interventions have affected the species composition and distribution of aquatic plants, and how the grazing waterfowl community associated with the plants has responded dramatically to these changes, both numerically and in their distribution. Although mappings of submerged aquatic vegetation (derived by combining ground-truth data and Copernicus Sentinel-2 satellite imagery) suggest that the distribution of aquatic plants in the lagoon in recent years is almost back at that found around 1930, and numbers of associated waterbirds likewise approach levels from the late 1960s and 1970s (the first period where birds in the entire lagoon was counted on a regular bases), this apparent recovery is not without losses. We thus finally illustrate that the multiple human management interferences come with a price, i.e., lowered plant diversity and loss of some of the previously associated waterbird species.

Todd Sink, Brittany Chesser

Texas A&M AgriLife Extension Service, United States of America
Texas A&M University, Department of Rangeland, Wildlife & Fisheries Management, United States of America

From blooms to balance: humic acid as a solution for pond eutrophication - Oral presentation

Eutrophication is a persistent challenge in static aquatic systems, often driving a shift from macrophyte-dominated ecosystems to dense algal blooms, including harmful algal blooms (HABs). Excess phosphorus and nitrogen—introduced through point and non-point source pollution—can disrupt the ecological balance, outcompeting native aquatic plants and fostering algal overgrowth. Managing these nutrients in ponds and other water bodies is often costly and impractical. Traditional methods, such as flushing with freshwater to dilute nutrients, are unfeasible during drought conditions, while chemical treatments like algaecides and potassium permanganate require precise application, are expensive, and may pose risks to non-target organisms. Humic acid, a naturally occurring organic compound formed through the decomposition of plant and microbial matter, presents a promising, low-cost, sustainable alternative for aquatic plant managers. The studies presented demonstrated that humic acid can act prophylactically to limit HAB formation, disrupt algal cell processes, and bind nutrients, reducing phosphorus availability. Additionally, by serving as a carbon source for naturally occurring beneficial bacteria, humic acid may enhance microbial nutrient cycling, fostering conditions that support native aquatic plants in place of nuisance algae. The studies presented involving *Prymnesium parvum* and *Microcystis aeruginosa* blooms suggest that humic acid can help stabilize aquatic ecosystems, promoting macrophyte resilience and preventing undesirable shifts to algal-dominated states.

Angelo Antonio Agostinho

Universidade Estadual de Maringá, Brazil

Association between fish abundance and macrophytes: exploring the importance of functional traits - Poster presentation

Macrophytes provide shelter, substrate for food organisms, spawning sites, and offspring care for many fish species. This relationship, however, is quite complex and likely varies between functional groups of macrophytes and traits exhibited by fish. This study aims to understand the relationship between the richness of different functional groups of macrophytes and the abundance of trophic categories and fish size. Seasonal data were obtained during a long-term study conducted between 2000 and 2024 in five floodplain lakes of the Paraná River floodplain in Brazil. Principal Coordinates Analysis (PCoA) was used to summarize the macrophyte composition data, with the Jaccard similarity metric as the resemblance matrix, applied to presence and absence data. The association of each macrophyte species with the ordination axes was assessed using a multivariate logistic regression, with the presence/absence matrix as responses and the scores of axes 1 and 2, retained for interpretation, as predictor variables. The species that most correlated with the axes are those that had significant Odds Ratios (significant model) with a given axis. To assess the association of fish, both at the species level and in trophic and size traits, with macrophyte richness in each functional group (submerged, emergent, and floating), two multivariate generalized linear models were fitted, with the Tweedie distribution. Thus, the response variables were the CPUEs of fish, while the predictors were the richness of macrophytes in each functional group. For the ordination of macrophytes presence and absence data, the data matrix contained 307 samples (rows) and 81 species (columns). The macrophyte species positively associated with fish traits were *Hydrilla verticillata*, *Egeria najas*, and *Eleocharis sp*. (axis 1); *Polygonum ferrugineum*, *Nymphaea amazonum*, and *Egeria najas* (axis 2). The negatively associated were *Hydrocotyle ranunculoides*, *Pistia stratiotes*, and *Pontederia crassipes* (axis 1); *Cyclosorus interruptus*, *Pontederia crassipes*, and *Pontederia parviflora* (axis 2). The analysis (Fourth corner) of the relationships between fish traits and the species richness of each macrophyte functional group reveals that lakes with higher submerged macrophyte richness tended to have fewer piscivorous and omnivorous fish species and smaller fish. Lakes with higher floating macrophyte richness tended to have more invertivorous and insectivorous fish. Higher emergent macrophytes richness tended to have fewer insectivorous fish and more herbivorous fish. These results clearly indicate an association between fish and macrophyte traits, and that different fish trophic groups exhibit distinct responses to the richness of the studied macrophyte functional groups.

Janne Alahuhta, Lars Baastrup-Spohr, Mary De Winton, Camino Fernández-Aláez, Seppo Hellsten, Balázs A. Lukács, Laura Sass, Jorge García-Girón

University of Oulu, Finland
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University of Illinois, United States of America

The signature of biotic interactions on lake macrophytes differs among seven metacommunities of three continents - Poster presentation

Biotic interactions are often neglected in broad-scale studies on species distributions, for which it is unclear whether biotic and abiotic mechanism's structure metacommunities in freshwaters. To overcome this shortage, we applied Hierarchical Modelling of Species Communities to investigate if similar species-to-species associations remain after taking into consideration species' different responses to environmental and spatial variation in lentic macrophyte communities in seven regions. We discovered that environmental filtering primarily explained lake macrophyte communities across the study regions. We also found that the variance explained by environmental characteristics varied between the regions. This would suggest context dependency, meaning that ecological patterns differ in magnitude or sign, depending on the environmental conditions under which they are studied. Moreover, species functional traits account for a relatively modest proportion of the total variation in species occurrences and species niches. However, environmental characteristics were statistically significant to individual species traits. Also, phylogenetic signals in each study region were weak in general. Most importantly, species-to-species associations varied strongly between the study regions, indicating context dependency. Alien-invasive species were mostly negatively associated with native species, although some positive relationships were also found. Lack of known relationships between alien-invasive and native species was noticed. This was one of the first attempts to integrate potential species-to-species interactions into broad-scale investigations on macrophyte communities. Despite some deficiencies related to, for example, study data, we encourage researchers to integrate potential biotic interactions into future investigations to comprehensively understand the interplay between environmental factors, dispersal, and biotic interactions in shaping freshwater community dynamics.

Sarkhan Ibrahimov, Mariusz Pełechaty

Adam Mickiewicz University Poznań, Faculty of Biology, Department of Hydrobiology, Uniwersytetu Poznańskiego, Poznań, Poland

Seasonal biomass dynamics and interactions of *Nitellopsis obtusa* with other macrophytes in charophyte- versus angiosperm-dominated lakes: implications for biodiversity and invasion ecology - Poster presentation

Nitellopsis obtusa is a widely distributed charophyte species. Native to Eurasia, it has expanded its range within its native territories in recent decades and has become an invasive alien macrophyte in North America, in both cases leading to a reduction in local macrophyte biodiversity. The species is considered perennial, and climate warming is believed to contribute to its recent spread. The study aim was to examine the co-occurrence and interactions of *Nitellopsis obtusa* with other macrophytes based on the seasonal dynamics of biomass of the studied aquatic plants. Macrophytes were sampled using a Bernatowicz's grab (sampling area: 0.16 m^2) from four clear-water, macrophyte-dominated lakes in Central Europe: two charophyte- and two angiosperm-dominated lakes (*Chara-lakes* and *Potemogeton-lakes*, respectively; all located in western Poland). In each lake, three distant sites were randomly selected and studied seasonally, during the summer and autumn of one year, and the spring and summer of the following year. Except for one season, *Nitellopsis obtusa* was present at all sites in *Chara-lakes*, where it was a dominant species. In *Potamogeton-lakes*, it was found at only one site per lake and was recorded in all seasons in just one of these lakes. The seasonal dynamics of *N. obtusa* biomass exhibited a similar pattern in both *Chara-lakes* and one Potamogeton-lake, with a significant biomass decrease from its maximum recorded in the first study year (either summer or autumn) to the spring of the subsequent year, followed by an efficient recovery towards the next summer. A limited site-specificity was also observed. The maximum total macrophyte biomass, as well as the biomass of *N. obtusa*, were recorded in the *Chara-lakes* in autumn, exceeding 930 $g \cdot m^{-2}$ and 640 $g \cdot m^{-2}$, respectively, on average. In the *Chara-lakes*, *N. obtusa* co-occurred with five species of Chara, four species of angiosperms, and one moss species, while in the *Potamogeton-lakes*, it was accompanied by one species of Chara and three species of angiosperms. The biomass of *N. obtusa* was negatively correlated with other macrophytes, particularly in the *Chara-lakes*. Our study did not confirm the presence of overwintering stands of *N. obtusa*, despite the relatively warm winters during the study period, but we support the previous suggestion that the dominance of *N. obtusa* is associated with a decrease in macrophyte biodiversity, even in waters of high clarity.

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Invasiveness and control

Session 3

Chairs:

Session 3A: Cristina Ribaudo (University of Bordeaux, France) & **Jonathan Newman** (Waterland Management, United Kingdom)

Session 3B: Deborah Hofstra (National Institute of Water and Atmospheric Research, New Zealand) & **Christian Chauvin** (INRAE – ECOVEA, Aquatic Ecosystems and Global Changes, France)

Invasive aquatic plant species are increasingly impacting aquatic ecosystems worldwide, altering habitat structure, threatening biodiversity, disrupting ecosystem functions, and challenging water resource management and the provision of ecosystem services. This is a timely and widely relevant issue that concerns researchers, managers, and policymakers. Effective control and mitigation strategies are urgently needed but remain complex, often requiring ecological, chemical, and mechanical approaches tailored to specific contexts. Case studies of this session span across multiple continents, multiple species and habitats, from the top worldwide freshwater invader *Pontederia crassipes* to less well-known *Utricularia* species, shedding light on emerging threats and adaptive responses. The session also addresses restoration dynamics, native plant recovery, and decision-support tools. These contributions reflect a growing shift toward data-driven, ecologically grounded solutions for managing aquatic plant invasiveness in an era of environmental change.

Samuel Schmid, Gray Turnage

Mississippi State University, United States of America

Drivers of plant community invasion for small lakes in the Southern United States - Oral presentation

A majority of surface freshwater is stored in small lakes, yet despite their ecological and environmental importance, research on these systems is scant compared to their larger counterparts. Aquatic plant invasion is a major threat to these ecosystems, as invasive plants can negatively alter the structure and function. The objective of this study was to determine biotic and abiotic factors that predicted the invasion probability (presence/absence) of four plant species invasive to the southeastern United States: *Alternanthera philoxeroides* (alligatorweed), *Cyperus blepharoleptos* (Cuban bulrush), *Panicum repens* (torpedograss), and *Triadica sebifera* (tallowtree). To meet this objective, we used multiple years of small lake survey data across the state of Mississippi. These surveys made use of shoreline point surveys to quantify the aquatic plant community, and from these data, we calculated the mean point richness and α-diversity for each lake and used them as environmental predictors. Additionally, we used latitude, longitude, lake perimeter, and Secchi depth as environmental predictors for our analysis. Using generalized linear models (GLMs), we determined the environmental variables that were most predictive of invasion probability for each of our target invaders. The best fit models for invasion probability varied by species, but some interspecific trends arose. Diversity and latitude were most commonly predictive of invasion probability, but lake perimeter, point richness, and Secchi depth were also predictive for one of the four species. These predictors suggest that the “rich get richer” hypothesis is important for describing patterns of invasion in Mississippi lakes. Additionally, similar survey data is currently being analyzed to predict the invasion probability in Mississippi lakes. This study will use water quality data to determine how these factors affect aquatic patterns of invasion in Mississippi.

Corentin Gaudichet, Michèle Tarayre, Gabrielle Thiébaut

Ecobio (Université de Rennes - CNRS), France

For decision-making support in order to better manage *Crassula helmsii* in France - Oral presentation

Crassula helmsii is an invasive aquatic alien plant species, native to Australia and New Zealand. The species colonize European freshwaters. In France, it was first detected *in naturae* in 1999, and it seems to disperse across the whole oceanic climate range, with an average rate of ten municipalities per year during the last 10 years. Different management trials have been implemented locally by managers. The results of these operations are often scarcely available. However, it appears that eradicating established populations seems almost impossible. The objective of this presentation is to review the management of *Crassula helmsii* to help managers and other stakeholders. Based on available scientific and grey literature, we have made an overview of the management method employed across Europe and available decision tools. We ran a survey to collect practitioners' feedback on *C. helmsii* management in France. We aimed to evaluate site characteristics (localization, size), invasion stage (invaded area, population dynamics), management and survey actions (motivations, goals, date, methods and success evaluation). Based on the survey and collected documents, we started to develop a decisional tool to help practitioners choose the adequate management. We collected about 30 sites' feedback, among which two-thirds have been managed for *C. helmsii* issues. Preliminary results were collected on 17 sites, most of which are lentic from small ponds to large wetlands, and two sites were found in a river. Respondent pointed out that conservationist considerations (protected area and heritage species) were the primary motivation for management actions, after the "invasive species control" label. With regard to management efficiency, small-sized sites and early colonization stages were the primary factors explaining successful management with regard to management goals. Among the management methods, biomass removal (manually or mechanically) was the most usual one, and showed various efficiency levels. Survey's results converge with scientific literature when eradication is not a realistic goal, methods combination using biomass removal and manipulating biotic and/or abiotic conditions seems the most suitable way to limit *C. helmsii* population.

Elisabeth Maria Gross, Hélène Groffier, Simon Devin

LIEC UMR 7360 CNRS, Université de Lorraine, France

Beyond limits and control – variable-leaved milfoil extending its ecological niche in small-gauge channels in North-Eastern France? - Oral presentation

The submerged macrophyte *Myriophyllum heterophyllum* Michx. (Haloragaceae) is an invasive alien aquatic plant (IAAP) present in Europe since the early 20th century. First observed in channels close to Leipzig, Germany, the species is now present in several European countries. In France, it is one of the most troublesome IAAP, especially in the north-east, where it colonises small gauge channels of about 900 km length. Between 2019 and 2023, we sampled 34 sites in 8 different small gauge channels in early summer. Six of the channels have been invaded by the species, the two remaining channels served as controls to identify potential differences in environmental conditions. We analysed different physiological plant traits such as pigment content, carbon, nitrogen and phosphorus content and the content in anthocyanins and total phenolic compounds, the latter known as potential allelopathic compounds. We also took water and sediment samples for nutrient analyses, as well as physical and chemical parameters. Two sites have been sampled several times per year to follow the impact of blue dye as a control measure on the plants. In contrast to expectations based on literature data covering laboratory experiments and field data from the USA and Germany, the species is dominating over other submerged macrophytes, including the congeneric *Myriophyllum spicatum* at medium to high levels of alkalinity. We found that the species occurs in a wide range of environmental conditions, and even tolerates occasional salinity peaks in a channel section close to the North Sea, exposed to tidal sea water intrusions. While first limited to channels, it is now observed also in some rivers and seems to tolerate higher flow velocities, probably because of its strong root system. The plants contained high levels of nitrogen and phosphorus in the upper leaves. The high plant nitrogen concentrations were significantly related to the concentration of inorganic nitrogen in the water. The attempt to control the plant by blue dye did not lead to apparent changes in plant performance. An additional laboratory experiment confirmed our hypothesis that this low-light adapted plant would rather benefit from the blue dye treatment at high sunlight irradiances. Only high-water temperatures and high sediment organic matter content might be factors limiting the growth of this species.

Jesse Beyer, Laurens Piet, Leni Duistermaat, Johan Van Valkenburg

NVWA (Netherlands Food and Consumer Product Safety Authority), Netherlands
Naturalis Biodiversity Center, Netherlands

Myriophyllum rubricaule (Haloragaceae) revisited, a search for the origin of an invasive species - Oral presentation

Myriophyllum rubricaule, back in 2022, was described as "only known from cultivation" and the authors assumed the species to be native to South America. The species had completely replaced *Myriophyllum aquaticum* in European horticultural trade since the addition of *M. aquaticum* to the list of invasive alien species of Union concern (EU regulation no. 1143/2014) in 2016, and started showing an invasive character in Belgium, Hungary and the Netherlands. Before the species was described, the plant was labelled as *Myriophyllum brasiliensis* or *M. brasiliense* and had been in the horticultural trade in north-western Europe for a number of decades, though its taxonomy has caused some confusion between botanists, plant growers, and regulators. In a 1981 revision for *Myriophyllum* of South America by Orchard, Chile is mentioned as a native region for *M. aquaticum,* with male specimens found there, whereas in Europe, only females are found. While on a visit to Chile for a conference in 2023, one of the authors seized the opportunity to check on natural occurrences of *M. aquaticum*. However, instead of *M. aquaticum* several populations of *M. rubricaule* were observed in the Araucania region. Surprisingly, the specimens were also monoecious, while in Europe only female ones were found. This also made a new difference with *M. aquaticum,* which is dioecious. Subsequent analysis of herbarium collections revealed multiple *Myriophyllum* specimens from the early 20th century, which in retrospect are determined to be *M. rubricaule*. iNaturalist records resulted in a provisional native range for the species to be Chile, from the region of Valparaíso in the north to the Los Ríos region in the south, and a further expansion of the introduced range in Europe to include the United Kingdom, Denmark and Austria. The recently discovered specimens from Chile and two herbarium collections (*Buchtien s.n.* (L & WAG) and *Hollermayer 1914* (US)) were successfully sequenced, using Illumina 150PE, and added to the already created phylogeny from 2022. Used loci for the analysis were chloroplast trnH-psbA, rbcL, and matK, and the nuclear ITS. Results further strengthen the notion that *M. rubricaule* is indeed a separate species.

Megan Reid, Melissa Smith, Seth Farris, Lyn Gettys

University of Florida, United States of America
USDA-ARS, United States of America

Managing a beautiful monster: efforts to improve management of waterhyacinth (*Pontederia crassipes*) in South Florida, USA - Oral presentation

Waterhyacinth (*Pontederia crassipes* Mart. [≡ *Eichhornia crassipes* (Mart.) Solms] is one of the worst aquatic weeds in the world, and despite an abundance of research, management of this species remains a challenge. Owing to its broad distribution and invasiveness, the plant has sparked collaborations between institutions on local and international scales. One of the major challenges to managing this species is eutrophication, providing a strong bottom-up input of nutrients driving growth. Where efforts to reduce eutrophication are slow and challenging to implement, recent research has focused on increasing the top-down forces suppressing growth, including inundative releases of biological control agents. Additionally, integrated pest management using herbicides and biological control can improve control, reduce the amount of herbicide used, and reduce costs. In this presentation, an overview will be given of the research being conducted in South Florida, USA, in collaboration with several institutions locally and internationally, in an attempt to improve the management of waterhyacinth. This includes research to optimize integrated pest management using biological and chemical control, as well as augmentative releases of agents, as inspired by other researchers. By going back to published literature, thinking critically about how current methods can be enhanced, and maintaining strong collaborative relationships, the challenges of controlling such a problematic species can be lessened, and chances of success improved.

Deborah Hofstra

National Institute of Water and Atmospheric Research, New Zealand

Native macrophyte response to invasive weed removal - Oral presentation

Since 2008, there has been a management programme in place to eradicate an alien invasive weed (*Hydrilla verticillata*) from the only lakes in which it occurred in New Zealand. To support the programme and inform future management actions for controlling the weed and to assess changes in the lake as a consequence of the weed removal, water quality, macroinvertebrates and fish populations have been assessed at different frequencies, and there have been annual assessments of the submerged macrophytes. The primary weed control tool is the stocking of the herbivorous fish grass carp (*Ctenopharyngodon idella*), as they can maintain the sustained browsing pressure that is necessary over many years to deplete the reserves of the subterranean hydrilla turions. The study presented here focuses on the response of native macrophytes to weed removal in the largest of the lakes. Within the lake, 13 sites have been monitored every year using a diver-based survey, with additional observations recorded from other sites in some years. Over the 17 years of data collection, external influences have included a cyclone and storm events with associated flooding and sediment inputs, and grass carp losses and re-stocking events. Macrophyte abundance, including depth distribution and cover, has changed dramatically over time, while overall species diversity has been maintained. Key changes are the removal of hydrilla and recolonisation of the littoral zone by a native macrophyte. Hydrilla was the most abundant species in 2008 and has not been seen since 2015. The most abundant species is now the native *Myriophyllum triphyllum.* Further recovery of native macrophytes (higher cover values) is anticipated once the grass carp grazing pressure diminishes after the conclusion of the eradication programme.

Susanne Schneider

Norwegian Institute for Water Research, Norway

Juncus bulbosus mass development: towards sustainable solutions for Norway's waterways - Oral presentation

Juncus bulbosus is a perennial vascular plant found in nutrient-poor lakes and rivers in Norway. Since the mid-1980s, its biomass has significantly increased, particularly in Southern Norway, where it grows tall and reaches the water surface, causing issues for, among others, boating and swimming. The causes of this mass development are complex, but they are in rivers often related to watercourse regulation. Mechanical removal of *J. bulbosus* is not a long-term solution, as it must be repeated every two to three years. I here summarize decades of work aiming to find sustainable solutions to prevent J. *bulbosus* mass development. Overall, our results suggest that the growth of tall *J. bulbosus* shoots can be minimized by: * Increasing the water level between late June and mid-August: Low water levels during this period may trick *J. bulbosus* into forming flower-bearing shoots. High water levels should reduce this formation; * Establishing a regulation regime that promotes ice formation: Prolonged ice-cover likely causes more *J. bulbosus* shoots to die or not survive upright, preventing the formation of long shoot chains; * Facilitating mechanical damage: Mechanical damage, for example during periods of high water flow, can erode *J. bulbosus* plants, helping to keep biomass low; * Minimizing the supply of CO_2 and nutrients: *J. bulbosus* needs CO_2 and nutrients to grow. Reducing their supply limits *J. bulbosus* growth. Winter light conditions may explain why *J. bulbosus* mass development first occurred in Southern Norway. In the south, the period during which rivers and lakes are ice-covered is shorter, and the winters are lighter. This provides better light conditions for *J. bulbosus* throughout the winter, likely increasing the chances that *J. bulbosus* shoots survive the winter in an upright form. Consequently, the likelihood is higher that, over several years, *J. bulbosus* can form shoot chains that eventually reach the water surface. In a future climate, warmer winters will likely lead to a shorter period of ice cover on Norwegian rivers and lakes. Therefore, climate change may well result in increased *J. bulbosus* mass development, also extending further north.

Brittany Chesser, Todd Sink

Texas A&M University, Department of Rangeland, Wildlife, & Fisheries Management, USA
Texas A&M AgriLife Extension Service, USA

Investigating herbicidal susceptibility of bladderwort (*Utricularia radiata*) - Oral presentation

Bladderworts (*Utricularia* spp.) are a diverse group of carnivorous plants with specialized utricle traps that allow them to capture microorganisms. Among the over 240 species worldwide, 16% inhabit aquatic environments, where they are typically free-floating or loosely anchored by rhizoids. While bladderworts play an important ecological role, some species are considered invasive depending on the region, and others, such as *Utricularia radiata*, can become a nuisance in pond and lake systems, forming dense mats that hinder recreational use, macrophyte biodiversity, and fish and other aquatic animal habitats. Previous studies on bladderwort control demonstrated the efficacy of fluridone, a systemic herbicide, but its high cost, extended contact time, non-selectivity, and water-use restrictions limit its application. Additionally, bladderwort species reproduce through both seed and fragmentation, making control efforts particularly challenging. This study evaluates five alternative herbicide options for controlling nuisance bladderwort populations cultivated in controlled outdoor mesocosms. While this research focuses on managing nuisance bladderwort populations, this research may also contribute to minimizing unintended consequences of herbicide control efforts on non-target bladderwort species globally.

Gray Turnage, Samuel Schmid, Gray Ervin

Mississippi State University, United States of America

Integrating chemical and biological control of alligatorweed (*Alternanthera philoxeroides*): submersed herbicides and thrips - Oral presentation

Alligatorweed (*Alternanthera philoxeroides*) is an invasive aquatic plant that is globally distributed and presents hazards for the use of water resources and impairs ecosystem structure and function. This species has been established in the United States for over a century and has been subjected to intensive chemical and biological control efforts. Chemical control conventionally consists of foliar herbicide application, but these methods often allow regrowth from robust stoloniferous networks underwater. Biological control is dominated by a flea beetle (*Agasicles hygrophila*), but this species is cold intolerant and unusable in large portions of the invaded range. This study investigated two alternative methods of alligatorweed control: submersed herbicide applications and thrips (*Amynothrips andersoni*) biological control alone and as an integrated technique. These methods were tested in 12-week mesocosm trials over two stages. Stage one tested five different chemistries applied in-water at a high and low rate compared to non-treated reference plants and plants receiving foliar applications of glyphosate + imazapyr (i.e., positive control). Stage two tested the most efficacious rate of each chemistry from stage one as solo treatments or in combination with thrips biological control. Herbicides tested in this study were penoxsulam (150 and 75 ppb), bispyribac-sodium (45 and 22.5 ppb), imazamox (500 and 250 ppb), fluridone (150 and 75 ppb), and topramezone (50 and 25 ppb). All herbicides (except bispyribac-sodium) effectively controlled alligatorweed as submersed applications (>76% reduction for most). Also, thrips effectively controlled alligator weed (54% reduction), although at the rates that were tested, no herbicide treatments benefited from the addition of thrips biological control. While this study shows both submersed herbicide applications and thrips effectively control alligatorweed, there are still substantial research gaps that need to be investigated.

Maria Rita Minciardi, Concita Daniela Spada, Matteo Massara, Pier Lefvebre, Augusta Rossi, Simone Ciadamidaro, Luca Cristaldi

Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
Regione Piemonte, Italy
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Fight against *Myriophyllum aquaticum* and *Elodea nuttallii* in Po river (Italy) - Oral presentation

Major infestations of two IAS of Union concern (Regulation (EU) No. 1143/2014) have taken place in 2016 and 2022, along the Po River in Piedmont Region (IT) upstream of a weir. In June 2016, after a dry spring, a local invasion of *Myriophyllum aquaticum* (species not previously reported in the region) was early identified in the city of Turin, upstream of a weir, and the species, in a short time, reached coverages greater than 60% of the overall macrophyte community. In 2022, after two years of severe drought and high summer temperatures, *Elodea nuttallii*, already reported in the river but with low coverage, gave rise to massive spreads in many sites along the Po: the species reached coverage of over 90 % in large stretches; also, for this species, the spread sites were all upstream weirs. For both species, manual removal interventions were carried out from boats and the banks. In both cases, a monitoring plan was defined (2016-2019 for *Myriophyllum aquaticum*, 2022-2025 for *Elodea nuttallii*) through the identification of sites of possible priority diffusion. For *Myriophyllum aquaticum*, the intervention carried out led to the eradication of the species, which, since 2019, has been classified as eradicated in Piedmont. For the species *Elodea nuttallii*, given its diffusion, it is not possible to think about its eradication but however, it was possible to strongly contain its spread and favor the competing native species. From 2022, it was definitively clear the importance of collaboration between public bodies, researchers and also the involvement of citizens, canoeists and farmers. From 2023, a monitoring plan has been in use and allows a quick identification of the spread (also of other species). These experiences demonstrate that for a new local invasion of IAS a quick intervention is the key factor against diffusion. On the other hand, to fight and contain widespread IAS, habitat management is a priority to counter environmental conditions that favor the invasive species. Furthermore, the combined effect of climate change with other pressures must be considered: drought and high temperatures create artificially “lentified” environments upstream of any weir; here, aquatic invasive alien species find ideal conditions for massive spread. Management methods for weirs are being defined to minimize lentification and impoundment to prevent the risk of introduction and spread of IAS.

Samuel Schmid, Maxwell Gebhart

Mississippi State University, United States of America

Using machine learning techniques to predict the spread of invasive species: *Cyperus blepharoleptos* as a case study - Oral presentation

The biogeography of invasive species is integral to the study of invasion ecology and one of the most important research questions in this respect is where invasive species are expected to spread. In the past few decades, many statistical tools have been developed that use machine learning to predict the ecological niches of species. One such tool is MaxEnt which can make use of small datasets of presence-only data to develop ecological niche models (ENMs) with environmental predictors. The objective of this study is to use a MaxEnt ENM to predict the distribution of suitable habitat of the poorly studied *Cyperus blepharoleptos* (Cuban bulrush) in present-day and future climate scenarios. Publicly available records of *C. blepharoleptos* and BioClim rasters (BIO1, BIO7, BIO12, BIO14, and BIO15) were used in this modeling effort as the response variable and predictors, respectively. MaxEnt models were iteratively tuned using combinations of four different feature classes and three different regularization multipliers to build 12 different candidate models. The best-fit model was selected using three criteria: omission rate < 0.05, corrected Akaike information criterion (AIC), and model parsimony. A jackknife analysis was run in MaxEnt to determine the relative importance of the BioClim variables through stepwise inclusion/exclusion. The best-fit model was used to predict the geography of suitable habitat in North and South America in five climate scenarios: present-day, SSP1-2.6 in 2040, SSP1-2.6 in 2060, SSP5-8.5 in 2040, and SSP5-8.5 in 2060. Model predictions show the expansion of suitable habitat in all future climate scenarios, with the greatest expansion occurring in SSP5 by 2060. We compare our findings with a study that used a different niche modeling approach to highlight the strengths and weaknesses of either approach as well as how these different approaches can complement each other.

Lucy Marshall, Jonathan Newman

Waterland Management, United States of America
Biosorb Inc., United Kingdom

Using the adjuvant TopFilm to improve herbicide control of invasive aquatic plants - Oral presentation

TopFilm is essential for managing alien invasive aquatic plants on a global scale. Using TopFilm has solved many aquatic invasive weed control problems. TopFilm is a natural cereal grain-based microsponge technology that absorbs the treatment in the tank mix, delivers a uniform coating while being sprayed and dries to form a protective microsponge film which promotes rain fastness. This characteristic is necessary to increase the efficacy of herbicide treatments on invasive aquatic plants that are normally partially resistant to herbicide treatment, either because of inability to penetrate waxy leaves, or due to climatic conditions that prevent adequate uptake of slower acting herbicides. The extended rain fastness of up to 22 days allows entry of a sufficient dose of herbicides to give effective control. The financial benefits achieved are due to the extension of the spraying season, including making the best use of the correct application timing periods by making unsuitable application days suitable. These optimise the cost efficiencies of herbicide applications and allow for more rapid conclusion of eradication programs. The advantages of TopFilm over other adjuvant types, specifically for aquatic weed control, have been demonstrated, especially with glyphosate as a relatively slow acting herbicide. TopFilm is non-toxic and was the first adjuvant approved for aquatic use in Europe. During regular use, we have shown benefits for effective control of *Fallopia japonica, Rhododendron ponticum* and many other waxy-leaved weed species. Use of TopFilm reduces drift, minimising non-target control. Results of extensive treatments conducted over 25 years are summarised here, and key findings for improving control of Invasive Aquatic Plants are presented. Results of herbicide trials on numerous invasive aquatic species from over 20 years of experience will be presented, and key learning points provided.

Madison Self

University of Florida, United States of America

Comparative analysis of light response of *Pontederia crassipes* and its congener, *P. cordata* in invaded regions - Oral presentation

Waterhyacinth, *Pontederia crassipes* Mart. [≡ *Eichhornia crassipes* (Mart.) Solms] is one of the world's worst invasive plants. Although there is an abundance of research investigating the management of this plant, there is minimal literature investigating the photosynthetic capabilities of waterhyacinth in varying light conditions. This study aims to provide insights into the mechanisms driving invasion success by comparing rapid light response curves of waterhyacinth and its congener, *Pontederia cordata*, in varying degrees of invasion across Florida, California, South Africa, and Argentina. Gas exchange measurements were performed using a LI- 6800 Portable Photosynthesis System (Licor, Inc., Lincoln, NE). The chamber conditions will be set around ambient CO2 (400ppm), 50% relative humidity (RH), and 25° C leaf temperature (Tleaf). Gas exchange will be measured at light intervals of 0, 50, 150, 300, 500, 1000, 1250, 1500, 2000, and 2500 µmol quanta m−2 s−1 PPFD. Light response curves will be used to assess Light Use Efficiency, Incident Quantum Efficiency (the slope of the first four points in the linear portion of the response curve), A max (area-based light-saturated photosynthetic rate), the Light Compensation Point (the extrapolated x-intercept of the line applied to the first four light points) and R d (dark respiration rates). Water samples will also be compared between these sites, as multiple studies have revealed that water nutrient levels heavily affect the growth and photosynthesis of aquatic plants. These data can be used to inform management efforts, such as maintaining dense native canopy cover in invaded areas.

Andrea Bertolo, Émilie Cherpin

Université du Québec à Trois-Rivières, Canada

Short- and medium-term effects of jute benthic barriers on the control of Eurasian watermilfoil (*Myriophyllum spicatum*) - Poster presentation

The Eurasian watermilfoil (*Myriophyllum spicatum*), native to Eurasia, has become a major concern in North America, especially in Canada, where it poses ecological and recreational challenges. Like many other invasive macrophyte species, the watermilfoil tends to reduce native plant diversity by forming dense monospecific mats. Effective control of this invasive species can yield varying outcomes, with some eradication programs improving biodiversity, while extreme measures might harm native species. In contrast to non-degradable benthic barrier materials, biodegradable alternatives like hessian burlaps are permeable, easy to manage, and environmentally friendly. Though limited by relatively rapid decomposition, these biodegradable materials offer significant ecological advantages, including a positive effect on native species with more rigid tissues, thus promoting biodiversity. This study focuses on the control of the watermilfoil in a shallow lake heavily infested by this species using biodegradable benthic barriers, specifically jute hessian burlaps, to suppress its growth by blocking light. More precisely, we investigated the short- and medium-term effects of hessian burlaps on watermilfoil meadow in Lac-à-la-Tortue (Shawinigan, QC, Canada). The objectives include evaluating the duration (1-3 years) of watermilfoil biomass reduction and analyzing the subsequent impacts on the native plant community six years after burlap application. We hypothesize that burlaps will significantly reduce watermilfoil biomass and favor the re-establishment of native species with more rigid tissues. Using data from echo sounding and visual surveys, we compared treated areas with control zones to assess changes in plant biomass and community species composition. Our results show that, despite the effects of the benthic barriers on the percent volume infestation of submerged aquatic vegetation in former watermilfoil patches fade after three years from their application, the macrophytic community is clearly different in the treated vs. the control areas six years after. Unexpectedly, we did not observe any significant difference on that occasion between treated and untreated areas in terms of watermilfoil percent abundance, which on average declined from >80% to less than 40%, suggesting a general decline of this invasive species independently of our manipulation. In contrast, six years after the manipulation, *Potamogeton robbinsii* dominated untreated areas while *Elodea* sp. dominated the treated ones, showing that jute burlaps can have strong effects on the macrophyte community well after their decomposition. The results will contribute valuable insights into the effectiveness of biodegradable benthic barriers for managing invasive aquatic species and enhancing native biodiversity in aquatic ecosystems.

Beatrice Fois, Alice Dalla Vecchia, Rossano Bolpagni, Carla Lambertini

Università degli Studi di Milano, Italy
Università degli Studi di Parma, United Kingdom

Genomic and functional approaches to explore the role of environment in the adaptation and diversification of invasive aquatic plants - Poster presentation

The introduction and spread of invasive alien species worldwide represent the second leading cause of biodiversity loss and related ecosystem services, following habitat destruction. Climate change is likely to worsen the situation further, impacting the distribution of native species and facilitating the increased presence of certain alien species. Freshwater ecosystems are more susceptible to biological invasions than terrestrial ones because it is difficult to contain and reverse the establishment of such invasive species in these habitats. Genetic diversity in the introduced population is important for selection and adaptation processes, but most of the invasive aquatic plants reproduce almost exclusively vegetatively and can reach a high abundance through the dispersal of propagules. In this case, they still manage to adapt to the environment due to high levels of phenotypic plasticity, i.e., the capacity to change phenotypes according to environmental conditions with no change in DNA sequence. Also, intraspecific variability, expressed through different traits of individuals, is key to ensuring successful invasive plant adaptation to novel habitats in the non-native range. Previous research has focused on how invasive species changed their phenotypic traits to compete with native species. Less attention has been paid to the relative effects of environmental heterogeneity and genetic diversity, the two main mechanisms determining plants' phenotypic expression. In addition, it has been recently suggested that epigenetic changes, like methylation of DNA, can contribute to adaptive phenotypic plasticity to abiotic stressors, but understanding the relationship between epigenetic modifications and phenotypic plasticity is still limited. This project aims to investigate the role and mechanisms of phenotypic plasticity in the adaptation and diversification of invasive species and identify two macrophytes in Europe, *Elodea nuttallii* and *Pistia stratiotes*, as useful study models. To do so, an approach based on functional traits, in particular the ones associated with the leaf since they're good predictors of plant performance, will be combined with a genetic and epigenetic approach and applied at the intraspecific level. The results of the study provide important information on the mechanisms of introduction and expansion of invasive plants, their competitiveness in functional terms, allowing for effective management strategies and protection of natural habitat biodiversity.

T. Lobato-De Magalhães, D. Larkin, J. Arturo De-Nova, K. Murphy, E. Molina-Navarro

Universidad Autónoma de Querétaro, Mexico
Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, USA
Universidad Autónoma de San Luis Potosí, Mexico
University of Glasgow, Scotland
Universidad de Alcalá, Spain

Does relatedness between invasive and congeneric native macrophyte species influence invader success in lakes and rivers worldwide? - Poster presentation

As part of a global study of the potential influence of relatedness between invasive and native congeneric macrophyte species on invader success, we looked at the species assemblages present in a total of 544 individual inland freshwater sites (lakes and rivers) sampled since 2000, worldwide. These comprised 127 sites in western Europe (England, Scotland, Ireland, Portugal), 187 in the USA (Minnesota, Mississippi), 34 in the Neotropics (Brazil, Argentina, Mexico), 55 in New Zealand, 107 in Zambia, and 34 in China. The number of invasive species present in the waterbodies examined in each region varied quite substantially, from 10 species in the Mississippi lakes dataset (of a total 104 macrophyte species recorded there: 9.6%) down to just four invasives out of 143 species found in the Neotropical rivers, lagoons, and cenotes surveyed (2.8%). We show maps of the world distribution of the 52 most invasive macrophyte species (at a global scale), and also the degree of congeneric relatedness with native species present. We also provide a preliminary analysis of both taxonomic and phylogenetic relatedness between invasives and native species present in the 544 sites studied. The results suggest a high degree of heterogeneity between different parts of the world, with relatedness particularly high in North American invasive species, on both taxonomic and phylogenetic measures, but substantially lower in lake and river sites in western Europe, where most invasive macrophyte species (notably *Elodea canadensis, E. nuttallii* and *E. densa*) have no congeneric native species present. In contrast, *Myriophyllum spicatum*, invasive in North America and present in 25 of the Minnesota lakes, was found co-occurring with a total of five native *Myriophyllum* species (*Myriophyllum alterniflorum, M. farwellii, M. sibiricum, M. tenellum, M. verticillatum*) across that regional dataset.

Robert Richardson, Kara Foley, Jens Beets

North Carolina State University, United States of America
USDA - ARS, United States of America

Addressing the challenge of submersed aquatic weed management in flowing systems in the United States - Poster presentation

The efficacy of aquatic plant management techniques can be influenced by site-specific environmental factors such as water quality and chemistry, hydraulic retention time, and ecological community composition. These factors are magnified in flowing systems, such as rivers and streams, where site characteristics are highly dynamic. Additionally, recent research outcomes have demonstrated that plant physiology and phenology can differ between lentic and lotic systems, potentially influencing necessary management prescriptions. Herbicides are often the most effective option for aquatic weed control in rivers due to factors such as access restrictions, degree of potential fragment migration, flow velocity, and overall practicality. However, achieving necessary concentration and exposure times of herbicides in flowing systems can be highly limited and largely directed by water discharge rates. In the Eno River, North Carolina, a metered drip application system effectively managed approximately 20 miles of monoecious *Hydrilla verticillata* over the course of 4 years. Additional chemical management options have been considered for future flowing system applications through greenhouse-based research trials that mimic short exposure periods through the use of timed herbicide 'pulse' treatments and water exchanges.

Samuel Schmid, Gray Turnage, Gary Ervin

Mississippi State University, United States of America

Alligatorweed thrips is a better climate match for the host than conventional agent - Poster presentation

Alligatorweed (*Alternanthera philoxeroides*) is an aquatic plant native to South America and invasive in the Southeastern United States. This species has a long history of biological control, namely with the alligatorweed flea beetle (*Agasicles hygrophila*), which effectively defoliates alligatorweed. However, the cold intolerance of the flea beetle limits its biological control utility, as large portions of the alligatorweed invaded range cannot support overwintering populations of this agent. Another natural enemy, the alligatorweed thrips (*Amynothrips andersoni*), has shown better cold tolerance in laboratory experiments, but there have been no efforts to model the ecological niche of this agent. This study seeks to construct ecological niche models (ENMs) for alligatorweed and these two biological control agents and compare their niche overlaps. These ENMs were developed using Maxent and predictions were made for the present climate and two future climate scenarios. Under future climate scenarios, the total niche area of alligatorweed is predicted to decrease by up to 10% whereas the predicted niche areas of the two agents are expected to increase by up to 10%. Despite the expanding niche of both agents, the predicted niches of the thrips showed much greater overlap with alligatorweed than the niches of the flea beetle in all three scenarios. These findings suggest the thrips is much better suited as an alligatorweed control agent, particularly in regions where the flea beetle cannot overwinter.

Alessandro Q. Scotti, Mariano Bresciani, Claudia Giardino, Monica Pinardi, Paolo Villa

Institute for Electromagnetic Sensing of the Environment, National Research Council of Italy (CNR-IREA)
NBCF, Palermo, Italy

Investigating phenological characteristics of two invasive macrophytes across gradients using satellite data time series - Poster presentation

Invasive macrophytes threaten shallow aquatic ecosystems by outcompeting native species and causing significant ecological and economic damage. This study examines two species that are widespread in the northern hemisphere and have colonised a number of sites in Europe and North America in the last decade: *Nelumbo nucifera* Gaertn. (sacred lotus, native to East Asia) and *Ludwigia hexapetala* (Hook. & Arn.) Zardini, H.Y. Gu & P.H. Raven (water primrose, native to Central and South America), comparing their phenological traits and productivity across different environmental gradients: native vs. non-native ranges and different climatic regions. Sentinel-2 satellite data (10 m spatial resolution, 12 spectral bands) were used to generate time series of the Water Adjusted Vegetation Index (WAVI), a proxy for canopy density and biomass, over six years (2017-2022) at seven study sites: Mantua lakes system and Lake Varese (humid subtropical climate, non-native range for both species) in Italy, Lake Fangzheng, Lake Bayangdian and Lake Xuanwu (humid continental, cold semi-arid and humid subtropical climate, respectively, native range for *N. nucifera*) in China, Lake Grand-Lieu in France and Santa Rosa Lagoon in the USA (temperate oceanic and warm-summer Mediterranean climate, respectively, non-native range for *L. hexapetala*). Seasonal dynamics parameters (phenological metrics and productivity) were extracted from WAVI time series, and their meteorological and environmental drivers were analysed using parametric generalised additive mixed models (GAMMs). The results indicate that *N. nucifera* has higher canopy density and productivity in non-native than in native sites, and that the onset and termination of the growing season follow a latitudinal gradient within the native range. For *L. hexapetala*, differences among invaded sites appear to be driven more by the timing of species establishment and its adaptation to local conditions. The GAMMs models showed that climate and site differences are key to understanding the phenology of *N. nucifera* - driven by temperature and summer radiation, which favours longer seasons and increased productivity - whereas water quality and local conditions determine that of *L. hexapetala*, whose growth rate is influenced by site turbidity, while senescence is accelerated by wind conditions and summer radiation. This approach can be easily extended to other macrophytes and can benefit studies on the variability of the eco-physiological characteristics of invasive macrophytes under climate change scenarios.

Riparian and aquatic plant dynamics and succession

Session 4

Chairs:

Session 4A: Anne Lewerentz (Institute of Geography and Geoecology, Karlsruhe Institute of Technology, Germany) & **Janne Alahuta** (Geography Research Unit, University of Oulu, Finalnd)

Session 4B: Francisca Aguiar (Instituto Superior de Agronomia, Universidade de Lisboa, Portugal) & **Daniel Gebler** (Poznan University of Life Sciences, Poznan, Poland)

This session focuses on the dynamics and successional processes of riparian and aquatic plant communities in response to both natural variability and human-induced change. Understanding vegetation dynamics in transitional zones is essential for assessing ecosystem integrity, informing restoration efforts, and anticipating responses to hydrological alteration. Contributions include the effects of flow regulation, long-term vegetation change, the role of plant architectural traits in anchoring and resilience, and the interplay between water level fluctuations, land use, and species turnover. Methodological and sampling approaches range from field surveys to UAV imagery, LiDAR analysis, and hydraulic modeling. By examining spatial and temporal patterns across diverse riverine landscapes, these studies enhance our understanding of plant-environment interactions and inform strategies for monitoring, management, and restoration of freshwater ecosystems.

Emanuele Pelella, Alessandro Bricca, Gianmaria Bonari, iberio Fiaschi, Andrea Picchiotti, Claudia Angiolini

Free University of Bolzano, Faculty of Agricultural, Environmental and Food Sciences, Italy
University of Siena, Department of Life Sciences, Italy

Vegetation resurvey using adjusted sampling methodology highlights the dynamism of aquatic plant communities in a Mediterranean river over a decade - Oral presentation

Macrophytes are key components of aquatic ecosystems and indicators of ecological status, susceptible to environmental variations like land-use changes and water pollution. Monitoring plant communities over time can accurately reveal how species composition and diversity shifts in response to environmental changes. However, in riverine environments, riverbed size can change over time, and keeping the original plot size may include non-aquatic vegetation. This study evaluates temporal changes of aquatic communities from 2013 to 2023 along a Mediterranean river in Central Italy. We resurveyed aquatic vegetation in quasi-permanent plots. We asked: i) if implementing adjusted-size plots rather than original-size plots brings different results, ii) which variation of environmental factors (chemical-physical, topographic, geomorphological, and anthropogenic) these changes are related to, and iii) if aquatic plant community composition has changed in 10 years along the river from source to downstream. A systematic sampling of 33 points each kilometer was conducted along the river, recording all aquatic macrophytes, their cover, and various environmental parameters at each site in 2013. The same plots were resurveyed in 2023. In addition, to account for changes in riverbed size, two parallel methodologies were implemented in the resurvey: “original-size plots”, matching the original plot area, and “adjusted-size plots”, including only the new wet riverbed area, to focus on aquatic plant communities. We related changes over time in species richness, species diversity, and beta diversity to changes in environmental variables. We found significant changes over the decade in plant community diversity and composition. However, the drivers of these changes differed by protocol. For standard-size plots, we found a positive effect of total vegetation cover, and negative effect of agricultural disturbance and river height on species richness, with the former also significant for species diversity. For adjusted-size plots, we found positive effects on both diversities of small rock; moreover, diversities changed differently according to river stretch. River height and pH positively affected beta diversity regardless of methodology. Beta diversity was affected by river stretches in original-size plots, and by huge rocks and total cover in adjusted-size plots. Lastly, we found a gradient of dominance of gained species from river’s source towards downstream, where it was counterbalanced by species lost. Different drivers affected various aspects of plant communities. Understanding which drivers influence single aspects of diversity, and how, is paramount for a holistic evaluation of vegetation changes over time. Implementing an adjusted sampling methodology can further reveal such relationships.

Francisca C. Aguiar, Ivana Lozanovska, Rui Rivaes, Cristiana Vieira, Teresa Ferreira

Centro de Estudos Florestais, Laboratório Associado TERRA, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal
Independent author
MARE – Centro de Ciências do Mar e do Ambiente, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal
Museu de História Natural e da Ciência da Universidade do Porto, Porto, Portugal

Going down and across the river: how aquatic and riparian plants cope with regulated flows - Oral presentation

Aquatic and riparian plant communities respond to the disruption of the natural river continuum by altering their cover, structure and function. The extent to which aquatic plants and their adaptive strategies cope with the effects of streamflow regulation is still understudied. This study investigates how aquatic and riparian plants respond to streamflow changes along a river and downstream of dams. Additionally, we aimed to assess the degree of regulation (DOR) and distance from the dam (DFD) at which river regulation no longer significantly influences plant communities. Our analysis focuses on two case studies in Portugal: a run-of-river dam and a storage reservoir. We collected data on 7 unregulated and 24 regulated sites. The assessment of the regulation effects used a functional trait-based analysis. We selected seven traits (growth form, life span, clonal spread, leaf shape, leaf anatomy, reproduction type, and dispersal vector) for vascular macrophytes; nine traits (canopy height, stem flexibility, rooting depth, leaf area, seed buoyancy, seed weight, reproduction type, diaspore type, and dispersal vector) for riparian woody vegetation, and three traits (life form, life strategy, and leaf length) for bryophytes. We conducted cluster and ordination analyses to identify plant guilds based on flow-responsive traits and used linear models to predict guild alterations along the regulation gradient and to determine the relationship between guild coverage and both DOR and DFD. Plant responses were mainly expressed through changes in recovery patterns rather than the reduction in the number of guilds. Our findings revealed: (1) an increase in vascular macrophyte cover and a decline in aquatic bryophyte cover with increasing regulation, alongside varied responses among riparian guilds; (2) a greater number of significant alterations in sites of the river impaired by a storage reservoir, compared to the sites of the river impaired by a run-of-river dam; (3) that regulation promotes shifts in the spatial location of riparian woody vegetation guilds on the riparian zone; (4) it was possible to assess for some guilds the projected DFD for the guild recovery (from 6 to 17 km down the river, downstream of the dam). Artificial environmental filtering governs plant species communities by accentuating species traits related to river regulation tolerance. Understanding how plant communities respond to different types of regulation and the extent to which various adaptive strategies mitigate these effects is crucial for optimizing river restoration efforts.

Claudia Irene Ortiz-Arrona, Jenifer Andrea Rojas Leguizamón

Centro Universitario de la Costa Sur. Universidad de Guadalajara, Mexico

Riparian ecological status in the El Cangrejo-Jalocote watershed, Jalisco, Mexico - Oral presentation

The assessment of the riparian ecological status is fundamental for achieving better river conservation and restoration goals. The objective of this research is to assess the ecological status of riparian zones in the El Cangrejo-Jalocote (C-J) stream watershed in the southwest of Jalisco state, Mexico. The C-J stream flows along 23 km, from the 2 220 m a.s.l. through a confined valley inhabited by rural communities to the Autlan city, and continues its course towards an extensive agricultural valley dominated by sugar cane, until its confluence with the El Coajinque stream at 850 m a.s.l. The C-J stream plays an important role in the maintenance of regional biodiversity and as a water source for agriculture and for domestic use to the rural and urban population within the watershed. The assessment of the riparian ecological status was realized in 2022, applying the Riparian Quality Index (RQI) methodology in 13 study sites, along the riparian corridor (dividing it into rural, peri-urban, and urban area, and agricultural valley). Seven attributes of the RQI were measured, three of which were related to the riparian vegetation structure: width of riparian corridor, longitudinal continuity, vegetation composition and structure; and four attributes related to their ecological functions: species regeneration, riverbank conditions, lateral connectivity and riparian substratum. RQI scores for each riparian attribute range from 1 to 15. The RQI result at each study site is obtained by summing the seven attribute scores; summed values will range from 130-150 (best status) to less than 10 (very bad status). The riparian quality status of the C-J watershed was: good (1), moderate (5), poor (4), and bad (4). The agricultural valley's sites were the most altered in structure and functions. Natural regeneration capacity and lateral connectivity were the most altered functional attributes by human intervention. Riparian native vegetation association contains *Enterolobium cyclocarpum, Salix bonplandiana*, *Ficus* sp., however, invasive species (i.e. *Ricinus communis*) and grasses were dominant in far-going altered sites. However, these statuses have been changed due to the occurrence of a mud and rock avalanche and a hurricane in 2023. A Post-impacts assessment of the environmental quality of riparian zones will be presented, discussing the status of the dynamics of the stream through the natural woody species regeneration, bank conditions, lateral connectivity and permeability of riparian soils, as key attributes to guarantee the self-maintenance of fluvial processes and riparian biodiversity in the watershed.

Jacqueline Hoppenreijs, Lutz Eckstein, Lovisa Lind

River Ecology and Management, Department of Environmental and Life Sciences, Karlstad University, Karlstad, Sweden 2 - Urban Ecology & Biodiversity, Institute of Geography, Ruhr University Bochum, Bochum, Germany

Not fewer, but different species: the effects of flow regulation on riparian vegetation - Oral presentation

Flow regimes shape the life cycles of riparian plants. Seed dispersal and deposition patterns follow peak flows, and water availability is an important determinant of germination and growth in the riparian zone. Many rivers are regulated for hydropower production, irrigation or drinking water supply, meaning that these natural functions decrease or fail. For example, dams form barriers that hamper long-distance dispersal of seeds. Riparian zones of regulated rivers are therefore thought to be less species-rich than those of free-flowing rivers. Decreased variation in discharge can also lead to narrower riparian zones and unsuitable habitat for riparian plants. Here, we compared riparian zones of two rivers in northern Sweden, that are comparable in every aspect but their flow regime. One of them is free-flowing, the other regulated. Along each river, we inventoried riparian width and species composition. Composition was measured in standardized plots (50 x 50 cm) as well as in 60 m long transects whose width varied with riparian width. We sampled upstream and downstream of six and seven tributaries to the regulated and free-flowing river, respectively, to test whether tributaries mediate any regulation effects. We found that the regulated river had narrower, but not necessarily less species-rich riparian zones. When measured in the standardized plots, species richness was similar between the two rivers, and the 60 m transects of the regulated river were slightly more species-rich than those of the free-flowing river. Species composition varied between the two rivers: they had 56 species in common, but each had over 25 unique species too. While we observed some differences in dispersal mechanisms, proportions of water-dispersing species were similar across the two rivers. This suggests that a lack of long-distance dispersal does not necessarily affect riparian vegetation in this way. Long-lived perennial species were dominant over all other life forms in both rivers, but we found more short-lived perennials along the regulated river than the free-flowing river. This was especially the case upstream of tributaries. Similarly, we observed somewhat more species that prefer dry to dry-mesic conditions along the regulated river, again more so upstream of tributaries. This suggests that flow regulation indeed favours different species than would occur under natural conditions, such as ruderal species. Our findings also suggest that tributaries may have potential to remediate some of the negative effects of flow regulation on riparian vegetation.

Sofia Santos, Maria Rosário Fernandes, Maria João Martins, Gonçalo Duarte, Juan Guerra, Francisca Constança Aguiar

Centro de Estudos Florestais, Laboratório Associado TERRA, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal

Unveiling riparian vegetation dynamics using aerial, UAV high-resolution imagery and LiDAR - Oral presentation

Riparian vegetation plays a crucial role in ecosystem functioning. However, these ecosystems are highly dynamic and susceptible to hydrological and land-use alterations, which affect plant succession and their capacity to serve as biodiversity reservoirs and providers of ecosystem services. In this study, we aim to assess floristic changes in riparian vegetation using remote sensing approaches, complemented by field data. We present two case studies conducted in central Portugal. In the first case study, we analyzed floristic alterations over 50 years following the construction of the Fronhas Dam on the Alva River (1965–2013). We used high-resolution airborne images (50 cm spatial resolution) from both pre-dam and post-dam periods, covering an 11 km stretch downstream of the dam. The pre-dam images correspond to the first national aerial survey conducted in the study area, while the post-dam images consist of multispectral airborne imagery. Field data were used to assess the dominant riparian woody species. For the second case study, we integrated multiple remote sensing technologies, including Light Detection and Ranging (LiDAR) and UAV optical imagery, to enhance the accuracy of riparian vegetation structure and species composition identification. We selected a stretch of the Alcolobre River, a tributary of the Tagus River, and analyzed remote sensing data from UAV and LiDAR surveys conducted in 2018 and 2024. For the first case study, the results revealed significant shifts in species composition due to hydrological alterations caused by the dam, as well as land-use and land-cover changes. Dominant native species, such as *Alnus lusitanica*, *Fraxinus angustifolia*, and *Salix* spp., expanded into the riverbed and towards abandoned agricultural lands. However, this expansion was accompanied by an increase in invasive species, particularly *Acacia dealbata*. In the second case study, LiDAR-derived structural variables provided accurate data on canopy height and biomass distribution of the main riparian species in the study area (*Alnus lusitanica* and *Salix salviifolia*). Additionally, we found that vegetation growth and dynamics could be effectively detected, which was further validated by field data. Notably, we clearly identified a reduction in 2024 of an area previously invaded by *Acacia dealbata* in 2018, following control efforts. These findings highlight the value of remote sensing technologies in monitoring riparian vegetation dynamics, providing essential insights for biodiversity conservation and ecosystem management in highly dynamic floodplains.

Morgan Botrel, Irene Gregory-Ives, Ulrike Hamann, Anne Lewerentz, Antonella Petruzzella, Stella A. Berger, Jens C. Nejstgaard, Lars L. Iversen, Sabine Hilt

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Leibniz Institute of Freshwater Ecology and Inland Fisheries, Department of Plankton and Microbial Ecology, Stechlin, Germany

Frequency, causes and consequences of boom-bust dynamics: lessons from invasive and native aquatic plant dynamics - Oral presentation

Boom-bust dynamics are of fundamental importance to interpreting and managing biological invasions. The concept, assuming that invaders may go through an initial outbreak (or 'boom') phase, in which their population becomes very large, before declining to a much smaller population size (the 'bust'), deviates from a steady and constant invasion scenario. Consequently, predicting the impact of an invasion on an ecosystem depends on the likelihood of observing boom-bust dynamics. However, knowledge about the frequency, causes and consequences of boom-bust dynamics is still scarce, partly due to a lack of empirical studies of large, representative, long-term data sets. Here, we compared the population dynamics of *Elodea canadensis, E. nuttallii* and *Myriophyllum spicatum* based on German monitoring data of the EU Water Framework Directive taken yearly (1 lake) or every 3-5 years (46 lowland lakes, 32 pre-alpine lakes with at least 4 samplings) between 2000-2024. These macrophyte species have shown boom-bust dynamics in their invasive range (*Elodea*: Europe, *M. spicatum*: North America), but the frequency, causes and consequences of such dynamics are unknown. In addition, we performed an enclosure experiment in the IGB LakeLab linking the growth of *E. canadensis* and *M. spicatum* to total phosphorus (TP) concentrations at different water depths and thus light levels. The most recent invader (introduced to Europe in 1939), *E. nuttallii,* showed a boom, boom-bust or bust dynamics in the majority of infested lakes (66%), while this proportion was lower for the earlier invader (introduced in 1836) *E. canadensis* (48%) and the native *M. spicatum* (38%). As expected, boom-bust dynamics of *E. nuttallii* were found more often in the more eutrophic lowland lakes (76%) than in the pre-alpine lakes (52%). The duration of boom phases ranged from 1 to 10 years. Lakes with a boom dynamic tended to have lower macrophyte maximum colonization depths, higher TP concentrations and more complex shorelines. The enclosure experiment showed a significantly positive response of *E. canadensis* growth rates to higher TP concentrations in deeper water (6 m) due to the formation of adventitious roots, while no correlation between growth and TP concentrations was found for *M. spicatum*. We conclude that boom-bust dynamics are common for invasive *Elodea* and are more likely in eutrophic lakes, but boom phases can be long and bust phases too difficult to predict to be used for reliable management.

Sara Puijalon, Ludovic Guillard, Baptiste Thévenet, Céline Lott, Nicolas Claude, Géraldine Nogaro

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EDF R&D, National Laboratory for Hydraulic and Environment, 78400, France

Anchoring of aquatic plants: role of architectural and biomechanical root traits - Oral presentation

Aquatic plants are frequently exposed to water movement, which can lead to mechanical failure, such as shoot breakage or plant uprooting. In lotic habitats, plants are permanently exposed to hydrodynamic forces induced by flow, whereas in lentic habitats, they may be episodically exposed to high levels of hydrodynamic forces induced by floods or waves generated by wind or boats. The impact of water movements on plants depends on the magnitude of the forces acting upon them and on their mechanical resistance to breakage or uprooting. The processes leading to the uprooting of aquatic plants have been poorly studied due to limited experimental devices and methods available. Here, we present 1) a new experimental device and a standardised procedure designed to study in situ the uprooting of aquatic plants through tensile tests and 2) the first measurements made on aquatic plants. The principle of the device is to apply a continuous tension to isolated plants or patches under standardized conditions (speed = 5 $mm.s^{-1}$; angle depending on the exposure conditions of the plants, with closed angles for plants exposed to the current and angles close to 90° for plants exposed to the waves) until plant uprooting. The force applied to the vegetation is recorded at high frequency throughout the test and the uprooting force is determined as the maximal force the plant can withstand before uprooting. Following the uprooting test, morphological, architectural and biomechanical traits were measured on the plant root systems. Initial measurements have been made on a diverse range of plant species and growth forms (hydrophytes vs. helophytes) and have shown a very wide range of uprooting forces between species, plant organisation and environmental conditions. Moreover, our results also show a significant relationship between uprooting force and some of the functional traits measured on the root system. The relationships between uprooting force and functional traits should enable the prediction of the effects of environmental factors on the anchoring of aquatic plants. This device offers new opportunities to investigate plant mechanical resistance to uprooting in the field, which is a key process of the responses of communities to flow.

Ewan Shilland, Iwan Jones, Don Monteith, Anne Jungblut, Anson Mackay

Queen Mary University of London, United Kingdom
UCL, United Kingdom
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30 years of aquatic plant surveys in the UK upland waters monitoring network - Oral presentation

The UK Upland (formerly Acid) Waters Monitoring Network (UKUWMN) was established in 1988 by the UK Government to monitor the effects of emission control legislation on the water chemistry and biodiversity of 22 lakes and streams across the UK. Since monitoring began, the water chemistry of most of these sites has shown clear signs of recovery (e.g., rising pH and declining labile aluminium concentrations). Aquatic plants are a key component of freshwater biodiversity, but their response to changes in water acidity has received much less attention than other biological groups, e.g., fish and macroinvertebrates. We present detailed records of aquatic plant communities collected from the full set of UKUWMN sites spanning over 30 years. Project-specific standardised methodologies have been used throughout the time series, and these have been augmented by Water Framework Directive Common Standards Monitoring Methodology survey techniques since 2009 at lake sites and in 2019 at stream sites. Ongoing doctoral study work is aiming to determine the extent to which these communities may have responded to regional reductions in aquatic acidity. There have been signs of recovery in aquatic plant assemblages at most non-control sites, but changes are less pronounced than in some other biological groups. At most stream sites, there has been an increase in the number of acid-sensitive moss species and at many lake sites, low numbers of new aquatic plant species have been recorded. Spates may be confounding the evidence of recovery at stream sites.

Enhua Li

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Evolution and ecological restoration of Honghu Lake - Oral presentation

Honghu Lake is a typical large shallow lake in the middle and lower reaches of the Yangtze River. Under the dual influence of human activities and climate change, the water ecological environment of Honghu Lake has undergone profound changes. In 2024, the concentrations of total nitrogen and total phosphorus in Honghu Lake were 1.65 mg/L and 0.148 mg/L, respectively. The annual average transparency of the water was 17 cm, and the annual average chlorophyll content was 29.61 ug/L. The submerged vegetation disappeared in 2020 and has not recovered since then. Based on the monitoring data collected over the years, through the application of sliding t-test, Pettitt test and Mann-Kendall trend test, the evolution process and change stages of water quality and aquatic vegetation in Honghu Lake since the 1990s were analyzed. It was concluded that the total phosphorus threshold for the transition from clear water state (a macrophyte-dominated state) to turbid water state (a phytoplankton-dominated state) in Honghu Lake is 0.092 mg/L, and the threshold for the transition from turbid water state to clear water state is 0.051 mg/L. Starting from 2022, comprehensive management and ecological restoration within Honghu Lake Basin were implemented. Through main restoration measures such as sunning the beaches, controlling fish populations and sowing seeds, the coverage of aquatic vegetation gradually increased from 6.60% (in 2022) to 13.67% (in 2023) and 31.33% (in 2024). The main types of vegetation included marsh, emergent and floating-leaf plants. The water quality in areas with high vegetation coverage also improved. In 2025, sunning the beaches and restoring vegetation continued to be carried out to reduce wind waves and increase water transparency, thereby promoting the recovery of submerged vegetation. We believe that for large shallow lakes like Honghu, after a steady-state transformation, attempting to restore aquatic vegetation by improving water quality first would be a lengthy process. This is because after the degradation and disappearance of submerged vegetation, the disturbance of wind and waves on the bottom soil intensifies, and the re-suspension of sediments becomes strong. As a result, the transparency of the water body is difficult to increase, and the concentrations of total nitrogen and total phosphorus cannot be reduced. Meanwhile, the Honghu basin is densely populated and under great pressure from economic and social development. The quality of the water entering the lake is unlikely to be fundamentally improved in the short term. Therefore, implementing hydrological process control measures mainly focusing on beach drying, and restoring aquatic vegetation, improving the water environment, and thereby improving the water ecology, may accelerate the restoration process of the degradation of large shallow lakes.

Kerstin Bouma, Gabriela Carrasco Oliva, Mats Douma, Perry Cornelissen, Mennobart Van Eerden, Ralph Temmink, Bart Nolet, Liesbeth Bakker

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Multi-year water level drawdown and grazing drive wetland vegetation succession - Oral presentation

Linear vegetation succession can become cyclic when disturbances reset the successional process. In wetlands, periodic multi-annual water level drawdowns and herbivory are disturbances that can trigger these cycles. These disturbances can be used in wetland management to increase the area of reed vegetation, an important habitat for wetland birds. However, the combined effects of a human-induced water level drawdown and herbivores on reed development remain poorly understood. To examine this combined effect, we conducted a field study in the eutrophic clay wetland Oostvaardersplassen in the Netherlands. We used satellite imagery to assess the impact of a water level drawdown by using both spatial and temporal variation to compare conditions with and without a water level drawdown, and with and without herbivores. Next, we conducted a three-year herbivore exclosure experiment (2022-2024) across a sediment height gradient in combination with camera traps to test the impact of red deer (*Cervus elaphus*) and geese (*Anser anser*) on vegetation development during a water level drawdown. Satellite imagery showed an initial colonisation of widespread pioneer vegetation followed by an expansion of reed cover by 560 ha without red deer (1987-1991) and 420 ha with red deer (2020-2024) during the water level drawdown, whereas there was no change in reed cover without a drawdown. The exclosure experiment highlighted a strong interaction between herbivory and water depth: in drier and ungrazed areas, reed cover and height increased more rapidly. The effect of geese on the reed development was more pronounced than the effect of red deer. Additionally, species composition differed between grazed and ungrazed areas during early successional stages. Our results show that a human-induced multi-year water level drawdown can serve as an effective restoration tool to reset wetland vegetation succession and increase reed cover. The presence of red deer had limited effects on reed expansion, whereas there was a strong interactive effect of geese and water depth. Maintaining dry conditions for several years, without persistent inundation in spring, is crucial for promoting reed development while minimizing the negative impact of geese. Cyclic water management can thus be used to steer vegetation succession; habitat use by herbivores and specifically facilitate reed expansion to maintain reed marshes and enhance species diversity at a landscape scale.

Tomasz Tymiński, Justyna Hachoł

Wrocław University of Environmental and Life Sciences, Poland

Macrophyte elements in near-nature river regulation – hydraulic research - Poster presentation

Macrophytic vegetation plays a very important role in restoring the naturalness of aquatic environments, including rivers. Very common and, at the same time, very useful in the close-to-nature regulation and vegetation development of rivers are reed plants, e.g., the common reed (*Phragmites communis*), typical of slow-moving waters. This particular species was the subject of our hydraulic theoretical analyses and experimental studies. In the water laboratory, tests were carried out on a river model with flexible bank vegetation. The main objective was to determine the hydrodynamic parameters and observe the hydraulic effects of the rushes. Geometrical and biomechanical characterisation of the studied vegetation zones was also performed. Sometimes, naturally valuable reed enclaves are so spatially developed and located in such places (e.g., islands located in the central part of the channel, riparian zone, constricted flow cross-section, natural stream deflectors) that they can have a significant impact on the hydraulic flow conditions, but also on the flood risk. The presence of reeds reduces the hydraulically active flow cross-section, increases the resistance to movement and often raises the water level. Vegetated channels can also create areas of turbulence, so-called flow blind spots, concentrations of flow and stream direction that threaten local erosion and scouring of the bed of the channel. The effect of flexible plants on flow conditions depends, to a large extent, in addition to hydrodynamic parameters, plant species, their developmental stage and geometrical characteristics, also on mechanical characteristics and especially elasticity, which is one of the typical characteristics of reeds. The results of our hydraulic studies and observations will be useful in predicting the behaviour of reed vegetation and determining the strength of hydrodynamic resistance in near-natural river regulation.

Justyna Hachoł, Tomasz Tymiński

Wrocław University of Environmental and Life Sciences, Poland

Long-term changes in aquatic macrophyte communities after river regulation - analysis of succession and ecosystem dynamics - Poster presentation

River regulation leads to changes in habitat conditions that directly affect the species composition and distribution of aquatic macrophytes. As a result of naturally occurring channel processes caused by the accumulative and destructive activity of water, the natural hydromorphological elements destroyed during the regulation works are gradually restored in the riverbed, which favours the re-succession of aquatic plants. The speed of this succession depends on many factors. This communication aims to analyse and evaluate the trends of changes in the diversity and structure of aquatic macrophyte communities observed after the implementation of regulation works in the long-term (up to several years), as well as to identify the factors influencing these changes. The paper presents the results of the inventory of aquatic macrophytes in small lowland watercourses in Lower Silesia (Poland) in the period from several to a dozen years after the implementation of regulation works. Twenty study sections in five watercourses were analysed. Due to their geological, hydromorphological and climatic conditions, the investigated watercourses are representative of the Central European lowlands. The field research was based on the Macrophyte Method for River Assessment, implemented in the monitoring of rivers in Poland. An analysis of available meteorological and hydrological data was also carried out. Both complete recovery and complete transformation of aquatic plant communities were observed in the studied riverbeds. In order to determine the influence of factors on the number of aquatic plant species, the SVR (Shapley Value Regression) method, which is dedicated to modelling with multicollinearity, was used. The dynamics of the changes were found to depend on the extent of the riverbed alterations, subsequent maintenance works, nutrient inputs from the catchment area, but also on factors related to climate change (lower water flows, higher temperatures). Based on the surveys and analyses, it can be concluded that the factors that had the greatest influence on the changes in the aquatic plant communities after regulation were shading and water level in the river bed. In the unshaded reaches with average water levels, the aquatic plant communities were most similar in species composition to the pre-regulation communities. This knowledge is crucial for the management and conservation of biodiversity in river ecosystems.

Laura Grīnberga, Jolanta Jēkabsone, Jurgita Butkuvienė

University of Latvia, Faculty of Medicine and Life Sciences, Latvia
University of Vilnius, Life Sciences Center, Lithuania
Latvian Environment, Geology and Meteorology Centre, Latvia

Growing distribution of *Hydrilla verticillata* in Latvia and Lithuania – good news? - Poster presentation

Hydrilla verticillata (L. f.) Royle is a rare and protected submerged macrophyte species, included in the Latvian Red Data Book and the regulations for rare and protected species of Latvia. In Lithuania, *Hydrilla verticillata* was also protected and listed in the Lithuanian Red Data Book; however, after the spread of this species in inland waters was observed, it was removed from the list of protected species in 2021. The first recorded finding of *Hydrilla verticillata* in Latvia occurred relatively late, in 1961, in Lake Lielais Stropu. In the following forty years, the number of localities of the species increased to twenty-three. Since 2015, studies in Latvian lakes have also demonstrated a northward expansion of the species' range, with its presence confirmed in three lakes in central Latvia, approximately 100 km beyond previously recorded locations. Additionally, species distribution has increased in the area where it was already present. *Hydrilla verticillata* usually forms dense stands in oligo-mesotrophic to eutrophic lakes in the southeastern part of Latvia and the northern to northeastern and southern parts of Lithuania. For this study, data from various research studies are used, including data from the national lake monitoring and EU habitat inventory. The relationship between the physicochemical and ecological quality of lakes in Latvia is analyzed. To assess species genetic variability, 20 individuals from Latvia and 16 individuals from Lithuania were assessed using molecular ISSR markers. Herbarium specimens from the Latvian National Museum of Natural History (herbarium LDM), Nature research centre (herbarium BILAS), Vilnius University (herbarium WI) were used for genetic research. Lake monitoring data indicate that the populations of *Hydrilla verticillata* remain stable in lakes where the species have been present for more than twenty years. The species forms stands with rare macrophyte species in oligo-mesotrophic lakes, including *Najas flexilis*, *Najas minor*, and *Chara filiformis*, as well as occurring in eutrophic lakes growing in dense stands with *Elodea canadensis*, *Ceratophyllum demersum*, and *Batrachium circinatum*. Genetic diversity may determine its ability to form dense stands and adapt to varying water conditions. This may be very important for the protected species and the entire plant community, of which *Hydrilla verticillata* is a component.

Ioanna Xynogala, Georgios Dimitrellos, Dionisis Tsoukalas, Konstantinos Stefanidis, Eva Papastergiadou

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Riparian landscape dynamics, ecological integrity, and ecosystem services in East Mediterranean rivers - Poster presentation

Rivers and riparian landscapes are among the most threatened ecosystems in the world. Riparian zones constitute dynamic and integral components of fluvial ecosystems that are responsible for many ecological functions, as well as direct benefits to human wellbeing by supporting several ecosystem services (ES). However, their ecological integrity is heavily influenced by human disturbances at basin and corridor scales, especially in the Mediterranean, where high population densities and water scarcity aggravate pressures around water bodies. Alterations in flow regime and hydromorphology are often responsible for changes in the riparian vegetation, habitat loss, narrowing of the riparian buffer zone, and loss of longitudinal connectivity. Lately, river scientists have shown increased interest in new tools and methods for quantifying the relationships between hydromorphological alteration, land use changes, and the ecological integrity of the riparian habitats. An integrative approach for assessing the impact of human intervention on two lowland Mediterranean rivers of Western Greece was conducted using multiple indicators. The riparian zone was mapped in a fixed buffer zone of 200 m and multi-temporal maps were created to assess land cover changes occurring in the area. The ES 'matrix' approach was used to assess the riparian areas' capacity to supply ES. In the studied areas, "forest and semi-natural areas" dominate in both catchments, followed by "agricultural areas." The upper and middle courses display natural conditions, showing the highest ecological integrity and provision of ES. However, their lower courses have experienced the most significant anthropogenic interventions, which reduce their EI and supply of ES. The results showed that land use changes in the lowlands, where natural land cover has been replaced by arable land and artificial surfaces, are the main driver of decreased ecological integrity and limited supply of ES. Overall, the results of the current approach provide useful information and could be a valuable tool for sustainable river basin management. Particularly, spatial analysis facilitates the detection of specific activities that threaten the ecological balance of the rivers, thereby improving conservation strategies that mitigate disturbances and preserve the essential functions and benefits provided by the riparian zones.

Aquatic plant collaborations: insights from emerging projects and growing networks

Session 5

Chairs: Antonella Petruzzella (Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany) & **Krister Kartunen** (Finnish Environment Institute - SYKE, Finland)

This session highlights collaborative efforts and emerging networks advancing aquatic plant research globally. It showcases updates from specialist groups and innovative projects that track phenology, explore functional traits, and investigate environmental changes across continents. Emphasizing the power of shared knowledge, these initiatives foster connections among researchers and support early-career researchers. They demonstrate how collaborative science drives progress in conservation, management, and ecological insight. We hope this session will plant the seeds for new ideas and inspire collaborative projects and networks among symposium participants.

Richard Lansdown, Thomas Abeli, Udo Schwarzer

IUCN SSC Freshwater Plant Specialist Group, United Kingdom
University of Pavia, Italy

The IUCN SSC Freshwater Plant Specialist Group update on activities - Oral presentation

The IUCN SSC Freshwater Plant Specialist Group includes more than 100 members from more than 70 countries. The work of the FPSG is based on the 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. 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 enables us to track trends in the conservation status of species and the wetlands on which they depend worldwide. Since 2023, Thomas Abeli of the University of Pavia has been appointed as co-Chair, and the Conservation Action Plan for the genus *Cryptocoryne* has been published.

Anne Lewerentz, Benjamin Misteli, Silvia Cannucci, Alice Dalla Vecchia, Euphoria Project Team

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https://euphoria-fresh.jimdofree.com/project-1/outreach/iapg-2025/

Tracking aquatic plant phenology across Europe: first insights from the EUPHORIA project - Oral presentation

Phenology, the timing of seasonal life cycle events, is a crucial indicator of environmental change and plays a fundamental role in shaping ecosystem interactions. Shifts in phenological traits of plants, such as earlier flowering or extended growing seasons, are well-documented in terrestrial ecosystems and have profound ecological consequences, including trophic mismatches and altered competitive dynamics. However, despite the ecological significance of phenology and freshwater habitats, research on the phenology of aquatic macrophytes remains scarce. Understanding how phenological traits vary across environmental gradients is essential for predicting freshwater ecosystem responses to climate change. Given the expected extent of shifts in seasonal dynamics, broad-scale assessments are needed to evaluate spatial variation in macrophyte phenology. To address this, we launched the EUPHORIA (European Plant Phenology Research in Aquatic Systems) project, a collaborative effort awarded by the European Federation for Freshwater Sciences (EFFS and EFYR). Our main scientific objectives are to document and analyze the phenological traits of aquatic macrophytes across Europe and to understand the environmental drivers of these traits. Over 100 Early Career Researchers (ECRs) across Europe will record key phenological events of common native and non-native macrophyte species across a geographically wide range of European freshwater systems. The sampling campaigns will take place from April to October 2025, following standardized protocols. Environmental data, including water temperature and light availability, are collected to assess their role in shaping macrophyte phenology along latitudinal and climatic gradients. We will present the first results on the spatial variation in phenological events and the correlations between macrophyte traits, temperature, and light conditions. These findings will contribute to a better understanding of freshwater plant responses to environmental change and improve predictions of macrophyte dynamics under future climate scenarios. By providing a continental-scale assessment, EUPHORIA offers valuable insights for conservation and management strategies in European freshwater ecosystems.

Janne Alahuhta, Jorge Garcia-Giron, Daniel Larkin, Danelle Larson, Michael Tseitlin

University of Oulu, Finland
University of Leon, Spain
University of Minnesota, United States of America
U.S. Geological Survey, United States of America

Introducing research project on historical and contemporary environmental changes of macrophytes in Europe and North America - Oral presentation

Freshwaters are the most severely threatened ecosystems on Earth, yet current ecological research too often neglects these vital ecosystems. We specifically lack information on longer-term changes in species occurrences and environmental conditions in freshwaters. Moreover, we are in short of information on the capacity to contrast and explain changes across the globe, particularly in relation to land use patterns on continents with different human settlement histories. In the project "Unraveling the effects of contemporary and historical changes in climate and land use on freshwater biodiversity in high-latitude regions of Europe and North America", we tackle these shortages by focusing on freshwater plants, which perform vital ecosystem functions and can serve as proxies for biodiversity in freshwaters worldwide. We will integrate freely available "big data" from Europe and North America to assess how changes in climate and land use have altered freshwater plant community dynamics during the past century. We will build a temporal database on freshwater plant occurrences, habitat variables, functional traits, phylogenetic relationships, climate, and land use since the early 20th century until the present in northern landscapes. The new database will address key macroecological questions: (i) How have variation in climate and land use since the early 20th century influenced freshwater plants in northern latitudes?, (ii) Is land-use intensification a stronger driver of change than changing climate in explaining freshwater plant diversity and distribution?, (iii) Are historical legacies of past climates and land use still shaping distribution and functions of present-day freshwater floras in Europe and North America?, and (iv) Are there long-lasting biotic imprints affecting contemporary freshwater plant communities, and do these legacies differ between continents? This research would contribute to contemporary debate in biogeography and ecology by revealing whether historical environmental changes have affected past and present-day communities. Our project will also address a major area of research in contemporary ecology by shedding light on the role of priority effects (order of species arrival) and evolutionary legacies in long-term and short-term community trajectories. Our research will have broader societal impacts by helping to define reference conditions for freshwater health that are crucial for guiding conservation, bioassessment, and environmental management in both continents.

Lindsay Louise Trottier, Yingji Pan, Jorge García-Girón, Janne Alahuhta, Simonetta Bagella, Pauline Balk, Lars Båstrup-Spohr, Ana Maria Bedoya, Rossano Bolpagni, Colin Burke, Bruno El Cerabolini, Brian Charles, Rafał Chmara, Alice Dalla Vecchia, Michele Dalle Fratte, Gary Ervin, Ana Luísa Fares, Maira Patricia Gayol, Charlotte Grasset, Emma Helman, Ashley Hoblyn, Migyeong Jung, Ji Yoon Kim, Laura M Kipriyanova, Gergő Koleszár, Yang Liu, Tatiana Lobato De Magalhães, Balázs András Lukács, Luz Manzo, Jeffrey M Matthews, Thaisa Sala Michelan, Gemma C Milly, Natalia Soledad Morandeira, Roger Paulo Mormul, Viktor Oláh, Eva Papastergiadou, Aes Patrick, Ole Pedersen, Lars Rhazi, Giovanni Rivieccio, Michał Rybak, Peter Ryser, Diana V Sityaeva, Konstantinos Stefanidis, Sándor Szabó, Chrisopher Tyrrell, Jonathan Urrutia-Estrada, Peter Van Bodegom, Ziqi Ye, Lars Lønsmann Iversen

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Institute of Environmental Sciences, Leiden University, Netherlands

The Macroecology of Aquatic Plant Functions (MAP) project: exploring the functional and environmental trait space of macrophytes - Oral presentation

Aquatic plants (macrophytes) are crucial for the maintenance of ecosystem functioning and structure. Functional traits (i.e., physical characteristics linked to growth, reproduction, and survival) can be used to explore the mechanisms by which macrophytes provide structure and stability to freshwater ecosystems. Similarly, functional traits link biodiversity to ecosystem functioning, which is essential for understanding how plants are shaped by and govern the abiotic characteristics of their environment. The phenotypic and physiological adaptations of plants to external factors and how species, communities, and ecosystems worldwide may differ in the future can be explained using functional ecology. This is especially important considering the impact of anthropogenic and climate-induced changes, such as eutrophication and global warming, on the structure and function of freshwater ecosystems worldwide. Despite the ecological significance of macrophytes, functional trait research has been largely centered on terrestrial plants, in part due to the absence of a centralised database for aquatic plant traits. Since 2021, the Macroecology of Aquatic Plant Functions (MAP) Project has been working to address this data gap by compiling measurements of plant height, leaf area, specific leaf area, leaf phosphorus content, and leaf nitrogen content for 3331 macrophyte species. To date, more than 45 collaborators from around the world have contributed functional trait data to the MAP Project. The MAP Database contains over 42,000 records, and 55% of macrophyte species have at least one trait measurement. As in other global trait databases, trait coverage varies by functional trait (ranging from 11% coverage of leaf phosphorus content to 53% for plant height) and by ecozone (ranging from 60% of species in the Neotropics with at least one trait measurement, to 93% in the Nearctic). Now, we have begun to employ this unique trait database, in conjunction with global information on environmental conditions (e.g., climate and bicarbonate availability) and species distributions, to explore how trait-trait relationships and trait-environment relationships of macrophytes compared to those of terrestrial plants. We also aim to quantify variation within the trait space of macrophytes and identify possible sources for variation, such as freshwater-adaptive traits, which enable aquatic plants to survive underwater. The work conducted through the MAP Project is the first attempt at understanding how ecological patterns and processes in freshwater systems are driven by the form and function of the macrophytes inhabiting them. Ultimately, the MAP Project will provide a foundation for future research and conservation efforts stemming from a trait-based ecological framework.

Gray Turnage, Ryan Wersal, John Madsen

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Understanding phenology of invasive aquatic plants to inform management initiatives in the United States - Oral presentation

Invasive aquatic plants are an increasing global problem that have limited management strategies when contrasted with terrestrial invasive plants. The most effective plant management strategies for invasive species are those that maximize stress on target species when internal energy reserves are low (i.e., weak points in the plant life cycle). Understanding the phenology of invasive aquatic plants can help resource managers time management initiatives to maximize stressors during weak periods of target species. Phenology is the study of the seasonal timing of critical life stages in plants in response to environmental cues (e.g., temperature or photoperiod), whereby the allocation of biomass and other resources, such as carbohydrates, are fundamental aspects during these life stages. Oftentimes, aquatic plants exhibit cyclical seasonal growth patterns that allow researchers to identify periods of low plant energy reserves (i.e., weak points in the life cycle) that can be exploited for management activities that maximize stress on the target species (e.g., mechanical, chemical, or biological control methods). Biomass data was collected over two years for invasive aquatic plant species in the United States (curly-leaf pondweed [*Potamogeton crispus*] and parrotfeather [*Myriophyllum aquaticum*]) and correlated to environmental parameters (air temperature and photoperiod) to predict natural weak points in plant phenology. Starch, which is a component of carbohydrate reserves, was also quantified in parrotfeather tissues to further validate predictions of weak points in the plant life cycle. Spring and late-fall were identified as weak points of curly-leaf pondweed phenology, based on biomass allocation, and therefore, suitable times to implement management strategies to maximize stress. Late summer was identified as the weakest phenological point in the parrotfeather life-cycle based on biomass allocation and starch content, suggesting management should coincide with this period to maximize stress on this species. Phenological data are necessary when developing management strategies to better manage invasive species and potentially selectively reduce target species when growing as part of a mixed plant stand. However, not all management strategies are appropriate for use during all plant life stages, as desirable species may be present during some stages of the target species' life-cycle. Therefore, target plant phenology and the presence of non-target species should be considered prior to initiating management activities, as each may influence the selection of appropriate management techniques that simultaneously target to weak points of the invasive species life cycle while minimizing impacts to non-target species.

Rossano Bolpagni, Alice Dalla Vecchia

Parma University, Italy

IMAD: updating ecological and functional knowledge on macrophytes in Italy - Oral presentation

Macrophytes are one of the biological components at greatest risk of (local/regional) disappearance in Italy, as is much of the freshwater biodiversity of central and southern Europe. At the same time, Italy represents a hot spot of floristic and vegetation diversity of considerable importance in the global context. Unfortunately, the level of knowledge about this fundamental biological component is overall inadequate for planning appropriate protection and management initiatives. To remedy this situation, the iMAD (development of the Italian MAcrophytes Database) project – funded by the Italian National Biodiversity Future Center – was launched in late 2024 as part of the implementation of the National Recovery and Resilience Plan (PNRR) of the program Next Generation EU. iMAD has three main objectives: [1] to update the available knowledge on macrophytes in Italy by reviewing the data edited by Bolpagni et al. (2018); [2] to collect and systematize ecological and environmental data on macrophyte-colonized ecosystems; [3] to associate ecological and environmental data with functional data for some target macrophyte species. In general, therefore, the iMAD project will enable significant implementation of Italian biodiversity databases, creating a new database specifically dedicated to “macrophytes” (iMAD). A large amount of data, both distributional and ecological-functional, will be collected during 2025. For the 10 most widespread (native) macrophytes and the 10 invasive macrophytes recognized as most critical at the national scale, environmental and functional niches will be defined – exploring the spectrum of leaf economics – by investigating at least 10 different populations each. Finally, special attention will be paid to rare and/or threatened macrophytes, for which environmental determinants will be characterized, both in terms of water and sediment physicochemical quality and risk and impact factors. Initial evidence gathered will be presented.

Giulia Lodi, Katharina Wilfert, Ewout Crombez, Quinten Bafort, Reindert Devlamynck, Marie Lambert, Yves Van De Peer, Thimo Groffen, Els Prinsen, Jonas Schoelynck

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The Charm(s) of Duckweed 2.0: breathing new life into the duckweed knowledge hub website - Poster presentation

The Charm of Duckweed, originally created by Dr. John W. Cross, served as a comprehensive online repository dedicated to the fascinating world of duckweed. This platform offered extensive botanical insights, experimental methodologies, and practical applications, establishing itself as an essential reference for researchers and enthusiasts alike. Despite its last update in 2003, the website remained a valuable archive of knowledge, but we nonetheless closed it in the end. Recognizing the enduring significance of this resource, the European Duckweed Network (EDN) has undertaken the initiative to revitalize and modernize the website. The updated platform aims to serve as a dynamic, up-to-date hub for the duckweed community, facilitating knowledge exchange, fostering collaborations, and providing a centralized resource for all aspects related to duckweed research and application. To further refine and expand the content of the renewed website, the IAPG-2025 conference in Lisbon presents an ideal opportunity to reach out to the duckweed community. We invite researchers, practitioners, and enthusiasts to provide input on desired features and topics and to collaborate in contributing content. This collective effort will ensure that the platform evolves in line with the community's needs and continues to support the advancement of duckweed research and its practical applications.

Lindsay Louise Trottier, Anne Lewerentz, Kerstin Bouma, Colin Lee Burke, Alice Dalla Vecchia, Louis Johansen Skovsholt

Institute of Geography and Geoecology, Karlsruhe Institute of Technology (KIT), Germany
Department of Biology, McGill University, Canada
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Department of Biology - Aquatic Biology, Aarhus University, Denmark
Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy
Globe Institute, University of Copenhagen, Denmark

The New Macrophyte Researchers Group: a network for students and early-career researchers - Poster presentation

Students and early-career researchers (ECRs) studying macrophytes often find themselves isolated within their institutions, lacking local peers with similar research interests. To address this, we established the New Macrophyte Researchers Group, a global online network that connects undergraduates, master's students, PhD students, and postdocs with a shared passion for macrophyte research. This initiative emerged following the 16th International Aquatic Plant Group (IAPG) conference in Antwerp, Belgium, where a group of students and ECRs created a mailing list to foster collaboration and support. Since then, we have organized semi-annual virtual meetings (Macrophyte Mondays), each attended by 15–20 researchers worldwide. These meetings provide a platform for participants to present their work through short talks, discuss recent papers and projects, and engage in open scientific dialogue. The enthusiastic and collaborative atmosphere enhances knowledge exchange and professional development, helping students and ECRs navigate the challenges of their academic careers and begin to establish their own research networks. By presenting this initiative at the 17th IAPG conference, we aim to raise awareness of the New Macrophyte Researchers Group and encourage broader participation by students and postdocs with an interest in macrophytes. We invite interested students and ECRs to join our growing network, strengthening connections within the macrophyte research community.

Macrophytes and global change

Session 6

Chairs:

Session 6A: Sara Puijalon (Université Claude Bernard Lyon 1, France) & **Krzystof Szoszkiewicz** (Poznan University of Life Sciences, Poland)

Session 6B: Esperança Gacia (Centre d'Estudis Avançats de Blanes, CSIC, Spain) & **Mariusz Pełechaty** (Adam Mickiewicz University, Poland)

This session explores the impacts of global change on aquatic plant communities, an increasingly urgent topic amid accelerating climate uncertainty and intensifying human-induced pressures on aquatic ecosystems. Research contributions examine the responses of aquatic plants to key environmental drivers, including rising temperatures, hydromorphological alterations, and land use and land cover change. Presentations also address the development and refinement of macrophyte-based bioindicators, shifts in species distribution and community composition, and the functional role of aquatic plants in carbon and nutrient cycling. The studies span a wide range of freshwater habitats, from oligotrophic alpine lakes to mediterranean and temperate river systems, offering valuable insights into species resilience, ecological thresholds, and the dynamics between native and invasive species in changing environments.

Rosi De Luca, Dario Salemi, Vincenzo Ilardi, Anna Geraci, Rosario Schicchi, Angelo Troia

University of Palermo, Dept. STEBICEF, Italy
University of Palermo, Dept. SAAF, Italy

Biodiversity in Italian rice fields: a test with aquatic macrophytes - Oral presentation

Rice paddies, although intensively cultivated and subject to various anthropogenic pressures, are unique ecosystems that support a rich biodiversity, providing habitats for numerous species. Within the framework of the Italian National Recovery and Resilience Plan (PNRR), the interdisciplinary project "InnovaRisi" (PNRR M4C2 Inv.1.4, CUP D13C22001330005) aims to enhance the ecological importance of rice paddies by integrating economy, environment and sustainable tourism. One of the project's objectives is to assess the sustainability of different cultivation methods and identify bioindicators to evaluate the health of rice ecosystems. For this purpose, three study areas were selected in the western Po Valley: Crescentino and Rovasenda (Vercelli), and Casalbeltrame (Novara). Within each area, conventionally cultivated rice paddies, organic rice paddies and natural wetlands (the latter used as reference sites) were sampled. Surveys were conducted in Autumn 2024, with a second sampling campaign planned for spring 2025. The project applies a multi-taxon approach, never before used in rice paddies, focusing on aquatic flora, aquatic invertebrates, soil fauna and microbiota. Here we report preliminary results for the aquatic flora, including vascular plants and charophytes, based on the samplings conducted in September 2024. The study involved phytosociological relevés and sample collection, with species identified on a morphological basis. A list of 31 taxa were recorded across the three study areas and the nine sampling sites, including information about their cover/abundance. Among the taxa of particular interest: *Marsilea quadrifolia* L., included in the Italian Red List and classified as an endangered species by the IUCN, and *Butomus umbellatus* L., considered vulnerable. For each "treatment" (organic, "O"; conventional, "C"; and natural area, "N"), the total specific richness (O > N > C) and the mean specific richness (O > C > N) were calculated. However, organic rice fields also hosted the highest number of alien species (O > C > N). Our observations confirm that rice fields are vulnerable to invasions by alien species, which represent 39% of the total recorded taxa. Exclusive native taxa were also identified, confirming greater uniqueness in natural areas > organic > conventional. The floristic component was analysed using Ellenberg indicators (revealing similarities among the three categories), life forms (with the abundance of therophytes consistent with the influence of dry sowing) and the chorological type (emphasizing two different barycentres of alien flora origin). These preliminary findings underscore the role of these agroecosystems in both supporting biodiversity and facilitating biological invasions.

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Associate Laboratory Terra, Portugal

Updates to the Portuguese aquatic flora - Oral presentation

Portugal published its first red list of vascular flora just five years ago (2020) and, so far, only one-fifth of the native species have been assessed. Alarmingly, 60% of the evaluated species are considered threatened, with aquatic and wetland plants being among the most affected groups, showing the highest numbers of threatened, extinct, or disappeared species. Some of the aquatic plants that have disappeared remain unassessed. Since 2017, a group of volunteers has been dedicated to mapping aquatic species. Several small regional projects have been initiated to enhance the knowledge of the distribution of these species, improve their conservation status and manage their threats, namely invasive alien species. Through these efforts, we have rediscovered several missing species (e.g., *Vallisneria spiralis*, *Limosella aquatica*, *Potamogeton coloratus*) and discovered some new aquatic plant species (e.g., *Ceratophyllum submersum*) and hybrids (five *Potamogeton* hybrids) for Portugal's flora, along with some new exotic and invasive species (e.g., *Ludwigia grandiflora*, *Najas gracilima*, *Wolffia columbiana*, *Lagarosiphon major*). This presentation will highlight our search efforts and the exciting and alarming discoveries we have made.

Esperança Gacia, Eric Baqué-Díaz, Lluís Camarero, Jordi Catalan, Joan Lluis Riera, Enric Ballesteros

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Macrophyte community responses to environmental change in Alpine Pyrenean high mountain lakes - Oral presentation

Recent studies highlight a global decline in macrophyte biodiversity in low- to midland-standing waters, driven by factors such as eutrophication, dam construction, aquaculture, fishing, and invasive species. Submerged macrophytes also play a crucial role in oligotrophic, soft-water lakes, which are highly sensitive to environmental changes. These lakes can serve as sentinels, providing valuable insights into subtle global change impacts that might go unnoticed in other ecosystems. The high mountain alpine Pyrenean Lake system comprises hundreds of soft-water, oligotrophic, shallow lakes that are particularly rich in aquatic flora. Historically, these lakes—situated between 1,600 and 2,500 m a.s.l.—were largely unaffected by human activity related to catchment land use. However, studies from the past decade indicate ongoing changes in the composition of atmospheric deposition and the introduction of various fish species, both of which have the potential to impact the biodiversity of aquatic macrophytes. Building on a 1987 study that analyzed the flora of shallow Pyrenean lakes, this research examines changes in macrophyte biodiversity in thirty high mountain lakes by comparing semiquantitative inventories from fixed transects over time. We assess shifts in species richness, abundance, spatial beta diversity, and species-specific trends across two time periods. These community changes are analyzed in relation to concurrent shifts in lake water chemistry, while also evaluating the potential influence of introduced minnows (*Phoxinus* sp.). Our results reveal overall stability in regional macrophyte richness but notable shifts in species abundance and composition at the lake level. Oligotrophic mosses and floating-leaved macrophytes have declined, while some natopotamids, typically associated with more nutrient-rich waters, have expanded. These trends align with regional increases in conductivity and alkalinity, and an overall reduction in nitrogen availability, with macrophyte community shifts more pronounced where conductivity exceeded a threshold of 20 µS/cm. No direct link was found between minnow presence and water chemistry changes. These findings underscore the importance of long-term monitoring of aquatic plant communities to better understand the ecological consequences of environmental change in these pristine ecosystems. They also illustrate how biodiversity serves as an integrated record of shifting environmental conditions over time.

Mariusz Pełechaty

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Biomass production and $CaCO_3$ precipitation by charophytes: environmental implications and carbon sequestration - Oral presentation

The study explores biomass production and $CaCO_3$ precipitation by charophytes (Charophyta), and their environmental and applicative implications. A comparison to angiosperms was made to test the hypothesis that charophytes play a substantial role in sedimentary processes and the long-term deposition of $CaCO_3$ in the sediments of marl lakes contributes significantly to the sequestration of excess carbon in bottom sediments. Literature review and original study allowed concluding that compared to angiosperms, charophytes produce significantly larger biomass. While tall and branchy charophytes produce higher dry weight (DW) per individual but form sparser communities, smaller and slender species tend to create very compact beds which may minimize species-specific differences in biomass production. In temperate climates, charophyte biomass frequently exceeds 1000 g DW m^{-2} or even 2000 g DW m^{-2}. Higher values were reported from Mediterranean climate, where they exceeded 4 kg m^{-2} and reached an extreme value of 11.5 kg m^{-2}. Charophytes are highly efficient at utilizing bicarbonate as carbon source for photosynthesis and precipitating calcium carbonate encrustation compared to angiosperms. The content of $CaCO_3$ encrustation in freshwater charophytes exceeds 50% of DW (up to 80%), which is higher than in brackish and saltwater charophyte species, and angiosperms. The share of carbonate encrustation varies depending on water chemistry, habitat conditions, and species-specific thally architecture. $CaCO_3$ precipitation per 1 m^{-2} is a function of DW production and may exceed 1500 g m^{-2}. This process leads to water decalcification, influencing water chemistry and carbon cycling in aquatic ecosystems. Charophytes play a significant role in excess carbon sequestration through the precipitation and deposition of $CaCO_3$ in bottom sediments. However, different species exhibit varying degrees of carbonate deposition and recirculation, necessitating further research to better understand the long-term impact of charophytes on carbon sequestration and permanent $CaCO_3$ deposition under climate warming conditions. This research emphasizes the multifaceted role of charophytes as ecosystem engineers, supporting the functioning and services of aquatic ecosystems, but the significance of charophytes is not limited to the contemporary aquatic environment. Charophytes are important in palaeolimnology due to their high fossilization potential, providing valuable insights into past vegetation structures and environmental conditions, which are crucial for paleoenvironmental reconstructions.

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Long-term research of the distribution of macrophytes in Alpine Lake Bohinj (Slovenia) - Oral presentation

Macrophytes play a crucial structural and functional role in the aquatic ecosystem and respond to the spatial, temporal, physical, chemical and biotic characteristics of the lake in which they thrive. Mosses and algae have a lower compensation point and can colonise greater depths. On the other hand, vascular plants require more sun radiation, thus their growth is limited to the shallower parts of the littoral. Lake Bohinj is the biggest permanent natural lake in Slovenia. It is located in the nature-protected area of the Triglav National Park (TNP) and is also a Long-Term Ecological Research Network (LTER) site. We have monitored macrophytes' presence, abundance, and depth distribution in Lake Bohinj for 18 years. Physical and chemical parameters and some other environmental parameters have been measured as well. After the WFD came into force in 2005, we assessed the lake's ecological status. According to the long-term set of data, the presence and depth distribution of the macrophytes changed during the years, especially the number of submerged macrophytes decreased. However, the ecological status according to macrophytes in Lake Bohinj has been very good. The presence and abundance of macrophytes are higher on the gently sloping littoral on the lake's south shore than on the steeply sloping north shore. *Myriophyllum spicatum* and Charophytes prevailed in the lake, while the genus *Potamogeton* had the highest number of species. In the year 2024, *M. spicatum* reached 6,9 m in depth, and *Chara delicatula* reached 10 m. Charophytes grew deeper in lake Bohinj than vascular plants. The water of the lake is transparent, and the nutrient content is low. However, we can see that the condition of the lake is deteriorating. On the eastern side, *M. spicatum* is growing more abundantly. The number of submerged macrophyte species has decreased. The lake is threatened by numerous bathers, unregulated sewage from holiday cottages, and nutrients that are run off from mountain farms and pastures, especially on the northern and northeastern sides of the lake. Fortunately for the lake, the water has a short retention time and is located in the TNP area, where human interference is limited. However, we must be careful and strive to maintain the lake in good condition so that it continues to provide habitats for many organisms that, through their processes, purify the lake and maintain ecological stability.

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Macrophyte communities in the reference network of Spanish rivers: river types and indicator species - Oral presentation

The application of the European Water Framework Directive 2000/60/CE, and more specifically the ecological status assessment of rivers and streams, implies the need to define the reference communities that correspond totally or nearly to undisturbed environmental conditions. The composition and abundance of aquatic flora are one of the biological quality elements to be monitored for the classification of the ecological status of rivers. Since the year 2019, macrophytes, which included algae (prokaryotic and eukaryotic), bryophytes and vascular plants, have been monitored along with other quality elements to establish the reference conditions of Spanish rivers ("REFCON" project). A national network of 319 sites without significant anthropic pressures was established to cover all river types across the Iberian Peninsula -Spain (32 abiotic river types previously defined by geographic, hydrological, geological and climatic variables). The main objective was to define river type-specific macrophyte communities under reference conditions, to analyse the correspondence between communities and the predefined abiotic river types, and to identify indicator species of environmental conditions. Of the total taxa collected (determined at genus or species level), 9% were cyanobacteria, 20% eucaryotic algae, 35% bryophytes, 0,9% lichens and 36% vascular plants. Multivariate analyses were performed to test significant differences in community structure between abiotic river types. Classification of river types based on macrophyte communities suggested the merging of some abiotic river types. Finally, we discuss some aspects of the use of macrophytes as bioindicators to evaluate the ecological status of river ecosystems.

Paulo Lemos

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The effects of industrial agriculture on residual populations of rare aquatic macrophytes in Western Portugal - Oral presentation

Agroindustry plays a decisive role in the decline of rare vascular hydrophytes in the coastal region of Peniche-Nazaré, as evidenced by a survey continued to date, started on its residual populations between 2018 and 2020 for the Red List of Vascular Flora of Mainland Portugal. The most threatened species are *Potamogeton coloratus* (stood out as the first confirmed record for the country, along with a new population from the southwest), assessed as Endangered (EN); *Potamogeton lucens*, as Endangered (EN); *Utricularia* × *neglecta* (assessed as *U. australis*-Vulnerable (VU)); the Near Threatened (NT) *Potamogeton trichoides*, and also a not yet assessed new species to Portugal, *Ceratophyllum submersum*, considered globally rare or overlooked despite its wide distribution, aspiring to the Critically Endangered (CR) category in Portugal. Most of these hydrophytes were found in lowlands subject to agriculture since time immemorial, and some had already disappeared from locations registered as historical long ago. They have survived decades of anthropogenic or exotic species impact by establishing themselves in alternative habitats to their natural, such as wells or similar stable structures in rural areas, sometimes close to well-preserved wild catenas. Agricultural intensification is now largely replacing abandoned traditional agriculture and uncultivated lands. The impact of earthworks and deep drainage, over-fertilization and possibly new pathogens, has drastically reduced in just 5 years even populations of common species such as *Potamogeton natans* (now regionally extinct) and *Potamogeton polygonifolius* (by half of the population), and it is confirmed that about 1/3 of the *P. lucens* population has been lost, 2/3 of the *P. trichoides* population has been destroyed, and of the two known populations of *P. coloratus* (of ten nuclei in 2018), only two nuclei remain, in a precarious situation. The effects of earthmoving and pollution also reduced three *C. submersum* sites, although it gained new ones to the detriment of *P. coloratus* (*C. submersum)* became a threat to *P. coloratus* in eutrophic environments. Surprisingly, the resilience of *Utricularia* × *neglecta* population was confirmed in eutrophic conditions, as part of cohesive hydrophytic communities, remaining as the dominant species, even sharing location with the nitrophile *Potamogeton pectinatus*. From all population nuclei of species considered locally rare, alive *genets* were collected between 2018 and 2021, currently preserved in nurseries, awaiting protection of the most important habitats, and ecological restoration actions must be planned.

Daniel Gebler, Andrzej Rybak, Andrzej Woyda-Płoszczyca

Poznan University of Life Sciences, Poznan, Poland
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Influence of environmental factors on macroalgae development in lowland rivers - Oral presentation

Freshwater macroalgae occur in various habitats, showing great diversity and morphological plasticity. These plants fulfil multiple functions in aquatic ecosystems as an essential part of the organic matter producers in the food webs. Therefore, macroalgae are often used as bioindicators of environmental changes, e.g., the trophic level, but are still a neglected or underestimated component of river biota. However, these organisms can cause nuisance problems for us, such as green tides. Our study aims to evaluate the impact of various environmental factors on the occurrence, abundance, distribution, and diversity of macroscopic algae in lowland rivers. We are focused on the ecological requirements of macroalgae identified at the species level that occur in temperate rivers under different levels of anthropopressure. The research is based on a complex habitat evaluation of 180 study sites selected in nine test catchments distributed across the Polish lowlands, where a field inventory of the occurrence and abundance of different species of macroalgae is conducted. Moreover, the laboratory analysis of general morphology and physiology differences under various environmental conditions is also included. The research involves a comprehensive characterisation and assessment of the environmental conditions of the river sections where macroscopic algae occur, identifying the factors most relevant to their development. The studies include a hydromorphological inventory of river stretches, a recording of abiotic elements of the rivers, such as flow type, bottom and bank material, anthropogenic alterations, and natural and artificial morphological features that create specific conditions for macroalgae development. Moreover, the diversification of various taxa among distinctive ecohydrological units – mesohabitats (riffle, run, pool) is also investigated, as well as water quality (e.g., pH, conductivity, BOD5, phosphorus, ammonia, nitrate and organic nitrogen, sulphates, sodium, and potassium) as an essential factor influencing aquatic plant development. Additionally, the isotopic signature of water (δ18O and δH) is determined to test the impact of hydroclimatic factors on macroalgae. Preliminary results showed the influence of the bottom substrate on macroalgae and their significantly better development on coarse-grained bottom substrate (e.g., pebbles, anthropogenic substrate). In the same sections dominated by sand and with few algae, a change to coarse-grained substrate (even in fairly small amounts) resulted in greater algal abundance. A similar relationship was observed for algae development in sections with varying degrees of shading of the watercourse. In this case, the development of other macrophytes also appeared to be important.

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Effects of lakeshore hydromorphological alterations on isoetids and invasive species in two Lobelia lakes in South-Western France - Oral presentation

The sandy, shallow natural lakes along the southern Atlantic coast of France support a remarkable diversity of aquatic plants. They are home to rare isoetid species, including one endemic, related to lake habitats of boreo-Atlantic regions. These lakes also experience the development of several invasive species when local biotope conditions are favourable. Isoetid and invasive macrophytes primarily colonise lakeshore zones where recreational and economic activities are concentrated. The occurrence of these activities can lead to both direct and indirect physical impacts on plants and their aquatic environment. The present study aims to determine the influence of lakeshore hydromorphological alterations on the occurrence, abundance, and species composition of aquatic plants. To this end, floristic surveys were initially conducted across 976 sectors distributed along the entire shoreline of Carcans-Hourtin Lake (60 km²) and Lacanau Lake (18 km²). In each sector, an inventory of anthropogenic disturbances was also conducted. Three grids (10,000 m² each), differently impacted by the passage of 4x4 vehicles, were surveyed. Each grid contained one hundred quadrats (100 m² each) where macrophyte species were recorded and the density of *Lobelia dortmanna* measured. The main findings indicate that isoetids were predominantly present in areas that had not undergone hydromorphological alterations. However, they were occasionally abundant in some slightly modified areas. The occurrence of invasive species was higher in areas affected by human activities, although their abundance did not differ significantly from that in areas not affected by physical alterations. A negative effect of vehicle traffic on the density of *Lobelia dortmanna* was observed. These results provide valuable insights to support management strategies aimed at preventing the artificialisation and simplification of lakeshore zones.

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Experimental testing of the effects of warming on periphyton, submerged vascular plants and charophytes in heated temperate lakes - Oral presentation

By the end of this century, global temperatures are projected to rise by between 0.5 and 3.5°C, posing a significant threat to freshwater ecosystems. This warming trend is expected to exacerbate eutrophication and could lead to a loss of submerged macrophytes. While much of the research has concentrated on the response of vascular plants in eutrophic lakes, emerging evidence suggests that charophytes, which dominate in oligo-mesotrophic hardwater lakes, are also vulnerable to warming. Higher temperatures are likely to lead to an increase in periphyton biomass, resulting in greater shading and inhibiting the growth of submerged vegetation, including both vascular plants and charophytes. However, the effects of warming on these interactions are still not well understood. To address this question, we conducted experiments in eight temperate lakes in Poland in the summer of 2024. Four of these lakes received heated water from a nearby power plant, making their temperatures approximately 2°C higher than those of unheated lakes. In each lake, we exposed plastic strips for periphyton growth and placed small pots containing sediment and pre-grown vascular plants (*Myriophyllum spicatum*) and charophytes (*Chara rudis*) at five different water depths for four weeks. Our results showed statistically significant differences in periphyton biomass across the study lakes, influenced by light availability, trophic state, and water temperature. Interestingly, no significant differences in periphyton biomass were observed between heated and unheated lakes. However, the survival of both vascular plants (*M. spicatum*) and charophytes (*Ch. rudis*) was significantly higher in unheated lakes compared to their heated counterparts. Charophytes also exhibited better survival rates than vascular plants, despite their greater sensitivity to environmental change. Possible explanations for these findings will be discussed.

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INRAE, UR EABX, France

Carbon fluxes under the littoral wet-dry continuum of natural shallow lakes - Oral presentation

Lacustrine littoral zones are generally considered carbon (C) sources towards the atmosphere because oxygen availability in sediments and dissolved organic matter stimulates bacterial respiration and carbon dioxide (CO_2) emissions. On the contrary, pelagic zones can promote methane (CH_4) emissions linked to anoxic conditions in sediments. These processes can be disrupted by aquatic primary production or by CH_4 oxidation stimulated by the presence of vegetation. In the context of climate change and anthropogenic water withdrawals, long-lasting droughts will significantly increase the exposure to the air in lake littoral zones, which likely accelerates the organic matter decomposition and C emissions. In this study, we assess net ecosystem uptake and emission from C fluxes at the scale of natural shallow lakes (SW of France) related to the hydroperiod. CO_2 and CH_4 fluxes were measured seasonally by terrestrial and floating chambers in the littoral zone on soils exposed to the air under different conditions (presence or absence of vegetation, sands or organic sediments, degree of water saturation) and in the pelagic zone according to the depth. Our results reveal significant variations in C fluxes along the littoral wet-dry continuum, which underlies the relevance of considering the lacustrine littoral zone and its vegetation for obtaining comprehensive carbon budgets, especially within climate change scenarios.

Manuela Ramírez Valle, Rosa María Ros,
Laura Monteagudo, José Luis Moreno Alcaraz

University of Castilla-La Mancha, Spain
University of Murcia, Spain

Macrophyte communities of Mediterranean Spanish rivers: diversity and indicator species - Oral presentation

According to the European Water Framework Directive 200/60/EC, macrophytes are part of the biological quality element "aquatic flora" and are used along with phytobenthos (diatoms) as bioindicators for the ecological status assessment. In this study, we gather data obtained in macrophyte surveys carried out during the years 2001-2014 in south-central Spain (Castilla-La Mancha region), including a great part of the Tagus, Júcar, Segura, Guadiana and Guadalquivir River basins. A total of 194 sites were monitored, belonging to 8 national abiotic river types. In each site, macrophytes were collected by hand in a 100-m reach, including benthic algae (prokaryotic and eukaryotic), bryophytes (aquatic and semiaquatic mosses and liverworts) and vascular plants (mainly hydrophytes). Specimens were determined at the genus or species level depending on their taxonomic group. Of the 229 collected taxa, 32% were cyanobacteria, 31% eucaryotic algae, 20% bryophytes and 17% vascular plants. The main objectives of this study were to analyse the macrophyte diversity and distribution in the studied region, to group the national river types according to macrophyte communities and to establish the environmental ranges of indicator species. Finally, we assess the ecological status of rivers using macrophyte indices and discuss the usefulness of macrophytes as tools for river management.

Alice Dalla Vecchia, Roger P. Mormul, Lars L. Iversen, Rossano Bolpagni

University of Parma, Italy
Universidade Estadual de Maringà, Brazil
McGill University, Canada

Using functional biogeography to study global plant invasions in freshwater systems - Oral presentation

Biodiversity and ecosystems are facing the imperative challenge posed by invasive species responsible for substantial impacts on habitat integrity and ecosystem functioning. In freshwater systems, invasive species are ranked as one of the biggest threats to biodiversity, with more than 12% of all taxa being threatened by invasives. Consequently, understanding how local, freshwater-specific drivers influence the distribution and the performance of invasive macrophytes will be essential to plan effective management and conservation actions of these habitats. Furthermore, freshwater habitats and invasive aquatic plants do not often follow the consolidated paradigms of terrestrial taxa's distribution models, in terms of environmental drivers and realized ecological niches. Here we present the first results of continental-wide mapping of the spatial range of functional variation of three invasive macrophytes (*Elodea nuttallii*, *Pistia stratiotes* and *Trapa natans*) in response to environmental conditions. We sampled over 100 wild populations spread throughout Europe, covering a wide ecological and geographical range. For each population, we measured leaf economics spectrum traits (area, specific area, dry matter content, pigments and nutrient content), and nutrient-related water parameters. Via this data, we describe intra- and interspecific differences in the responses to environmental conditions across Europe. This work is part of the MSCA-Global DIVE IN project ("Predicting DIVErsity of INvasive aquatic plants"), aiming at understanding the mechanisms underlying the invasion performance of aquatic plants. The project includes three main steps: description of leaf traits-environment relationships, prediction of trait variation at a continental scale, and validation of the observed trends with controlled growth experiments. The project's next step will be to implement the same approach in the native (for *E. nuttallii* and *P. stratiotes*) and invasive range (for *T. natans*) and compare the results. By integrating spatial modelling with functional ecology, the DIVE IN project will create a functional biogeographic framework for studying plant invasions in freshwater systems, thus providing the opportunity to understand functional adaptations across different spatial scales and environmental gradients.

Sandrine Loriot, Thibault Feret, Marie Wach, Léonard Heinry, Christian Chauvin

INRAE - ECOVEA – Aquatic Ecosystems and Global Changes, France

Ecological traits for improving macrophyte-based indicators - Poster presentation

Since the early 2000s and the implementation of the European Water Framework Directive (WFD), macrophyte-based biological indicators in rivers have been developed to assess ecological status. These indicators are constructed based on the structure and composition of macrophyte communities, and their responses to anthropogenic pressures are generally integrative (Birk et al., 2012). The implementation of restoration measures aimed at achieving good ecological status, as promoted by the WFD and in line with the objectives of other European environmental policies (such as habitat restoration and biodiversity conservation), requires diagnostic methods that enable more precise assessments of ecological conditions and impact pressures. One approach to developing such methods is to rely on species functional traits within communities, using multimetric indicators. This approach has already been applied in several studies (Alric et al., 2021). In the case of macrophytes, the relatively recent emergence of this biological element monitoring initially limited the availability of wide and representative datasets across river typologies, which are necessary to define species ecological profiles. However, with over 15 years of monitoring data now available, these approaches can be implemented with sufficient steadiness. As part of a project aimed at improving the understanding of relationships between macrophyte communities and environmental parameters, and developing diagnostic metrics based on macrophytes, we computed ecological profiles for over 1,000 taxa occurring in inland French rivers. These profiles were derived from both physico-chemical and hydromorphological metrics. More than 7,250 survey records were used, supported by data on physico-chemical parameters (nutrients, mineralization, organic matter, temperature), morphological parameters (altitude, substrate, light availability, depth, water velocity), and hydrological metrics (discharge stability, stream power). For each metric, classes were defined based on data distribution using the k-medoids clustering method (Reynolds et al., 1992). The probability of occurrence of each species was modeled in relation to these parameters. After validation of the results for each taxon, the process yielded an ecological profile available under a trait matrix for 345 taxa (species level for phanerogams and bryophytes, genus level for algae). These profiles are presented as two series of radar charts (10 hydromorphological parameters, 11 physico-chemical parameters), and are also available as numerical tables.

Donatas Naugžemys, Jurgita Butkuvienė, Zofija Sinkevičienė (Lithuania), Carla Lambertini, Rossano Bolpagni, Fabrizio Buldrini, Jolanta Patamsytė

Vilnius University, Lithuania
Nature Research Centre, Institute of Botany, Lithuania
University of Milan, Italy
University of Parma, Italy
University of Bologna, Italy

Aquatic plant communities: what can we expect as temperatures change? - Poster presentation

Aquatic plants are among the most essential components of aquatic ecosystems, which are most likely to respond to changing environments. Not only do plant abundance changes, but also species composition, thus influencing the sustainability of different aquatic plant habitats. One species' drastic decrease or disappearance can degrade the entire plant habitat. The loss of plants or changes in species composition can be caused by more than one factor. However, with climate change and its consequences increasingly being discussed, temperature is one of the most worrying factors. With rising environmental temperatures and more frequent droughts, assessing possible changes in the species composition of aquatic plants is very important. This is especially important for habitats of European importance. One of the important and protected aquatic plant habitats is "River rapids with *Batrachium* communities" (EU Habitat code 3260 Habitat Directive). The main components of this habitat (*Ranunculus* sect. *Batrachium* (water-crowfoots)) have an enormous diversity of forms, and, from a morphological viewpoint, the identification at the species level is doubtful. Aquatic *Ranunculus* spp. are underrepresented in floras and distribution maps, and their typical habitats are often neglected. Characterized by low water temperatures and high amounts of oxygen, this habitat is threatened by global change. Our study aims to compare the species diversity of running water plants in three different countries (Lithuania, Italy, Russia) (different temperatures) and to assess the species dependence of *Ranunculus* sect. *Batrachium* at different temperatures. In the studied sites of Lithuanian rivers, five *Ranunculus* sect. *Batrachium* species were found; accordingly, four in Italy and three in Russia. Significant differences were also shown in other aquatic plant species composition and abundance. The distribution of the main haplotype of *Ranunculus* sect. *Batrachium* species were checked using molecular markers.

Zofia Sotek, Małgorzata Stasińska, Małgorzata Gałczyńska

University of Szczecin, Szczecin, Poland
West Pomeranian University of Technology in Szczecin, Poland

Condition of lobelian lakes in the Nature 2000 area. The case analysis of Bobolice lobelian lakes, PLH320001 - Poster presentation

Lobelian lakes with their characteristic plant species: *Lobelia dortmanna*, *Isoëtes lacustris*, *I. echinospora*, *Littorella uniflora* and *Myriophyllum alterniflorum*, reach in Poland their southwestern European range. They belong to the group of valuable natural habitats protected by the Natura 2000 project. Area PLH320001 of Bobolice lobelian lakes includes 13 reservoirs of this type, and six of them were examined in our study: Chlewo Wielkie, Chlewienko I, L. Szare, L. Głębokie, Kiełpino and Piekiełko. The assessment of their status was based on the indicators typical for these habitats: water pH, colour of water and presence of characteristic indicator species. Chlewienko I is the most transformed and endangered lake, in which some small patches of *L. dortmanna* and single individuals of *I. lacustris* were found. This is a mesotrophic reservoir and shows a tendency towards dystrophy. In turn, the best-preserved habitat is the Chlewo Wielkie, the largest of the examined reservoirs. Despite an increased tourist and recreational pressure, especially in the S and SW parts of the lake, the vegetation typical for this habitat is still abundant. Four out of five indicator species were found here. However, the symptoms of eutrophication are noticeable (the presence of filamentous algae on underwater plants). The greatest threats to the studied habitats include factors like the intensive recreation by causing an excessive penetration of the habitat and water pollution, and fishing by destroying rush, aquatic vegetation and littoral, restocking, baiting fish, fishery and forest management in the immediate vicinity of reservoirs, and humanization of lake waters.

Maria Rita Minciardi, Concita Daniela Spada

ENEA, Italy

A repertory of aquatic macrophytes and herbaceous species most frequent and widespread in the river corridor and wetland in Italy - Poster presentation

From 2022, as part of a project aimed at optimizing the information derived from the use of aquatic macrophytes, a Repertory of aquatic macrophytes (algae, lichens, bryophytes, ferns, and angiosperms) and herbaceous species most frequent and widespread in the river corridor coenosis and wetland in Italy was drawn up. In addition to the species considered aquatic macrophytes, species that constitute other communities present in river corridors have also been considered, such as species of riverbed, banks and floodplain plant coenosis. Over 1200 *taxa* were taken into account, deriving from the samplings throughout Italy. Repertory provides ecological information in a systematic way on the taxa considered for a better interpretation of the data deriving from the surveys of aquatic macrophytes, as well as riparian herbaceous coenosis. Traits used are: morpho-ecological type, life forms, growth forms, aquaticity and exoticism. Aquaticity explains the level of dependence/adaptation of the species to the aquatic environment and, more generally, the level of hygrophily/hydromorphism of habitat. The use of traits enabled a classification derived from Italian ecological data, from literature and also taking into account the database used in the Central and Mediterranean Geographic Intercalibration Groups of ECOSTAT. The proposed ecological classification allows the use of aquatic and riparian communities to analyze a wide range of pressures on water bodies. The use of traits like aquaticity, life-forms and growth forms has been tested in river contexts (aquatic and riparian areas) and also in wetlands, such as lowland springs. The investigations conducted allowed for the effective detection of the impacts deriving from hydrological alterations on aquatic and riparian communities due to extremely dry years (such as 2021 and 2022). Plant communities present in river corridors and wetlands can be very efficient ecosystem indicators of the pressures deriving from ongoing climate change, especially when combined with other anthropogenic pressures. Repertory, developed for Italy, can also be useful at a European level and will soon be available in English online among the ENEA publications.

Cristina Ribaudo, Jérémy Mayen, Sabine Schmidt

Univ. Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805, F-33600 Pessac, France

Carbon and nitrogen stock and sequestration in oligotrophic temporary ponds of South-West of France - Poster presentation

Wetlands and shallow water bodies provide essential ecosystem services, justifying their conservation and restoration as nature-based solutions to mitigate climate change and pollution. In temporary wetlands, such as vernal pools and forest ponds, alternation of dry-wet periods as well as anoxic-oxic transitions favor the development of peculiar amphiphytes and many biogeochemical processes, including nitrogen retention and carbon storage. Anthropogenic pressures and climate change can strongly increase temporary wetlands' drying out, making it crucial to maintain a high-water table through various restoration strategies, including sediment excavation. However, the impact of this practice on carbon and nutrient storage in isolated wetlands remains uncertain. This study examines restored oligotrophic natural ponds of SW of France to assess their carbon and nitrogen storage and sequestration by the vegetation, testing the hypothesis that these environments have low carbon burial rates and require a long recovery time after sediment excavation. Within the studied temporary ponds, significantly lower abundance and diversity in vegetation, as well as lower carbon and nitrogen stocks, were recorded in disturbed sediments than in undisturbed ones, mainly related to very low plant biomasses in ponds having undergone sediment excavation. Thus, according to their sediment management, oligotrophic temporary wetlands may play a different role in the global/regional land carbon cycle.

Nature-based solutions, conservation and management

Session 7

Chairs:

Session 7A: Eva Papastergiadou (University of Patras, Patras) & **Jan E. Vermaat** (Faculty for Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Norway)

Session 7B: Alice Dalla Vecchia (University of Parma, Parma, Italy) & **Sándor Szabó** (Institute of Environmental Sciences, University of Nyíregyháza, Hungary)

Nature-based solutions have gained significant momentum in recent years, aiming to enhance human well-being through the adaptive and resilient qualities of biodiverse ecosystems. Aquatic ecosystems, among the most threatened globally, urgently require cost-effective, nature-inspired approaches that deliver environmental, social, and economic benefits. This session brings together research on the physiological responses of aquatic plants to environmental stress, spatial and temporal patterns of biodiversity, and innovative conservation strategies. Covering both freshwater and marine environments, contributions explore the challenges and opportunities of active restoration, sustainable management, and biological control. By deepening our understanding of species diversity, community dynamics, and environmental drivers, these studies help inform sustainable practices and the development of effective nature-based measures to protect aquatic ecosystems for the future.

Astrid Biddle, Penny Williams, Colin Brown

Freshwater Habitats Trust, United Kingdom
Environment Department, University of York, United Kingdom

Nature-based measures increase freshwater biodiversity in agricultural catchments - Oral presentation

Water Friendly Farming is a long-term (2010 onwards) demonstration project in the UK evaluating the role of ponds in the management and protection of freshwater biodiversity and is a demonstration site for the EU-funded PONDERFUL project. Water Friendly Farming is an experimental study assessing the effect of pond creation and management on whole landscape freshwater biodiversity, evaluated through a comprehensive catchment-wide assessment of all freshwater habitats in the landscape (streams, ditches, ponds; the study area has no waterbodies large enough to be described as rivers or lakes). This study also compares this with the effectiveness of broader nature-based solutions on freshwater plant diversity. Census data on wetland plant communities were collected from all freshwaters in the project area to give alpha (site) and gamma (catchment) diversity, generating a three-year baseline to compare with post-intervention monitoring. Alpha rarity (regionally or nationally) of the plant species was determined. This allowed us to evaluate: (1) long-term background trends in freshwater biodiversity, (2) the effect on freshwater biodiversity of creating ecosystem services ponds and wetlands designed to reduce the impacts of nutrient pollution and rapid runoff, and (3) the effect of new clean water ponds and other habitat creation measures in enhancing freshwater biodiversity. Statistical differences between the species richness of waterbody types and catchments were tested. Over 13 years, in the absence of mitigation measures, there was a gradual loss of wetland plants from the project landscape at a rate of 0.6 species/year. The addition of measures to mitigate the impacts of diffuse pollution and trap runoff (nature-based solutions) stopped this decline but did not increase whole landscape wetland plant species richness. Creating clean-water ponds, but not other habitat creation measures, led to a 16% increase in whole landscape wetland plant species richness and an increase in the richness of uncommon species by 80%. This shows the potential of creating clean-water ponds to help stem, or even reverse, ongoing freshwater plant biodiversity decline across farming landscapes.

Daniel Larkin

University of Minnesota, United States of America

Quantifying aquatic plant species' commonness and coexistence to guide conservation and management - Oral presentation

Decisions about which species to prioritize for conservation (or control) are shaped by species' commonness across their ranges, local abundance where they occur, association with high-quality habitats, and local dominance. For example, regionally rare species can be subject to special protections, locally scarce ones may be supplemented through restoration, and highly dominant ones (especially if non-native) are often targeted for removal. These decisions are sometimes constrained by data limitations, and these different dimensions of species' distributions are sometimes conflated, e.g., common species and rare species may be assumed to be competitively strong and weak, respectively. An advantage of submersed vegetation being difficult to sample is the widespread adoption of standardized protocols within certain regions. In the Midwestern USA, a point-intercept (PI) survey method wherein grids of points in lake littoral zones are sampled has been widely adopted. Recent multi-institutional efforts have brought two decades of PI survey data together, enabling new research opportunities in macrophyte community ecology. These datasets comprise occurrence data over multiple scales: the point level represents the local scale at which plants interact; points aggregated to the lake level capture overall species composition; and regional patterns emerge across lakes. Additionally, they can be aligned with environmental data from point to regional scales. We leveraged 4,564 surveys of 1,660 lakes to characterize regional commonness (proportion of lakes in which a species was found) and within-lake abundance (proportion of points where it was found) for 122 well-resolved taxa. We calculated "diversity fields" for species (richness of co-occurring taxa) at lake and point scales. Lake-level diversity fields indicate whether a given species is found in particularly diverse, "high-quality" lakes, while point-level diversity fields indicate a tendency towards dominance vs. coexistence. These metrics were estimated using statistical models to account for covarying effects of environmental conditions. We found that species sorted across all combinations of regionally common vs. rare, locally abundant vs. scarce, associated with species-rich vs. species-poor lakes, and locally dominant vs. coexisting. Invasive species were notable for being common, abundant, occurring in species-poor lakes, and exhibiting high local dominance. But there were also regionally rare native species that were locally abundant and dominant, indicating that their populations can be robust within their more restricted habitats. This is an easily adaptable framework for untangling different aspects of species' distributions to support objective assessment of aquatic plants for conservation and management.

Jennifer Bishop, Lynn Gettys

University of Florida, United States of America

Illinois pondweed common nursery and reciprocal planting research - Oral presentation

Illinois Pondweed, also known as *Potamogeton illinoensis* is a native submersed plant that is useful in aquatic restoration projects. In these greenhouse (mesocosm) experiments, we collected eight ecotypes of *P. illinoensis* from separate ecosystems throughout Florida and evaluated their growth under common nursery and reciprocal planting conditions to identify ecotypes that might be more widely adapted than the species. The common nursery study used five artificial substrates that ranged from 100% peat to 100% sand and four fertilizer levels ranging from 0 to 4 g of controlled release fertilizer per L of substrate, whereas reciprocal plantings utilized substrates collected from the eight "pondweed source" lakes plus two additional lakes where Illinois pondweed is scarce or absent. Plants were cultured for 16 weeks; plant height (longest shoot in each container) was recorded, and then all material was subjected to a destructive harvest. Harvested plant material was separated into aboveground shoots and belowground roots, washed clean of substrate and other debris, and then dried in a forced-air oven at 65 °C until a constant weight was achieved. The dry weight of these plants was weighed, and the data was analyzed. Ecotype and fertilizer rate had significant effects on Illinois pondweed growth under both common nursery and reciprocal planting conditions. Also, substrate affected most growth parameters in the reciprocal planting experiments. These experiments revealed that ecotype selection may be an important consideration when planning aquatic restoration projects that include Illinois pondweed, as ecotype influences plant growth and establishment, at least in greenhouse studies.

Krzysztof Szoszkiewicz, Krister Karttunend Karttunen, Pedro Pinho, Vladimíra Dekan Carreira, Jonas Schoelynck, Krzysztof Achtenberg, Tomasz Kałuża, Mariusz Sojka, Joanna Rosinska, Szymon Jusik, Robrecht Debbaut, Jan Staes, Ana Júlia Pereira, Silvia Martin Muñoz, Kati Vierikkod

Poznan University of Life Sciences, Poland
University of Antwerp, Belgium
University of Lisbon, Portugal
Finnish Environment Institute (SYKE), Finland

Environmental drivers of macrophyte communities in urban aquatic nature-based solutions across Europe - Oral presentation

Urban aquatic ecosystems face degradation due to urbanization, impacting biodiversity and water quality. Aquatic Nature-Based Solutions (aquaNBS), such as ponds and streams, offer sustainable ways to restore habitats and enhance urban biodiversity. However, the environmental drivers shaping macrophyte communities in these systems remain understudied, particularly across diverse European climates. This study examines how environmental factors influence macrophyte communities in aquaNBS across four European cities (Antwerp, Helsinki, Lisbon, Poznań). We tried to find what is the role of climate, hydromorphology, and water quality in shaping these communities. A stratified sampling approach was used to survey 96 sites. Macrophyte diversity and environmental variables were analyzed using diversity metrics, Jaccard similarity indices, and Canonical Correspondence Analysis (CCA). A total of 93 macrophyte taxa were identified, with higher richness in ponds than streams. Permanent water bodies supported greater diversity compared to temporary ones. Jaccard analysis revealed distinct communities between running and standing waters, with temporary ecosystems showing unique compositions. CCA highlighted substrate type and altitude as key drivers. This study highlighted the importance of water availability and substrate characteristics in shaping macrophyte communities in urban aquaNBS. It emphasized the need for tailored management strategies to enhance biodiversity, particularly in temporary water bodies, and advocates for integrating natural substrates and stable hydrological conditions.

Fei Ma

Peking University, China

The effect of trait-based diversity on productivity in macrophyte communities - Oral presentation

Trait-based methods are key to understanding the biodiversity–productivity relationship (BPR) of macrophyte communities. Community-weighted mean traits (i.e., community trait structure) have been proven to have more influence on macrophyte community productivity than species richness. However, the underlying mechanism by which community trait structure variation affects macrophyte community productivity along an environmental gradient is still not well understood. A mesocosm experiment was used to investigate how community trait structure shapes macrophyte community productivity along the water depth gradient. Three submerged macrophyte species (*Myriophyllum spicatum*, *Vallisneria natans* and *Potamogeton malaianus*) were assembled into all possible combinations (one, two and three species per community) at three different water depths (1, 2.5 and 4 m). We fitted the relationships between community-weighted mean traits and community productivity, and between species richness and community productivity as a comparison. We compared functional traits under different water depths and species composition at the species and community levels and disentangled the community trait structure into species turnover and intraspecific trait variability effects. he results showed that community trait structure had various influences on macrophyte community productivity, which was based on traits per se. However, species richness had a non-significant impact on macrophyte community productivity. Water depth had a significant impact on most traits of the three species at the species level, whereas both water depth and species composition had significant impacts on community trait structure, which was mainly affected by intraspecific trait variability along the water depth gradient. Our findings highlight the importance of considering intraspecific trait variability and species turnover under water depth gradients to understand the relationship between trait-based biodiversity and productivity.

Ioannis Bazos, Ioannis Kokkoris, Panayotis Dimopoulos

Department of Biology, National and Kapodistrian University of Athens, Greece
Department of Sustainable Agriculture, University of Patras, Greece
Department of Biology, University of Patras, Greece

Interpretation of the Greek natural capital: exploring the diversity of freshwater plants and habitats - Oral presentation

Freshwater habitats cover less than 1% of the Earth's surface and yet they host a relatively large number of species, representing about 10% of the world's known species. In this sense, freshwater habitats are considered biodiversity hotspots. Freshwater habitats are also among the most threatened habitats globally, as changes in the hydrological regimes, climate change, pollution, invasive species, overexploitation, urbanisation and agriculture contribute to their degradation and loss. In this study, we present an analysis of the biodiversity of inland waters in Greece, both in terms of the number of vascular plants they host as well as of the number of corresponding habitat types in Natura 2000 protected areas. The vascular flora of Greece is one of the richest in Europe; in the most recent online version, it comprises 5987 species and 2011 subspecies (native and naturalised), representing 6861 taxa. Of these, 748 species and 188 subspecies, corresponding to 796 taxa (11.6% of the total Greek vascular flora), belong to 91 families and 278 genera, and are distributed in freshwater ecosystems assigned to nine (9) habitat types (Annex I, Dir. 92/43/EEC). The diversity of the vegetation syntaxa within each habitat type, as well as the assignment of the aquatic plant taxa to the high-rank syntaxa, is presented and mapped. The vast majority of taxa (760 species and subspecies) are native, and 36 (4.5%) are naturalised alien taxa. In terms of life forms, hemicryptophytes dominate (44%), followed by therophytes (21.5%) and geophytes (18.8%), while hydrophytes are, as expected, particularly well represented (10.7%). Thirty-seven taxa (4.6%) are Greek endemics and 66 taxa are range restricted (taxa whose extreme limits of distribution are not more than 500 km apart in a straight line). Among the Greek endemics, *Isoetes heldreichii* is considered extinct, while *Veronica oetaea* is an extremely rare and threatened narrow endemic. Among the hydrophytes, some such as *Aldrovanda vesiculosa*, *Callitriche pulchra* and *Marsilea quadrifolia* are only known from one of the 13 floristic regions of Greece, while others such as *Helosciadium nodiflorum* are quite common and occur in all floristic regions.

Silvia Cannucci, Rossano Bolpagni, Gianmaria Bonari, Alice Dalla Vecchia, Emanuele Fanfarillo, Tiberio Fiaschi, Simona Maccherini, Francesco Mascia, Claudia Angiolini

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NBFC, National Biodiversity Future Center, Palermo, Italy
Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parma, Italy

Diversity and conservation value of farmland ponds: identifying key sites and drivers - Oral presentation

Mechanisms affecting aquatic plant diversity are essential to be understood due to their implications for conservation. Given the vulnerability of aquatic ecosystems and the ongoing biodiversity decline, analyzing the components of beta diversity (turnover and nestedness) is crucial for understanding the ecological processes influencing diversity. Among wetlands, ponds are small water bodies inserted in a terrestrial matrix. This pattern creates a network in which species disperse and migrate. In this study, we aimed to characterize the diversity and conservation value of permanent farmland ponds. Our main objectives were to: i) assess the beta diversity of macrophyte plant communities in farmland permanent ponds, including its turnover and nestedness components, and analyze the contribution of single sites (local contributions to beta diversity, LCBD) and single species (species contributions to beta diversity, SCBD) to beta diversity for macrophyte species; ii) define the macrophytes composition based on environmental variables (physicochemical and climatic) and identify those driving variation in LCBD, and iii) explore the relationship between SCBD values and species frequency. We selected 115 permanent farmland ponds among three regions of Italy (Sardinia, Tuscany, and Emilia-Romagna) under varying agricultural land-use extents. In total, we surveyed 345 vegetation plots in which we collected data on macrophyte coverage and water physicochemical parameters. Preliminary results show that the overall beta diversity is almost entirely driven by species turnover and there are sites contributing more than others to the total beta diversity. Evapotranspiration, annual precipitation amount, nitrate, and dissolved oxygen are the environmental variables mainly affecting macrophytes species composition, while LCBD values were negatively affected only by evapotranspiration and turbidity. The first three species with the highest SCBD values are the ones with the highest frequencies. From this preliminary screening, it is evident that drivers of macrophyte diversity are both local (pond-specific) and regional. A holistic approach is necessary for developing effective conservation plans for diversity in permanent ponds.

Thomas Abeli

University of Pavia, Italy

First systematic assessment of germination requirements in the endemic quillwort *Isoetes malinverniana* - Oral presentation

Quillworts (genus *Isoëtes*) are iconic but understudied wetland plants suffering severe declines globally because of alterations in their habitats. Knowledge gaps in distribution, biology, ecology, population genetics and reproductive biology hamper proper conservation actions. In particular, spore germination requirements and cultivation protocols are unknown for most species. In this study, we present for the first time a systematic assessment of spore germination requirements for a critically endangered quillwort, the Italian endemic *Isoëtes malinverniana*. Macro- and microsporangia of *I. malinverniana* were collected at maturity from randomly selected plants cultivated ex situ at the Botanic Garden of the University of Pavia. After disinfection with a 2% alcohol solution, macro- and microspores were extracted by cutting the sporangia with a scalpel. Spore germination tests were performed at 5°C, 10°C, 15°C, 20°C, 25°C, 30°C and 25/15°C. Each treatment consisted of sowing three replicates of 15 macrospores in petri dishes filled with 1% agar. A distilled water suspension of microspores was added to the petri dishes, which were then placed in temperature-light controlled incubators according to the abovementioned temperature and light regime of 16h light/8h dark. Additional tests at 20°C were performed 1) by placing a petri dish in an aluminum bag to test the ability of spores to germinate in the dark and 2) without fertilization with microspores to test for apomixis. Spore opening and germination (emission of shoot and rootlet) were scored once a week for three months. The first germination event occurred after one month. Spore germination was highest at 20°C, reaching values of about 90%, followed by 30° and 25/15°C. Germination also occurred in the dark at 20°C but was slower than in light conditions. No germination occurred in non-fertilized spores, showing that the species is not apomictic. Spore neither germinated nor opened at 10°C after three months. This first study of the spore germination requirements in an endangered quillwort showed that optimal germination conditions can be quite narrow, which may affect conservation both in situ and ex situ. This study will be particularly useful for optimizing ex situ cultivation conditions and for selecting a suitable site for translocation for *I. malinverniana*. A systematic assessment of germination conditions in other endangered quillworts may help understand the causes of rarity and/or vulnerability to habitat changes.

Morgan Botrel, Roxane Maranger, Mathieu Cusson, Lars L. Iversen, Fanny Noisette, Christian Nozais, Katrine Turgeon, Lindsay L. Trottier, Andrea Bertolo, Thibaud André-Alphonse, Simon Bélanger, Arthur De Grandpré, Jean-Olivier Goyette, Sabine Hilt, Ladd Johnson, Valérie Langlois, Martin Laporte, Félix Lauzon, Brigitte Légaré, Anne Ola, Marie-Pomme Poissant, Matthieu Prugne, Richard Saint-Louis, Caroline Susini, Richard Zimmerman, Irene Gregory-Eaves

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Aquatic macrophytes as nature-based solutions: challenges and opportunities across inland and marine waters - Oral presentation

Nature-based Solutions (NbS) are an approach that is growing in popularity as a path forward to address the twin crises of climate change and biodiversity loss. NbS involves working with nature to solve societal challenges that co-benefit humans and biodiversity. Macrophytes have been recognized as NbS, however, the discrepancy between the study and application of macrophytes as NbS across inland and coastal

ecosystems represents an opportunity to expand the concept and learn from different scientific approaches. Here, we report on a recent initiative bringing together macrophyte specialists working across marine and inland water ecosystems to: 1) evaluate and compare current knowledge on macrophytes as NbS across realms; 2) identify knowledge gaps and advances in the use of macrophytes as NbS; and, 3) synthesize challenges and opportunities for restoration of these critical habitats. To do this, we first conducted a workshop with local stakeholders in Quebec, Canada, to understand the research needs surrounding macrophytes and what the concerns and attitudes are toward these organisms. We then conducted a literature review and a bibliometric analysis, followed by an expert participatory exercise around the most recent (2014 to 2024) review papers. Our literature synthesis revealed that the majority of papers on macrophytes as NbS are marine-focused, with the emphasis on climate change mitigation and adaptation. Conversely, the literature on macrophytes as NbS in inland waters focuses on biodiversity and eutrophication mitigation, and the topics covered are more stable over time. Our exercise shows the complementarity of the expertise across freshwater and marine ecology, and highlights a need to reverse negative perceptions toward macrophytes. We lay down recommendations to encourage researchers and managers alike to embrace the value of macrophytes and begin to recognize the opportunity that marine and inland macrophytes provide as NbS to reverse biodiversity loss and mitigate the impacts of climate change.

Krister Karttunen, Jukka Aroviita, Anna Suuronen, Annika Vilmi

Finnish Environment Institute (Syke), Finland
Finnish Environment institute, Finland

Aquatic bryophytes in deteriorating rivers - Oral presentation

Bryophytes are an integral and important part of aquatic vegetation and biodiversity, especially in river rapids and riffles. We modelled aquatic macrophyte data, some 50 bryophyte and 150 tracheophyte taxa, from 295 river sites with standardized sampling to estimate ecological quality. Using RIVPACS type approach with local and catchment area characteristics, we could recognize eleven distinct plant communities in a natural or near-natural state. Soil of catchment area, peatland, clay or moraine, size of catchment area, less than 100 km2, 100-1000 or over 1000 km2, and location, North or South Finland, can be used to characterize natural macrophyte communities in pools and riffles. Based on these reference communities, we could estimate the ecological quality of impacted sites utilizing two indices: taxonomic completeness (O/E-taxa) and percent model affinity (PMA). Just bryophytes in rapids can serve to get ecological classification of river water bodies, though most reliable results are achieved by studying all aquatic plants in both riffles and pools. To assess changes in biodiversity, we further modelled how species frequencies change due to environmental loading and other disturbances, with a larger dataset of 780 sites and 124 bryophyte taxa. Many of those are very rare or only occasionally aquatic, therefore, we paid special attention to more common proper aquatics with a higher confidence interval in the model. Of these, four species (*Ptychostomum pseudotriquetrum, Scapania undulata, Jungermannia pumila, Blindia acuta*) have clearly lower frequency even in sites in good ecological status than in reference sites, whereas three (*Fontinalis antipyretica, F. dalecarlica, Hygrohypnella ochracea*) were more frequent. Sites in high ecological status naturally did not differ from reference sites. This may indicate that the target of the European Water Framework Directive, good ecological status of all water bodies, is not good enough to conserve aquatic biodiversity.

Tafara Frank Bute, Julie Coetzee, Ryan Wasserman

Centre for Biological Control, Rhodes University, South Africa
Wetland Ecology Lab, Rhodes University, South Africa

Does heavy metal pollution from acid mine drainage undermine the biological control of water hyacinth, *Pontederia crassipes* in invaded East Rand wetland systems in South Africa? - Oral presentation

Acid mine drainage from tailings dumps and abandoned mines can significantly contribute to degraded water quality in urban and peri-urban aquatic systems through the release of acids, metals, and sulphates. These systems are, however, often also the recipients of excess nutrient pollution, which can facilitate weed propagation. The Blesbokspruit wetland, in East Rand, Johannesburg (South Africa), is one such ecosystem characterised by incessant nutrient pollution. Raw sewage and agricultural runoff have fuelled the proliferation of water hyacinth, *Pontederia crassipes,* across the region. While biocontrol efforts for the control of *P. crassipes* are largely successful in southern Africa, field observations suggest that the same measures are less effective in the East Rand, particularly the Blesbokspruit wetland system. This study seeks to evaluate the nature and extent of heavy metals and nutrient pollution at Blesbokspruit, the degree of bioaccumulation in water hyacinth plants, and ultimately, if these dynamics hinder biocontrol agent efficacy. For the water quality and plant components, water, sediment, plant leaves, and root samples were collected in October 2023 and April 2024. A total of twenty different heavy metal concentrations were determined using inductively coupled plasma–optical emission spectrometry with nitric acid digestion. Nutrient concentrations were quantified using the Hannah machine. Preliminary findings suggest that nitrates (mean 14 mg/L), ammonia (mean 13 mg/L), and phosphorus (mean 5 mg/L) were above recommended thresholds by the Department of Water and Sanitation (DWS). Sixteen heavy metals, including iron (Fe) (mean 3.7 mg/L) and manganese (Mn) (mean 0.8 mg/L), exceeded the recommended threshold levels in water. Copper (Cu) and lead (Pb) bioconcentration in leaves surpassed acute effect values, with means of 0.03 and 0.004 mg/L, respectively. Work assessing the direct deleterious effects of these metals on *Megamelus scutellaris* populations is underway. This study provides a valuable reference for the management of municipal, industrial, and mining waste, regionally and internationally.

Antonella Petruzzella, Morgan Botrel, Jens C. Nejstgaard, Stella A. Berger, Igor Ogashawara, Armin Penske, Sabine Hilt

Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany
McGill University, Canada

Critical light and nutrient conditions for shifts between charophytes and vascular aquatic plants: implications for charophyte restoration in hardwater lakes - Oral presentation

Charophytes are the typical submerged vegetation of most oligo-mesotrophic hardwater lakes and play a crucial role in their functioning. Despite protection by the European Union Habitats and Species Directive, charophyte populations have continued to decline across many European lakes. Increased nutrient loading has been proposed to be one of the main causes of charophyte loss, leading to a replacement by submerged vascular plants. Yet, our mechanistic understanding of this process remains incomplete. Here, we investigate how light availability at depth and nutrient concentrations in the water affect plant and periphyton growth, plant tissue stoichiometry and decomposition of charophytes and submerged vascular plants, thus identifying critical conditions for shifts between species dominance and their respective effects on nutrient immobilization. We ran two consecutive enclosure experiments at the IGB LakeLab (NE Germany) in summer 2024. For the first experiment, shoots of the charophyte *Nitellopsis obtusa* and the vascular plant *Ceratophyllum demersum* were exposed for 4 weeks in sediment-filled cups in 8 enclosures along a gradient of depths (0.375, 0.75, 1.5, 3 and 6 m) and nutrient concentrations ranging from oligo-mesotrophic to eutrophic conditions. Plastic strips for periphyton growth were also deployed at the same depths. After harvesting, plant material was further used to determine plant mass loss as an indicator of decomposition rates in a subsequent second experiment over 2 weeks. Preliminary results suggest that vascular plant performance is maintained across a gradient of light and nutrients, whereas charophyte competitive ability increased with decreasing light availability. However, charophyte growth was negatively affected by the increase in nutrient concentrations, particularly nitrogen. Knowledge of light and nutrient concentration requirements for charophyte dominance is needed and a critical prerequisite for establishing the right conditions to achieve restoration goals and proper management actions in oligo-mesotrophic lakes.

Fred Lubnow, Mike Hartshorne, Christopher Mikolajczyk, Paul Cooper

Princeton Hydro LLC, United States of America

The management of submerged aquatic vegetation to prevent the development of harmful algal blooms - Oral presentation

While submerged aquatic vegetation (SAV) has the potential to attain nuisance densities relative to recreational use and access, it also has the potential to reduce the occurrence of cyanotoxin producing Harmful Algal Blooms (HABs), which can negatively impact the health of people, pets, livestock, and wildlife. Additionally, stands of SAV provide a variety of valuable ecosystem services, including producing cover, habitat, and food for a variety of aquatic and terrestrial species, stabilizing sediments, buffering shoreline areas against erosion, and contributing toward the oxygenation of water. Thus, lake, pond and reservoir management frequently favor the establishment of SAV in shallow waterbodies and the shallow near-shore areas of larger lakes. However, the interaction between SAV and cyanobacteria, which is the group of algae that has the potential to produce HABs in freshwater ecosystems, is complex, as described in the concept of Alternative Stable States. These alternative states are a clear-water SAV-dominated state on one end of the continuum and a turbid HAB-dominated state on the other. While a number of factors contribute toward where a lake or shallow section of a lake will fall on this continuum, one of the primary factors is nutrient availability. In general, as nutrient availability, primarily phosphorus and nitrogen, increases, these ecosystems will favor the HAB-dominated state. These nutrients can originate from external, watershed sources and/or from internally driven sources. In addition, climate change and extreme weather events can directly impact the magnitude of these external and internal sources of nutrients. Balancing a lacustrine ecosystem by the existence of SAVs can compete for nutrients, as well as providing shading, suppressing the initiation of HABs. This presentation will use several case studies for waterbodies in the Mid-Atlantic region of the United States to demonstrate how Alternative Stable States can be used to manage SAV communities and offset the occurrence of HABs. Review of various in-lake restoration techniques will be discussed that are used to manage SAV as well as HABs, and how to avoid shifting from a SAV-dominated system to a HAB-dominated system or flipping a HAB-dominated system to a SAV-dominated system. Finally, the role of overwintering cyanobacteria, either as vegetative cells or akinetes, will also be discussed on how it can influence the Alternative Stable State of a lake or near-shore section of a lake.

João Neiva, Duarte Frade, Ester Serrão

Centro de Ciências do Mar do Algarve, Portugal
Universidade do Algarve, Portugal

Endangered aquatic halophytes in a cultural landscape: importance and habitat partition in man-made habitats - Oral presentation

In Ria Formosa natural park (PNRF), active and abandoned artificial water reservoirs and channels associated with saltpan, fish-farms and other aquaculture-related activities are the primary habitat of several aquatic halophytes, including 4-5 species with unfavorable conservation statuses – *Ruppia spiralis* (VU), *Ruppia marina* (NT, but including a cryptic species), *Ruppia drepanensis* (CR) and *Althenia filiformis* (re-discovered in 2024 after 168 years after last collection). These man-made habitats have very diverse typologies and environmental conditions, ranging from temporarily to permanently inundated water bodies, associated or not with freshwater (stream) inputs, partially to completely disconnected from the main (marine) system, and ranging from hypo- to hypersaline conditions. We mapped the distribution of aquatic halophytes in the PNRF and characterized all the different water bodies where they occurred to assess how the different species were partitioned among natural and artificial habitat types and environmental gradients. We found that *Ruppia spiralis* was unexpectedly common in the PNRF, where it was clearly associated with the first water reservoirs of active saltpan systems ("tejos"), and equivalent water bodies characterized by limited but regular water exchange with the marine system and slightly hypersaline conditions (39-45 PSU). *Ruppia marina sensu stricto* was only confirmed in the periphery of the PNRF in hyposaline coastal lagoons fed by temporary streams. A second, genetically confirmed cryptic entity, was much more common and typically associated with temporary mediterranean lagoons – either natural, or much more expressive in terms of area, abandoned fish-farms and saltpans, whose temporary flooding resulted exclusively from winter rainfall and where salinity ranged, depending on the amount of salts in the sediments, from hyposaline to hypersaline conditions (4-46 PSU). *Althenia filiformis* was also associated with these temporary habitats, but was only detected in artificial habitats such as inactive saltpans and fish-farm ponds, particularly in sandy areas. *Ruppia drepanensis* was the rarest species and was only found in a few inactive saltpan ponds, mixed with *R. maritima* and *Althenia*. True seagrasses (Cymodocea, Zostera sp.) were only exceptionally found in reservoirs where water exchange was high, and chemistry was very close to the marine system. Our results emphasize the importance and often dependence of halophyte macrophytes for man-made habitats, and the need to consider economic activities to promote the conservation of otherwise rare species in the PNRF.

Catarina Gomes-Domingues, Teresa A. Paço, Maria Cristina S. Costa, Ana Caperta

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Long-term cultivation of salt marsh sea lavenders under high saline conditions affects plant physiological status and growth performance - Poster presentation

Coastal ecosystems such as salt marshes are experiencing extensive degradation due to sea level rise, pollution, erosion, and pressure from introduced invasive species. These ecosystems comprise halophytic (salt-tolerant) flora and vegetation such as *Limonium* species and their respective communities, presenting high conservation value. Halophyte *Limonium* spp. thrive in saline environments due to the presence of salt tolerance traits, including salt glands in the leaf epidermis. The Critically Endangered *Limonium daveaui* Erben and the Near Threatened *Limonium algarvense* Erben species thrive in communities with medium to low conservation levels. Pre-reintroduction cultivation studies are essential to the successful re-introduction and establishment of self-sustaining populations. To understand the effect of long exposure to high salinity levels at 200 mM NaCl, an experimental assay was established in a greenhouse with *L. daveaui* and *L. algarvense* plants grown under saline and non-saline irrigation and monitored for one year. Overall, two months after applying 200 mM NaCl, beneficial effects were observed on plant performance since plants in saline conditions had significantly high photosynthetic indexes, leaf temperature and stomatal conductance values. Besides, changes in leaf anatomy induced by salinity were also observed. In saline conditions, *L. daveaui* plants had significantly bigger stomata than those measured in plants cultivated in freshwater. Contrastingly, after one year in salinized substrates, plants showed lower stomatal conductance and higher temperature values (salt induced an increase of 3 °C) than those measured in plants grown in freshwater, although photosynthetic indexes didn't differ significantly. The studied species showed an iso-hydric pattern and, consequently, high leaf temperatures associated with decreased latent cooling when in stress conditions. By the end of the experiment, plants presented smaller leaves and a lower number of flowers and seeds than those seen in freshwater irrigated plants. Altogether, this study showed that plants tolerate, grow and reproduce in high levels of salinity.

Laís Nunes, Victor Saito, Steven Pennings, Antonio Camargo

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Universidade Federal de São Carlos-UFSCar, Brazil
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Spatial variation in biomass, richness and species pool of aquatic macrophytes in subtropical and tropical estuaries - Poster presentation

Estuarine regions have spatial gradients of salinity, flooding and nutrient concentration. However, tropical and subtropical estuaries present differences in relation to the occurrence and organization of aquatic vegetation. In tropical estuaries, there are mangroves and the macrophyte stands fringe these forests, forming assemblages distributed in a mosaic. In subtropical estuaries, macrophytes occupy the entire intertidal plain, forming marshes. We hypothesized that there is a negative relationship between salinity and nitrogen content in the sediment to biomass, richness and species pool in tropical and subtropical estuaries. Our study was carried out in the National Estuarine Research Reserve (Sapelo Island, Georgia, southeastern US) – subtropical estuaries, and in the estuaries of the Itanhaém and Itapanhaú Rivers (São Paulo, southeastern Brazil) – tropical estuaries. We determined the upper, middle and lower estuarine regions, respectively, the freshwater, brackish and salt areas. In each of the three areas, we established and georeferenced 30 plots (1m^2 squares) with the presence of aquatic vegetation. In each plot, we recorded the occurrence of emergent species and the species pool, considering species richness in a set of ten plots centered on the plot of interest. We also measured photosynthetically active radiation (PAR) above the canopy and at the sediment surface to calculate shading. We collected a sediment sample to determine nitrogen content and salinity. With a square of 0.25 m^2 we collected the emergent fraction (leaves, stems and culms) of the species present to estimate the biomass in each plot. We observed a positive and significant linear regression between salinity and nitrogen content for the subtropical estuaries (r^2=0.55; p<0.01) and for the tropical estuaries (r^2=0.10; p<0.01). In the subtropical estuaries, emergent biomass had a negative relationship with salinity (r^2=0.23; p<0.01), however, we did not observe a relationship between these variables in the tropical estuaries. Salinity and species pool were negatively related in the subtropical estuaries (r^2=0.24; p<0.01) and tropical estuaries (r^2=0.25; p<0.01). The sampling sites in the upper and middle areas (freshwater and brackish) in the subtropical estuary presented different characteristics from the tropical estuaries, due to the higher values of shading, emergent biomass and nitrogen. In the subtropical estuaries, we observed a reduction in biomass and richness with increasing salinity. In the tropical estuaries, we did not observe any pattern between salinity, richness and biomass. The greater rainfall and smaller tidal range in the tropical region than in the subtropical region are probably the causes of the observed differences.

An Leyssen, Jo Packet

Research Institute for Nature and Forest (INBO), Belgium

Abiotic characteristics and local conservation status of protected freshwater habitats in Flanders (Northern Belgium) - Poster presentation

Freshwater ecosystems are increasingly threatened by anthropogenic pressures, including nutrient enrichment, acidification and hydrological alterations. In Flanders, the northern part of Belgium, a number of ponds and lakes contain habitat types that are protected by the European Habitats Directive, such as habitat types 3110 (oligotrophic waters containing very few minerals of sandy plains; Littorelletalia uniflorae), 3130 (oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or Isoeto-Nanojuncetea), 3140 (hard oligo-mesotrophic waters with benthic vegetation of Chara spp.), 3150 (natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation) and 3160 (natural dystrophic lakes and ponds). Despite legal protection, the conservation status of these habitats remains poor. In this study, we assess the abiotic characteristics of ponds and lakes with protected habitat types and evaluate their ecological quality using vegetation-based indicators. Vegetation surveys were conducted to determine the local conservation status of each site, and water samples were collected to analyse key abiotic parameters, including pH, conductivity, nitrogen and phosphorus concentrations and dissolved oxygen levels. These abiotic data are compared with favourable abiotic ranges established for each habitat type. Furthermore, we investigate whether vegetation-based assessments of habitat quality reliably reflect abiotic stressors, in particular acidification and eutrophication. Understanding this relationship is important for improving conservation strategies and refining ecological assessment methods. Our results provide insight into the effectiveness of current conservation policies and their efforts. They can inform future management actions to increase the resilience of these freshwater ecosystems under ongoing human-induced pressures.

Konstantinos Stefanidis, Eva Papastergiadou

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Filling the Wallacean shortfall of the aquatic quillworts in Greece - Poster presentation

Currently, there is a significant knowledge gap in the distribution of freshwater plants compared to other biota. The changes in the distribution and occurrences of aquatic plants due to global changes are not well documented and remain unknown for a large fraction of taxa, such as *Isoëtes* taxa. Aquatic *Isoëtes* species (quillworts in common) are of conservation concern due to their habitat loss globally. Some *Isoëtes* species are very rare and are found in only one site or have shrunk to a few known populations. In Greece, *Isoëtes* is considered among the most under-collected taxa of the Greek flora. Only a handful of studies on Greek quillworts exist, highlighting that the current distributional patterns are incomplete, and further surveys are needed to fill the gaps. Besides this, Greek *Isoëtes* population surveys are totally missing from the recent global assessment of the aquatic *Isoëtes* species. The main objective of this study is to address the Wallacean shortfalls for the known Greek freshwater quillworts by providing new information on their distributions and population trends. Extensive samplings will be conducted in freshwater habitats of mainland Greece as well as the islands Crete, Lesvos and Milos, where recent findings of quillworts have been reported. Emphasis will be placed on the two Greek endemics, the Pindus quillwort *I. heildrechii* characterized as possibly extinct and the Greek quillwort, *I. haussknechtii.* Other species of increased interest are the *I. phrygia*, known only from few localities in Turkey, Crete Island and Milos Island and *I. todaroana*, until recently an endemic of Italy that was discovered a few years ago in Western Greece. In addition, we will estimate the population sizes which is of high importance for conservation purposes. The habitat conditions will be assessed and compared with those recorded in previous studies to evaluate possible changes in the extent of the habitat and their environmental conditions (e.g., hydrological and physicochemical parameters). The findings are expected to significantly enhance our understanding of the distribution of important freshwater quillworts, thereby updating their current conservation status, and further contributing significant knowledge to the global assessments.

Maxwell Gebhart, Gray Turnage

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Phenological and morphological trends of *Vallisneria* in North America - Poster presentation

Vallisneria is a genus of submersed macrophytes that offers numerous ecosystem services to aquatic environments as forage and shelter for multiple organisms. Historically, *Vallisneria* has undergone numerous major taxonomic revisions which have confounded most previous knowledge on the genus. Taxonomic changes combined with several North American invasions by non-native taxa prompt a necessary study on the phenology and morphology of taxa found in North America. Currently, management efforts suffer from little to no information on invasive *Vallisneria* which has led to numerous systems being heavily impacted. In mesocosms, *V. americana*, *V. neotropicalis*, *V. × pseudorosulata*, *V. spiralis*, and *V. australis* were grown as separate cultures in which 30 plants are harvested each month, with temperature, photoperiod, and water quality metrics collected continuously. At each monthly collection, plants are measured for several morphological traits related to leaf shape and structure, separated into aboveground and belowground tissues, then dried and weighed. Phenological traits, such as aboveground biomass, were regressed against the collected environmental data to determine environmental effects and morphological metrics were analyzed using a linear discriminant analysis. Preliminary phenological hypotheses argue that aboveground biomass production for all taxa peaks in the late summer after an extended period of high temperatures; however, *V. × pseudorosulata* and *V. spiralis* will produce the most aboveground tissue of all taxa. Belowground tissue is hypothesized to peak just before the aboveground biomass peak; however, the belowground biomass will not senesce during cold temperatures. Morphologically, major differences between taxa are suspected to be statistically significant in the leaf tip angle and leaf width, with *V. australis* and *V. spiralis* being the most distinct from one another. The results of these studies aim to describe life history strategies and refine in-field identification of several *Vallisneria* to inform management decisions as well as improve rapid response efforts.

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Aquatic plant communities rarely occurring in freshwater habitats of Greece - Poster presentation

In the current study thirteen aquatic plant communities with limited distribution in Greece are presented. The reviewing of literature data published during the last 25 years revealed that among the 95 hitherto known communities of vascular aquatic plants of Greece thirteen are rare or under-recorded. Syntaxonomic and ecological comments concerning these syntaxa, are given, while a crosswalk between syntaxa and the EUNIS habitat types was made. Detection of links of the vegetation units discussed here with specific habitat types was achieved through the floristic composition and the concept of indicator species (diagnostic, constant, dominant), following the phytosociological approach and according to the FloraVeg.EU database. Many of the species that differentiate the vegetation units as well as species that are constantly present in these units (constant species), are listed as indicator species of particular habitat types of the EUNIS classification system. The results showed that on the basis of their floristic composition the thirteen communities of increased interest belong to seven alliances of the EuroVegChecklist and correspond to six EUNIS habitat types of FloraVeg.EU. Five of the detected EUNIS habitat types are included in the Annex I (Council Directive 92/43/EEC) with the codes 3150, 3130 and 7230 and one (72A0) is of national interest. The alliances and the habitat types closely related to the vegetation units described here are the following: Eleocharito palustris-Sagittarion sagittifoliae (EUNIS habitat type- Q52/NI- 72A0), Magnocaricion gracilis (EUNIS habitat type- Q53/Annex I- 7230), Caricion davallianae (EUNIS habitat type- Q41/Annex I- 7230), Nanocyperion (EUNIS habitat type- Q62/Annex I- 3130), Littorellion uniflorae (EUNIS habitat type- p3f/Annex I- 3130), Potamogetonion, Ranunculion aquatilis (EUNIS habitat type- p3d/Annex I- 3150). Among these, the Annex I habitat type 3130 'Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletalia uniflorae and/or Isoeto-Nanojuncetea' is of high responsibility and high monitoring importance for Greece. Its conservation status, at the national level, is characterized as Unfavourable-Inadequate (U1) with drought and decreases in precipitation, overgrazing and dumping/depositing of inert materials representing the main pressures and threats.

Eli Russell

University of Florida, United States of America

Evaluating abrasive weeding as a potential method for controlling floating aquatic plants - Poster presentation

Floating aquatic plants, like water hyacinth (*Pontederia crassipes*) and water lettuce (*Pistia stratiotes*), can cause many issues in lakes and rivers. If these species are not controlled, their growth can prevent the use of waterways by impeding navigation and reducing recreational activity. Additionally, these species can outcompete native flora, reducing plant biodiversity. Herbicides are commonly used to control these species and prevent them from reaching problematic levels. However, public opinion surrounding the use of herbicides in public waterways has necessitated the need to research novel non-chemical approaches for aquatic plant management. In terrestrial systems, such as organic crop production, abrasive weeding offers a unique weed control method that fits organic systems. Abrasive weeding is also being tested in vegetable production, where growers face limited herbicidal control options and mounting herbicide resistance challenges. While abrasive weeding has been explored in terrestrial systems, its potential application in aquatic environments remains untested. So, it is important to evaluate the efficacy of abrasive weeding for use against floating aquatic plants. Aquatic environments have unique challenges that other systems that have implemented abrasive weeding do not have to consider. For instance, aquatic systems do not always allow applicators to be right on top of the target weed. So, this study will evaluate three grit types (fine, medium, and coarse) at four application distances (1, 2, 3, and 4 meters) for controlling water hyacinth and water lettuce. Control efficacy will be assessed at intervals of 3, 7, 14, 21, 28, 35, and 42 days after treatment (DAT), with final biomass measurements taken at 42 DAT. If effective, abrasive weeding could provide a useful alternative to traditional herbicide applications. It could be rotated with traditional herbicides to provide an integrated weed management approach that would slow herbicide resistance development. This method could potentially be incorporated into sustainable aquatic plant management strategies, reducing the reliance on herbicide control. However, there are potential drawbacks that need to be addressed by further research, such as its use could affect native non-target flora, increase fragmentation in some species, and the use of sand or other inorganic material could add sediment to the bottom of the waterway.

Abha Panda

University of Minnesota, United States of America

To revegetate or not: a meta-analysis of aquatic plant community outcomes with and without active revegetation - Poster presentation

While the reintroduction of native plants following management interventions is a well-established practice in terrestrial systems, its application in aquatic ecosystems remains limited, largely due to resource and knowledge barriers. Current aquatic management practices often operate under the assumption that management interventions alone (e.g., invasive species removal, decreasing nutrient/pollutant loads, etc.) will be sufficient for native species recovery. However, in many cases, native species fail to recover on their own, and degraded environmental conditions and invasive species persist. In this meta-analysis, I evaluate the outcome of revegetation practices in aquatic ecosystems globally to determine if active revegetation (i.e., actively reintroducing native plants in restoration sites) better promotes native plant community re-establishment than passive recovery. While active revegetation can help overcome ecological barriers such as dispersal limitations for native plants, it can also be more resource intensive. By evaluating differences in plant communities with and without active revegetation, I aim to better characterize when active revegetation may be most beneficial as a management practice and under what conditions. In particular, I consider the role of geography, habitat type (i.e. lake vs river), revegetation purpose, and revegetation method (i.e., seeding, plugging, etc.) across 100+ screened studies to determine how these factors influence revegetation practices and outcomes worldwide. By looking across studies at material and labor costs, I also highlight practical challenges in our current methods of evaluating revegetation outcomes and ways to move forward to potentially integrate revegetation as a practice in aquatic habitat restoration.

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The reference network of Spanish rivers: defining bryophyte communities of national river types - Poster presentation

The composition and abundance of aquatic flora, and specifically macrophytes, is one of the biological quality elements to be monitored for the classification of ecological status of rivers according to the European Water Framework Directive 2000/60/CE. Since the year 2019, macrophytes, which include aquatic and semiaquatic bryophytes, are being monitored along with other quality elements to stablish the reference conditions of Spanish rivers (the "REFCON" project). A national network of reference sites (without significant anthropic pressures) included a total of 252 sites covering the whole Iberian Peninsula and the 32 national abiotic river types (typology based on geographical, geological, hydrological, and climatic variables). The main objectives of this study were to analyse bryophyte diversity across river types, to merge abiotic river types with similar bryophyte communities, and to define indicator species and environmental characteristics for the resulting biotic groups. Stream reaches of ca. 100 meters long were waded in an upstream zigzag pattern, collecting all bryophytes found submerged and in the immediately emerged zone above the water line. A cluster analyses was performed on river type-species matrix, and indicator species were obtained for the resulting groups (IndVal, RStudio; SIMPER, Primer-E Ltd). Environmental gradients were defined by overlying environmental variables on an ordination of river types (NMDS, Primer). A total of 258 bryophyte species were recorded, of which 74% were mosses, 25% liverworts and only 1% hornworts. The most frequent species, occurring in more than 50% of the sites, were: *Rhynchostegium riparioides*, *Apopellia endiviifolia*, *Bryum sp.* and *Fissidens crassipes*. The cluster analyses grouped the abiotic river types into six biotic river types: mineralized/calcareous streams (indicator species: *Didymodon tophaceous, Fissidens crassipes, Hydrogonium bolleanum*), mountain streams (*Rhynchostegium riparioides*, *Apopellia endiviifolia*, *Cratoneuron filicinum*), northern siliceous streams (*Fontinalis squamosa*, *Scapania undulata, Rhynchostegium alopecuroides*), southern silicious streams (*Lunularia cruciata, Bryum* sp.), high order streams (*Rhynchostegium riparioides*, *Leptodictyum riparium, Cinclidotus riparius*) and northern plateau streams (*Kindbergia praelonga*, *Fissidens osmundoides*, *Pogonatum aloides*, *Campylium stellatum*). Finally, we discuss some aspects of the use of bryophytes as bioindicators to evaluate the ecological quality of river ecosystems.

Łukasz Łuczaj

Rzeszów University, Faculty of Biology, Nature Protection, and Sustainable Development, Poland

The use of edible aquatic and emergent plants in Eastern Europe - Poster presentation

This research concerns the ethnographic, historical, and archaeological evidence of the use of aquatic and marsh plants in the eastern part of Europe, mainly from Poland but also Belarus and Slovakia. Water caltrop (*Trapa natans*) is an annual plant producing edible nuts rich in starch and proteins. Species from the genus *Trapa* have been extensively used as food in many countries around the world. Water caltrop became critically endangered in many European countries, e.g., Poland and Germany, due to the disappearance of oxbow lakes and the introduction of fish that eat water caltrop plants. Recently, however, it has been spreading due to climate warming. Other aquatic and emergent plants used as food in Eastern Europe in the past include *Typha* spp. (young shoots and rhizomes), *Acorus calamus* (young shoots and base for baking bread), *Schoenoplectus lacustris* (young shoots), *Nymphaea alba* (seeds), *Nuphar luteum* (leaves for wrapping dough), *Veronica beccabunga* (salad), *Caltha palustris* (buds pickled like capers, underground parts used as famine food), *Scirpus sylvaticus* (inner parts of young shoots as a snack), *Cardamine amara* (salad, soup), *Glyceria fluitans* (grains used in soups and bread), and *Stratiotes aloides* (cooked as a vegetable). Excavations from a Mesolithic site in central Poland also revealed the use of *Sagittaria sagittifolia* bulbs.

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Ecophysiology of aquatic plants

Session 8

Chairs: Elisabeth Gross (Laboratoire Interdisciplinaire des Environnements Continentaux, CNRS, Université de Lorraine, France) & **Arie Vonk** (Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Netherlands)

This session explores the ecophysiological responses of aquatic plants to environmental variability and anthropogenic pressures, including the climate change. Aquatic plants exhibit complex physiological adaptations that allow them to survive and thrive under diverse and often challenging conditions, including fluctuations in light, temperature, nutrient availability, hydrodynamics, and pollutants. Contributions provide insights into stress responses, dormancy mechanisms, stoichiometric variation, gas exchange strategies, and physiological trade-offs across plant morphologies and environmental gradients. Particular attention is given to how multiple stressors, both natural and human-induced, interact to shape plant function and performance. By integrating experimental, field, and modeling approaches, this session contributes to a deeper understanding of the mechanisms underlying aquatic plant resilience and the functional role of aquatic plants in freshwater ecosystems.

Giulia Lodi, Marc Reynders, Patience Ayesiga, Rogers Tinkasimire, Medard Twinamatsiko, Jonas Schoelynck

University of Antwerp, Belgium
Plantentuin Meise, Belgium
Mbarara University of Science and Technology, Uganda

Spatiotemporal variation in C:N:SI stoichiometry of *Cyperus papyrus*: insights from herbaria and field studies - Oral presentation

Climate change is inducing increases in CO2 and air temperature, affecting plant chemistry and susceptibility to stress. Particularly, it is unknown how these factors will affect the hyper silicon accumulators grasses and sedges. Recently, some studies have hypothesized that contemporary grasses, growing under elevated CO2, accumulate less silicon than their ancestors. Little attention has been given to the topic, and especially tropical sedges have not yet been included in these analyses. Within this framework, we have studied the spatiotemporal variation of *Cyperus papyrus*, the largest sedge worldwide. Papyrus is a high silicon accumulator as well as an important nitrogen filter. Additionally, it shows high rates of photosynthetic CO2 assimilation. To analyse the temporal variability, we investigated the change in C:N:Si ratio in papyrus samples from herbaria collections. 102 papyrus specimens have been sampled from the collections of Meise Botanical Garden, ranging from 1895 to today, and analysed for carbon, nitrogen, and biogenic silica concentrations. Papyrus wetlands can be found across the whole African continent, especially in floodplains with optimal growing conditions for papyrus vegetation: permanently waterlogged soil and intermediate water velocity. To study the spatial variation of papyrus, we have performed two studies at different scales on contemporary papyrus plants. The first was done at a small/plot scale, where three sets of six plots each have been inspected: natural environment, degraded due to fire, and recovery after fire. Five papyrus shoots have been collected from each plot, divided into their organs, and analysed for carbon, nitrogen, and biogenic silica concentrations. With this setting, it was possible to study how papyrus growth and chemistry are affected by anthropogenic stresses. The second investigation was conducted at a larger scale: contemporary papyrus shoots from wetlands in Uganda, Botswana, Egypt, and Burundi were compared to see differences in nutrient concentrations between locations.

Michał Rybak, Yagmur Güngör, Zofia Książkiewicz, Maria Wojciechowicz, Oskar Kamiński, Magdalena Woźniak, Przemysław Niedzielski

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Department of General Botany, Faculty of Biology, Adam Mickiewicz University, Poznań, Poland
Department of Gene Expression, Faculty of Biology, Adam Mickiewicz University, Poznań, Poland
Department of Chemistry, Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, Poznań, Poland
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AL- inclusive: an unintentional journey of aluminum through a food chain during lake restoration - Oral presentation

Accelerated eutrophication of surface waters is a tremendous environmental challenge of the 21st century. To mitigate this problem, aluminum (Al) based coagulants are commonly used in restoration projects to inactivate phosphates. While their effectiveness at reducing phosphorus levels is well known, the ecological impact remains poorly understood. We tested the direct effect of Al on the plant *Myriophyllum spicatum* and on snails *Lymnaea stagnalis*, as well as the indirect impact on snails through feeding on exposed plants. Growth parameters of *M. spicatum* (shoot/root length and biomass, relative growth rate) and Al concentrations in plant tissues and snails were analyzed. The environmental changes following Al-based coagulant exposure included a pH drop, increased conductivity, and phosphorus precipitation. *M. spicatum* maintained shoot and root growth and relative growth rates, although root biomass was reduced. Aluminum accumulation in plant tissues after the enrichment phase reached 4419.0 ± 1389.1 µg g^{-1} (low dose) and 3576.7 ± 353.3 µg g^{-1} (high dose) and was significantly higher than the control (22.0 ± 1.1 µg g^{-1}). Snails feeding on Al-exposed plants accumulated more Al (low dose: 145.5 ± 20.1 µg g^{-1}; high dose: 223.6 ± 37.7 µg g^{-1}) than in the control (48.2 ± 12.1 µg g^{-1}), indicating a significant relationship and trophic transfer. However, direct snail exposure on the coagulant resulted in even higher Al accumulation (low dose: 1234.9 ± 447.3 µg g^{-1}; high dose: 1143.8 ± 308.8 µg g^{-1}), indicating direct uptake as well. Our findings demonstrate a serious but previously unconsidered problem. Although former studies have shown that Al-based coagulants effectively inactivate phosphorus, our study reveals a significant risk: the application of these coagulants may lead to substantial metal bioaccumulation in aquatic organisms. This, in turn, has the potential to disrupt food webs. These results highlight the need for further ecological risk assessments to balance eutrophication control with ecosystem health.

Takashi Asaeda, Mizanur Rahman

Saitama University, Japan
The University of Ryukyus, Japan

The characteristics of H_2O_2 generation in submerged plants under a flowing environment and its mechanism - Oral presentation

Submerged macrophytes in natural streams are exposed to various abiotic stressors, including solar radiation, temperature fluctuations, and mechanical stress caused by water flow. During photosynthesis, carbohydrates are synthesized using electrons generated from absorbed solar radiation. However, an excess of electrons—resulting from either overproduction or insufficient consumption, often due to a lack of carbon dioxide (CO_2) or inorganic carbon—can lead to the formation of reactive oxygen species (ROS). This, in turn, increases hydrogen peroxide (H_2O_2) concentrations, using oxidative stress in plants. Consequently, the intensity of these stressors can be assessed by measuring H_2O_2 concentrations in plant tissues. The primary objective of this study was to determine how submerged macrophyte species produce H_2O_2 in response to varying environmental conditions, including different flow patterns in streams and exposure to high photosynthetically active radiation (PAR). Observations were conducted across three rivers during different seasons, as well as in outdoor experimental flumes. At each site, unidirectional mean flow velocity (MV), turbulence velocity (TV), solar radiation intensity, and water temperature were measured within patches of *Egeria densa*, *Elodea nuttallii*, and *Myriophyllum spicatum*, among others. Measurements were taken for plants both exposed to direct solar radiation and those in dark-adapted conditions, where they were shaded by a black sheet placed on the water surface. Plant samples were collected alongside PAR measurements, and H_2O_2 concentrations in plant tissues were analyzed using the $TiSO_4$ method. In streams under dark-adapted conditions, H_2O_2 concentrations were highest in areas with very low flow rates. However, as the flow rate increased to moderate levels, concentrations declined, then gradually rising with further increases in velocity. In contrast, H_2O_2 concentrations induced by solar radiation were species-specific and increased in correlation with PAR intensity and temperature. In both scenarios, extreme stress conditions led to a decline in H_2O_2 levels, likely due to the deterioration of plant shoots. These findings suggest that low carbon availability, resulting from boundary layer resistance or high temperatures limiting inorganic carbon supply, leads to an accumulation of surplus electrons produced by PAR intensity. Alternatively, at higher velocities, more electrons may be generated as plants consume additional energy. These excessive electrons contribute to elevated H_2O_2 production, ultimately causing oxidative stress in plant tissues.

Mégane Jeanmougin, Geneviève Chiapusio, Mathilde Berthelon, Christelle Boisselet, Viet Tran-Khan, Annie Millery-Vigues, Aurélie Guillou, Nathalie Mondy, Sara Puijalon

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Anthropogenic pressure of aquatic ecosystems: isolated and combined effect of night-time light pollution and temperature on the ecophysiology of aquatic plant species - Oral presentation

Emissions of greenhouse gases resulting from human activities have led to a rise in global surface temperature of 1.1°C over the last century. In parallel, the concentration of human populations and activities around freshwater bodies induces additional anthropogenic pressures on aquatic ecosystems. In particular, population growth, transportation networks, and urbanization have caused a rapid expansion of artificial night lighting. Artificial Light At Night known as ALAN, alters natural light regimes by creating skyglow, visible up to several dozen kilometers away. Light pollution now affects a range of ecosystems, from natural habitats to those only slightly modified by humans. The combination of several stressors, such as temperature and ALAN, often induces a unique response of organisms that differs drastically from those triggered by each factor isolated. This study aimed to investigate the effects of artificial nocturnal lighting, temperature increase, and their interaction on photosynthesis, leaf traits, and leaf pigment content in three macrophyte species: *Potamogeton coloratus* Hornem, *Berula erecta* (Hudson) Coville, and *Myriophyllum spicatum* L. For this purpose, an experiment was conducted under controlled conditions, where plants were exposed to six treatments according to a full factorial design with two light conditions (ALAN: 0.0655 µmol m^{-2} s^{-1} or total darkness) during a 16:8 light:dark photoperiod, and three temperatures (19°C to 21.1°C), selected to represent typical summer values (as thermal optima are unknown for most species). Photosynthetic performance, pigment content, and leaf traits were measured. The results particularly outline that the three species displayed distinct sensitivities to temperature, ALAN, and their interaction. For *Berula erecta,* the combination of both factors led to lower leaf dry matter content, but higher leaf chlorophyll and lutein concentrations, as well as higher maximum electron transport rates and photon-to-electron conversion efficiency. Temperature alone induced lower β-carotene content in leaves. For *Potamogeton coloratus*, the combined effect of ALAN and temperature only led to higher leaf chlorophyll concentration,

while higher photosynthetic capacity and efficiency were observed for both *Potamogeton coloratus* and *Myriophyllum spicatum* in response to temperature alone. These results demonstrate that both ALAN and temperature can significantly impact photosynthesis, leaf structure, and pigment composition in aquatic plants. Their combined effects may therefore affect plant metabolism even though their ecological niches differ. In a natural environment, these differences could then affect interspecific interactions by driving species dominance and leading to differential changes in phenology.

Yang Liu, Yang Liu, Wei Li, Lars Iversen, Yu Cao

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Wuhan Botanical Garden, Chinese Academy of Sciences, China

Divergent stomatal strategies in heterophyllous aquatic plants: reduced hydraulic investment in floating leaves and enhanced gas exchange in emergent leaves - Oral presentation

Stomata regulate gas exchange and water loss in plants, linking water transport and photosynthesis. In floating-leaved aquatic plants, stomata are concentrated on the upper surface, enhancing CO_2 diffusion and mesophyll conductance and therefore promoting photosynthetic efficiency. Notably, some aquatic plants exhibit heterophylly, developing both floating and emergent (aerial) leaves, to adapt to fluctuating environments. However, how stomatal traits diverge between these two leaf types and integrate into broader hydraulic and photosynthetic trade-off strategies remains unknown. Here we examine stomatal, petiole, and photosynthetic traits in two types of heterophyllous leaves for 15 aquatic species. We found that floating leaves tended to have fewer but larger stomata, whereas emergent leaves had smaller stomata, enhancing gas exchange capacity in aerial environments. Allometric relationships between total stomatal area and petiole xylem area revealed reduced hydraulic investment in floating leaves, with a weaker positive relationship compared to emergent leaves. Furthermore, floating leaves formed a cohesive network with strong inter-trait correlations, while emergent leaves exhibited higher modularity, reflecting functional differentiation linked aerial adaptation. These findings highlight stomatal traits' role in balancing water transport and photosynthesis in heterophyllous aquatic plants. The development of emergent leaves is linked with enhanced leaf gas transport capacity and plasticity, driven by a stomatal trait structure optimised for rapid environmental responses. In contrast, floating leaf stomata exhibit limited stomatal variation, likely due to stable CO_2 and water supply in aquatic environments combined with structural constraints (e.g., stomatal restriction to the upper surface). By showing how heterophyllous species integrate stomatal traits across contrasting environments, this study provides novel insights into the evolutionary and ecological significance of heterophylly and enhances our ability to predict plant growth responses to environmental change.

Amine Mohamed Mahdjoub, Elisabeth Maria Gross, Sabine Hilt

Universite de Lorraine, France
Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

Physiological response of submerged freshwater macrophytes to multiple stressors: current knowledge and future research directions - Oral presentation

Submerged macrophytes, which are key components of many freshwater ecosystems, are increasingly subject to multiple stressors due to global change. This may explain their accelerating global loss in lakes. Research on multiple stressor interactions in freshwater ecosystems has increased exponentially in recent decades, but less than 10% of experiments have focused on submerged macrophytes. Understanding the effects and interactions of multiple stressors on submerged macrophytes, however, is critical for their effective conservation and management. As most previous reviews focused on multiple freshwater taxonomic groups with little to no attention to submerged aquatic plants, we aimed to summarize current knowledge and identify future research directions on the effects of multiple stressors on submerged aquatic plants. Using a machine learning tool, we screened 4226 publications, ranging from 1979 to 2024, identifying 138 relevant articles. These were analyzed to determine which macrophyte species, stressor combinations, measured response factors and experimental approaches have been tested so far. 25 stressor classes were identified, with eutrophication and trace metal pollution being the most investigated. Main response factors used were pigment content, chlorophyll fluorescence parameters, element stoichiometry and antioxidant enzymes. The 2020's are marked by the emergence of studies combining morphological and physiological measurements to omics, shedding light on transcriptomic and metabolomic responses of plants and their epiphytic communities to combined stressors. Furthermore, as climate change is a difficult-to-manage long-term global stressor that is accelerating, we analyzed studies investigating the physiological response of macrophytes to warming in interaction with other stressors. This is done by comparing null model predictions to observed experimental effects, assessing whether warming exacerbates or mitigates other effects. Based on these results and a comparison to marine and terrestrial plants, we discuss the needs and potential for future research in this field.

Suting Zhao, Xuesha Ke, Jielin Li, Ruifen Zhang, Qianru Cai, Yixuan Huang, Yuanyan Chen, Junyao Sun, Liyan Yin, Wei Li

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Wuhan Botanical Garden, Chinese Academy of Sciences, China
School of Life and Health Sciences, Hainan University, China

Studies on germination characteristics and mechanisms of vitality maintenance in aquatic plant seeds - Oral presentation

Aquatic plant seeds represent a vital resource in the recovery of aquatic plant populations following extreme disturbance damage. Consequently, the investigation into the germination and storage characteristics of aquatic plant seeds holds significant theoretical and practical value. In the preceding two decades, our research group has developed a series of germination and storage tests on more than 10 species of aquatic plant seeds. The objective of our research was to study the germination, storage characteristics and vitality maintenance mechanism of these seeds. The results of the germination test demonstrated that the optimal germination temperature for the seeds of *Vallisneria natans* and *Ottelia alismoides* was between 25°C and 35°C. The presence of mud was found to promote the seed germination of *O. alismoides*, while sand was observed to inhibit the seed germination of *Trapa arcuata*. The study also found that low oxygen levels were conducive to the seed germination of *V. natans*, while high oxygen levels were conducive to the seed germination of *T. arcuata*. Furthermore, light was found to promote the seed germination of *V. natans*, *O. alismoides*, *Hydrocharis dubia*, *T. quadrispinosa*. The depth of burial was found to significantly inhibited the seed germination of aquatic plants. The seeds of *O. alismoides*, *T. quadrispinosa* and *T. arcuate* require a period of refrigeration to break dormancy before germination. The application of butachlor resulted in a substantial inhibition of *V. natans* seed germination. High seed density has been observed to enhance the germination of the Hydrocharitaceae family plants, including *V. natans*, *V. spinulosa*, *V. denseserrulata*, *O. alismoides*, *O. acuminata*, *O. emersa*, *H. dubia* and *Blyxa aubertii*. The findings of the storage test demonstrate that desiccated storage at 4°C resulted in a significantly higher seed germination rate compared to storage under moist conditions at the same temperature for the seeds of *O. acuminata*, *V. natans*, *Potamogeton wrightii* and *Stuckenia pectinata*. Following a two-year storage period under natural temperature-sand-water storage conditions, the seeds of *O. alismoides* and *H. dubia* exhibited high levels of vitality. Subsequent studies have demonstrated that the maintenance of seed vitality is closely related to seed respiration rate and active scavenging of reactive oxygen species by the intracellular antioxidant system. The findings of our study can provide data support and reference for the use of seeds to protect and restore aquatic plants.

Neumarcio Vilanova Costa, Dagoberto Martins, Sidnei Roberto De Marchi, Cibele Chalita Martins

Universidade Estadual Paulista/ UNESP, Brazil
Universidade Estadual do Oeste do Paraná/ UNIOESTE, Brazil
Universidade Federal de Mato Grosso/ UFMT, Brazil

Breaking dormancy of *Ceratophyllum demersum* seeds - Poster presentation

Ceratophyllum demersum, commonly known as coontail, is prominent among the several immersed aquatic weeds that proliferate in the reservoirs of hydroelectric power plants due to high reproductive capacity and biomass production. Despite this problem, studies related to the propagation and persistence of those species in aquatic ecosystems are quite scarce. Thus, the objective of this study was to determine a method to overcome dormancy and promote seed germination of coontail seeds collected in 'Tietê' River- Brazil. The collected seeds were grouped into two lots, one with seeds in a container with distilled water and the other with seeds in paper bags under cold camera conditions (16.8 ºC). Tests of dormancy break were accomplished 650 days after seed collection using the following treatments: I) scarification with sandpaper, II) immersion in concentrated sulfuric acid (98%) for 5, 15, 25 and 35 minutes, III) immersion in hot water (98 ºC) and IV) control A (seeds in a container with distilled water) and control B (seeds in paper bags). The results showed that this species produces fertile seeds that remain viable in the sediment for several years. Seed scarification with sandpaper was the most effective method in breaking dormancy and promoting seed germination, followed by storage in paper bags (control B), which was superior to the other treatments. While control A showed 99% dormancy and 1% seed germination, scarification with sandpaper resulted in 27% dormancy and 65% germination, and control B in 45% dormancy and 53% germination at 79 DAT.

Katharina Wilfert, Jonas Schoelynck, Els Prinsen

University of Antwerp, Belgium

Defining the spatial variation of plant responses to hydrodynamic flow in a submerged macrophyte patch - Poster presentation

Submerged macrophyte patches (SMP) have many crucial ecological roles, including biodiversity preservation. Earlier studies suggest that hydrodynamic flow limits the expansion of SMP by physically damaging and uprooting shoots. However, adaptive growth strategies have been observed, such as changes in shoot stiffness, biomass, and internal signalling molecules. Examining physiological and morphological changes on a patch scale will challenge our understanding of patch expansion and its driving factors. To advance our knowledge on this topic, we plan to focus on hydrodynamic-induced stress, the associated adaptations, and their spatial variation within patches of *Egeria densa* Planchon (1849). However, preparatory experiments need to be conducted first to determine reference concentrations and concentration changes on a single shoot level. To do so, small preparatory experiments will be conducted using flumes in climate chambers. We will expose *E. densa* to three different flow velocities (5, 18, and 30cm/s) for six weeks to determine baselines for both physiological and morphological parameters. Focal parameters of these experiments are phytohormones, enzyme activity, shoot length, biomass, flexural stiffness, and cellulose/lignin content. Additionally, changes in cellular structures will be evaluated. Methodologies will include spectrophotometric quantifications, ULPC-MS/MS measurements, gravimetric determinations, three-point bending tests, and microscopy. On our poster, the first results of the preparatory experiments and the lessons learned will be presented.

Aquatic plant genetic diversity and evolution

Session 9

Chairs: Lindsay L. Trottier (McGill University, Canada; Quebec Centre for Biodiversity Science, Canada) & **Rossano Bolpagni** (Università degli Studi di Parma, Italy)

This session addresses the important topics of aquatic species conservation, genetic diversity, and evolutionary processes. Communications examine the complexity of aquatic macrophytes through studies of genetic variation, speciation, reproductive strategies, and phylogenetic relationships. They explore both sexual and asexual reproduction, the role of hybridization, and the biogeographic and ecological factors driving diversification in aquatic environments. The use of molecular tools and evolutionary frameworks reveals patterns of cryptic diversity, informs conservation priorities in a changing climate, and supports the reassessment of species for conservation and taxonomic purposes. Freshwater habitats, as well as brackish and saline wetlands are included in the session.

Elisa Denis

HES-SO, UNIGE, Switzerland

The intraspecific diversity of macrophytes in European pondscapes - Oral presentation

European ponds support up to 70% of the regional freshwater species pool and are increasingly acknowledged as key habitats due to their abundance on Earth. Besides, ponds' biological diversity suffers both from more threats than lakes and rivers and from a lack of consideration in conservation policies, despite the key ecosystem services they provide. This lack of awareness comes with a deficit of monitoring, which, if filled, could become a fundamental asset to assess freshwater biodiversity trends due to the cost-efficient nature of studying pondscapes. As part of the Biodiversa+ project "TRANSPONDER", this research's aim is threefold. First, understanding the intraspecific diversity of two different macrophytes (*Lemna minor* and *Potamogeton natans*) to get insights into signs of genetic erosion of these abundant species in European pondscapes. Second, understanding the differences and potential advantages of pooling individuals versus studying them as separate entities to assess the genetic diversity between populations. Finally, developing transnational standardised biodiversity monitoring guidelines for permanent and temporary ponds in Europe. The first two objectives will be met by using different genomic approaches (target enrichment, ddRAD sequencing) and subsequent analysis to assess various indicators of genetic diversity. The third objective will be met by compiling the work of several other European working groups on different monitoring aspects. These three objectives will contribute to the development of a standardised methodology to assess the biodiversity and ecological status of ponds, as it already exists for lakes and rivers.

Luca Braglia, Laura Morello, Cristian Perna, Yuri Lee, Silvia Gianì, Maria Adelaide Iannelli, Ingo Schubert, Anton Stepanenko

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Reticulate evolution at the origin of duckweed diversity and shapes its evolution - Oral presentation

Members of the small family of free-floating, aquatic macrophytes Lemnacea, are cosmopolitan inhabitants of freshwater bodies. Under the name of duckweed or water lentils, they are gaining growing interest due to their exploitability as feed and food, as well as for wastewater remediation. On the other hand, rising mean temperatures and longer warm seasons in temperate regions, in combination with water eutrophication, favor extensive overgrowth of Lemnacea and the spreading of alien, tropical species. This picture calls for a deeper knowledge of this monocot family, starting from taxonomy and species delimitation, since long hindered by the intrinsic difficulty posed by the extremely simplified water body of most species, in extreme cases reduced to a tiny, spherical, thallus-like structure with few differentiated tissues. The development of molecular methods and deep sequencing of whole genomes, together with the availability of large germplasm collections, are allowing rapid progress in species identification and the reconstruction of the genetic relationships among species. It's becoming more and more clear that the 36 currently accepted species cannot explain the huge physiological and ecological diversity observed. A systematic genetic analysis of about 600 clones from the Landolt duckweed collection, the largest living germplasm collection of Lemanceae worldwide, is ongoing in our laboratory, where a large part of this collection has been hosted since 2021. The most striking result, besides the discovery of many mistakes in the morphological classification of the accessions, is that many species in the genus *Lemna* are faintly reproductively isolated, and interconnected through hybrids of variable ploidy, forming species complexes. The common species *Lemna minor* can hybridize with both *L. turionifera* and *L. gibba*, producing the hybrids *L.* × *japonica* and *L.* × *mediterranea*. The tropical species *Lemna aequinoctialis* hybridizes with the closely related species *L. perpusilla,* forming tetraploid hybrids. Similar data are also emerging from the study of the *Wolffia* and *Wolffiella* genomes. These observations revealed for the first time how sexual reproduction in duckweed must be more common than previously thought, despite prevalent clonal reproduction, and pose interesting questions about the evolutionary history of these plants. Thorough investigation of sexual reproduction in these plants is now helping to recognize the evolutionary potential of different hybrid lineages in the genus *Lemna*.

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First molecular insight into Pannonian *Batrachium*: revealing high diversity and distant origins - Oral presentation

Water crowfoots (*Ranunculus* section *Batrachium*) are a taxonomically intricate group of aquatic plants. Due to their reduced morphology, high phenotypic plasticity, polyploidy and hybridization, species identification is often a challenge. We combined morphological evaluation, flow cytometry (FCM), DNA sequencing and chromosome counting to investigate the diversity of *Batrachium* in the yet unexplored Pannonian basin. The Pannonian Basin hosts specific habitats of temporary pools and saline wetlands and is thus rich in aquatic plants. In total, 234 individuals from 47 populations were sampled and measured for genome size using FCM, which is a good tool for species identification in *Batrachium*. From each population, at least one individual per cytotype was sequenced for two non-coding plastid loci and the nuclear ITS region. We recorded seven species known from previous research in Central Europe. We also detected hybrids of several parental combinations. In addition, four new, previously unknown, putatively non-hybrid cytotypes were discovered: two from the *Ranunculus peltatus* complex, and two from the *R. trichophyllus* complex. *Ranunculus peltatus* is represented by a common Central European tetraploid cytotype, another tetraploid cytotype with specific genome size, and by a hexaploid cytotype. There are only singular records of the latter ploidy in this species (Great Britain, Mykonos Island in Greece, and one putative autopolyploid individual in Czechia). Both new *R. peltatus* cytotypes differ from the common Central European tetraploids somewhat morphologically and clearly genetically. They are more related to diploid *R. peltatus,* which grows in the Iberian Peninsula. The new diploid and tetraploid *R. trichophyllus* cytotypes markedly differ from the Central European cytotypes of the *R. trichophyllus* complex in sequenced markers; diploids are so far reported only from the Iberian Peninsula. Both new cytotypes are genetically related to *R. circinatus* and *R. rionii*, a completely different genetic group from the rest of the *R. trichophyllus* cytotypes. Similar genotypes are reported from the Mediterranean without information about the ploidy. All the new cytotypes may represent cryptic taxa and seem to show some bond to the Mediterranean area. They might be spread in the Mediterranean and are undersampled so far. The similarity of Pannonian and Mediterranean seasonal pools likely allows the Mediterranean types to thrive in the Pannonian Basin. Their long-distance dispersal may be facilitated by migratory birds, for which the Pannonian marshes are important resting and feeding areas.

Yu Ito, Norio Tanaka, Jie Li, Stephan Gale

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National Museum of Nature and Science,Tokyo, Japan
Kadoorie Farm & Botanic Garden, Hong Kong
Xishuangbanna Tropical Botanical Garden, China

Cryptic diversity of *Monochoria* (Pontederiaceae) with description of two new species - Oral presentation

Monochoria is a pantropical genus of aquatic plants belonging to the family Pontederiaceae (Commelinales) with many narrowly distributed taxa in Africa and Asia-Pacific. Various key taxonomic questions remain unaddressed there, especially with regards to apparent cryptic diversity within *M. vaginalis*, a widespread species complex. Here we test taxonomic concepts and evaluate species boundaries using a phylogenetic framework. We collected virtually all species of *Monochoria* apart from a small number of extremely rare species in Africa and Australia; multiple samples of *M. vaginalis* were obtained throughout its range from India to Japan through Vietnam and Indonesia. Molecular phylogenetic trees based on five plastid DNA markers and the nuclear *phyC* region shared almost identical topologies. A Bayesian coalescent method of species delimitation using the multi-locus data set discerned seven species. The results lead us to conclude that certain populations in the Asia-Pacific region represent hitherto unrecognised cryptic species within widespread species complexes. Ecological niche modelling further suggested ecological differentiation among the species. Revised morphological keys to the species of *Monochoria*, including the two new species *M. pedunculata* and *M. pseudohastata* will be proposed.

Yuri Lee, Luca Braglia, Anton Stepanenko, Joerg Fuchs, Silvia Giani, Chiara Forti, Ingo Schubert, Laura Morello

Institute of Agricultural Biology and Biotechnology, Italy
Leibniz Institute of Plant Genetics and Crop Plant Research, Germany

Hybridity of mainly asexually propagating duckweeds of genus *Lemna* - dead end or breakthrough? - Oral presentation

Interspecific hybridization, which requires sexual propagation, is a major mechanism of speciation. Duckweeds are tiny aquatic monocotyledons that propagate clonally, rarely flower. Recently, at least three cryptic hybrids between different *Lemna* species have been uncovered based on multiple molecular and cytogenetic evidence; their successful propagation and dispersal is documented by their geographic distribution. Investigating their reproductive morphology and fertility is crucial to recognizing their potential to evolve via hybridization. We then started to systematically study flowering, seed set and germination, and the ploidy level of hybrids and their parental species. We revealed differences in flower development (protogyny, vs. homogamy), fertility (seed set and germination), as well as different ploidy levels of sexual hybrid progenies (indicating the occurrence of reduced and unreduced parental gametes in parent species). While tetraploid hybrids between *Lemna aequinoctialis* and *L. perpusilla* are fertile and produce viable seeds, natural di-haploid and triploid hybrids between *L. minor* and *L. turionifera* (*L.* × *japonica*) and *L. gibba* (*L.* × mediterranea) are male-sterile. Artificially induced tetraploid *L.* × *mediterranea* did so far not yet recovered male fertility. These results indicate unexpected diverse sexual pathways among duckweeds, suggesting that some hybrid lineages can only propagate asexually, while others are fertile and have an evolutionary potential in terms of reticulate speciation.

Ruffio Delphine, Boissezon Aurélie, Pouchon Charles, Naciri Yamama

Université de Strasbourg, France
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Conservation genetics of *Chara strigosa* A. Braun and its ecologically and morphologically related species in Switzerland - Poster presentation

Characeae, a family of multicellular green macro-algae found in still, fresh, or brackish water, are considered to be the closest cousins of terrestrial plants. Most of the taxa observed in Europe are highly vulnerable, the main causes being habitat loss (drainage, for example), loss of natural dynamics in aquatic environments, pollution (nutrient enrichment and pesticides) and the introduction of invasive species. In Switzerland, 25 species of Characeae are currently listed. One of these, *Chara strigosa*, classified as endangered on the 2012 Swiss National Red List, is a native boreo-alpine species, considered a glacial relict, whose range extends to northern Europe (France, Finland, Sweden, Norway, Latvia, Russia, Poland). In Switzerland, it exists in two different forms (Figure 1): *Chara strigosa* A. Braun, known as the "strict" form, found in the lakes of the Upper Engadine, at an altitude of 1,800 m in the eastern Alps of Grisons canton, and *Chara strigosa* f. *jurensis*, a microendemic form found in lakes and ponds in the Swiss and French northern Jura Mountain range (between 400 and 1,000 m altitude), as well as in lower-altitude lakes around Geneva (350 m altitude). During this study, we sampled specimens of *Chara strigosa* from the cantons of Grisons, Jura and Geneva and analyzed them morphologically and genetically. The results show that the two forms are clearly distinct, whatever the method used. *C. strigosa* from the eastern Alps is genetically closer to *Chara virgata* and *Chara globularis* than to *C. strigosa* f. *jurensis*. The latter is genetically similar to *C. contraria* and *C. aspera*. This implies that (i) *Chara strigosa* A. Braun is present in Switzerland only in the Upper Engadine lakes, which will therefore see its threatened status in Switzerland worsened, and (ii) that the *jurensis* form corresponds to a new species, *Chara jurensis*, which now needs to be formally described and which, due to its restricted geographical distribution and the threats to aquatic environments in general, is already in danger of extinction. However, the origin of *Chara jurensis* remains enigmatic. The species could be of hybrid origin or the result of chromosomal doubling. These results have direct consequences for the Characeae Red List, which is under reassessment. Although Switzerland can boast an additional species, it is nonetheless endangered, and its responsibility for its conservation is engaged.

Duarte Frade, Jose Martínez-Garrido, João Neiva, Gareth Pearson, Ester Serrão

CCMAR/University of the Algarve, Portugal
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Cryptic diversity and conservation of euryhaline seagrasses, *Ruppia* - Poster presentation

Ruppia (Ruppiaceae) is a key habitat-forming species in brackish to saline wetlands worldwide, often occupying ecosystems that are too extreme for other submerged macrophytes. The genus is taxonomically complex due to its simplified morphology, complicated nomenclature, and the occurrence of hybridisation and polyploidy. We investigated the diversity of *Ruppia* using nuclear and chloroplast DNA markers, with a focus on the Mediterranean and Macaronesia. Results revealed cryptic diploid/polyploid species pairs with similar morphology despite different habitat preferences, distributions and reproductive strategies, which conflicted with current species delineations based on morphology. Moreover, misidentifications were found to widespread, particularly for sequences available on GenBank. Though no island-endemic lineages where detected, different archipelagos (Azores, Madeira, Canaries, Cabo Verde) harboured different lineages, indicating several long-distance dispersal events, most involving polyploid lineages. Rather than one or two cosmopolitan *Ruppia* species, results support multiple species with more localised distributions, highlighting the need for using local germplasm in restoration projects. Our results highlight the importance of integrative taxonomy and the urgent need for a revision of the genus to reflect its evolutionary history.

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Fluvioralfsia iberica gen. et sp. nov., *fluvioralfsiaceae* fam. nov.: the first freshwater member of the Ralfsiales (Phaeophyceae), collected from streams in Spain - Poster presentation

A novel brown alga found inhabiting freshwater streams in Spain is described herein as *Fluvioralfsia iberica* gen. et sp. nov. The new species is the first member of the Ralfsiales from freshwater environments globally. Phylogenetic analyses establish it as a novel lineage within the Ralfsiales, Fluvioralfsiaceae fam. nov. It is an epilithic crust, typically orbicular with a radial growth pattern, formed by dichotomous fan-like branching of filaments. Crusts show a bilateral symmetry with horizontal medial filaments that bend upwards and downwards to form circular or semilunar protrusions in concentric bands that overlap at different levels. Older crusts are easily seen with the naked eye, becoming greater than 50 cm in diameter and to 1 cm in thickness and can cover a high percentage of the stream bottom in optimal habitats. Differentiating characters from other families of Ralfsiales include the absence of phaeophycean hairs and plurangia, and most notably the unangia originating intercalarily from lower cells of paraphyses. Most populations were located in 1st to 3rd order calcareous streams and rivers, altitudes of 14 to 870 m.a.s.l., in the mountainous Cantabrian coast, N Spain, and in one river in SE Spain. Sites were entirely non-marine, 2 to 118 km from the sea, with a median conductance of 219 µS/cm (range: 112-859) in well oxygenated, oligo-mesotrophic waters, and moderate to high current velocities. As freshwater brown algae are a species-poor group, *Fluvioralfsia iberica* represents an important addition to the global freshwater algal flora and raises additional questions about the origins of phaeophytes in fresh waters.

Petr Koutecký, Jan Prančl, Eliška Záveská, Vojtěch Dolejšek, Zdeněk Kaplan

Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic
Institute of Botany, Czech Academy of Sciences, Průhonice, Czech Republic

Origin of *Ranunculus fluitans*: from vernal pools to permanent rivers and from the south to the north? - Poster presentation

Ranunculus sect. *Batrachium* (Water-crowfoots) includes several widespread species in Europe, some of which are represented by different cytotypes or genetic lineages in different parts of the continent. Morphological similarity between the species (e.g., in the leaf type and shape and the flower size) may not correlate with their genetic relatedness. Some morphologically similar species are quite unrelated, and vice versa. One surprising case is the well-recognized species *Ranunculus fluitans* and *R. peltatus*. The former is morphologically highly specialized for fast-running waters (perennial, with long stems, firm capillary leaves and usually no floating leaves on the water surface) and occurs in permanent rivers from northern Spain to southern Scandinavia. It is mostly diploid, but triploids and tetraploids are also known; these polyploids are most likely of the autopolyploid origin. *Ranunculus peltatus* is annual or perennial and develops soft submerged capillary leaves as well as floating leaves. In Europe, there are two widespread cytotypes: diploids occur mostly on the Iberian Peninsula, inhabiting mostly Mediterranean vernal pools and small periodical streams, while tetraploids occur mostly in Central Europe in various types of still and running waters. In the north of the Iberian Peninsula and southern France, populations of intermediate character exist, growing in small streams to medium-sized rivers. The recent research shows that *R. fluitans*, diploid *R. peltatus* and the 'intermediates' are closely related, while the Central European tetraploid *R. peltatus* is more distant, based on DNA sequence data, nearly identical monoploid genome sizes specific for the diploids, as well as some peculiar morphological features (such as nearly glabrous flower receptacles in all diploids). There is considerable genetic variation both within and between populations of the diploid *R. peltatus* and the morphologically 'intermediate' plants, while *R. fluitans* is more uniform and its populations are often highly clonal. We hypothesize that this pattern is connected with Quaternary climatic oscillations and adaptation to a different habitat. Diploid *R. peltatus* seems to be an ancestral taxon surviving in the glacial refugium. One or a few genotypes adapted to permanent rivers instead of periodical vernal pools and small streams, giving rise to *R. fluitans*, which spread northwards during the Holocene. The 'intermediate' plants are likely genotypes in the course of adaptation to running waters rather than hybrids between the two species.

Sidinei Magela Thomaz

Universidade Estadual de Maringá, Brazil

Asexual reproduction of aquatic macrophytes via stem fragments: a review on determinants of plant fragmentation and propagule dispersal - Poster presentation

Many species of aquatic macrophytes rely on asexual reproduction to maintain populations and recover after disturbances. Stem fragments are relevant asexual propagules for numerous macrophyte species. I conducted a systematic review (i) to compare reproduction via stem fragments with other reproductive strategies, (ii) to identify the mechanisms and agents driving macrophyte fragmentation and (iii) the vectors of fragment dispersal. Reproduction via stem fragments offers some advantages over other strategies, because it is nearly aseasonal, fragments are produced in large quantities, and their production is less affected by disturbances compared to sexual reproduction. I identified 88 macrophyte species studied in relation to stem fragmentation mechanisms and agents, and dispersal vectors, representing approximately 2.6% of estimated global macrophyte diversity. The most frequently studied species were *Myriophyllum spicatum* (23 studies), *Elodea canadensis* (19 studies), *Ceratophyllum demersum* (13 studies), *Elodea nuttallii* (9 studies), *Hydrilla verticillata*, and *Egeria densa* (7 studies each). Conversely, the majority of species (47) were examined in only one publication. These findings highlight the disproportionate research focus on a few, typically invasive, species, while most remain significantly understudied. Fragmentation occurs through autofragmentation and allofragmentation. Autofragmentation typically peaks after biomass reaches its maximum and is influenced by various factors, with nutrients being one of the most important. Allofragmentation is mainly driven by water flow and wave action, though animals and human activities also contribute significantly. Most studies on macrophyte fragment dispersal highlight the importance of hydrochory (dispersal by river flow or wind-driven currents). While zoochory (dispersal by fish and birds) and anthropochory (dispersal through boating and plant trade) are also important, they have received less attention. Changes in aquatic ecosystems, particularly those driven by rainfall dynamics linked to global change and those resulting from dam construction, can impact macrophyte metacommunities by altering plant fragment production and dispersal. However, most macrophyte species, especially non-invasive ones colonizing tropical regions, remain understudied with respect to their ability to reproduce via stem fragments.

Pollutants and the use of aquatic plants in water treatment

Session 10

Chairs: Elisabeth M. Gross (Laboratoire Interdisciplinaire des Environnements Continentaux, CNRS, Université de Lorraine, France) & **Takashi Asaeda** (Saitama University, Japan)

Lakes, ponds, wetlands, rivers and streams face growing pressure from pollutants, including artificial fertilizers, heavy metals, and emerging contaminants. Aquatic plants play a critical role in both buffering these impacts and offering nature-based solutions for water quality improvement. This session explores the dual function of aquatic macrophytes as indicators of water quality and active agents in treatment and remediation. Presentations examine the biofiltration capacity of free-floating and submerged species, the ecological implications of pollutant exposure, and the influence of plant community structure on water quality. Discussions also highlight the potential of aquatic plants in long-term monitoring, the effects of combined stressors on plant growth and function, and the importance of providing guidelines for near-natural planting arrangements and selecting optimal plant compositions for restoration. These contributions underscore the importance of aquatic plants as key allies in addressing pollution in freshwater ecosystems.

Udo Schwarzer, Claudia Schwarzer

Bio Piscinas Lda., Portugal

Aquatic plants for maintaining recreational water quality - Oral presentation

The use of aquatic plants to serve human needs has a long history, exemplified by rice as food and reeds for roofing. Today, aquatic plants are increasingly employed in wastewater treatment plants. Moreover, where high recreational water quality is important, aquatic plants are now replacing harmful chemical solutions for water treatment, benefiting both human health and the environment. Natural swimming pools are about to replace chlorinated pools in private, tourist used and public settings. Germany has more than 300 public swimming ponds, where aquatic plants and other biological features, such as plant filters, maintain water quality for hundreds of swimmers daily. Austria is set to become the first country globally with more biological than chemical solutions for swimming pool water treatment. To avoid the use of non-native species and select the most suitable aquatic plants for specific water chemistry, we utilize the ecological preferences of species as categorized by ELLENBERG values. The software PONDANALYST, designed by the authors, assists in identifying the best-suited plants for any given mineral freshwater composition and provides recommendations for near-natural planting arrangements. A five-year monitoring program in a Portuguese tourist used swimming pond investigated the performance of plant communities and the spontaneous growth of new aquatic plant arrivals. The results demonstrate that this nature-based plant selection approach fosters resilient secondary freshwater plant ecosystems that produce exceptional recreational water quality. Originally developed for nature-based solutions in landscape architecture projects, the approach can be employed in reverse to assess prevailing water chemistry in natural habitats by identifying their dominant aquatic plant species.

Gergo Koleszar, Gyorgyi Zavanyi, Dahlia Del Castillo, Viktor Oláh, Mihaly Braun, Sándor Szabó

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Biofiltration potential and toxicity assessment of ionic gadolinium using free-floating aquatic plants: *Lemna gibba* and *Pistia stratiotes* - Oral presentation

Cumulative discharge from hospitals has introduced approximately 4500 tons of gadolinium (Gd) into surface waters in its non-toxic chelated form. Over time, these chelates may release toxic Gd^{3+} ions into aquatic ecosystems. Once discharged into aquatic ecosystems, ionic Gd can interact with other elements, potentially leading to the formation of persistent compounds that pose ecological risks. Additionally, industrial and agricultural activities could significantly contribute to the release of ionic Gd into the environment. This highlights an urgent need to investigate the toxicological impacts and bioaccumulation behaviour of ionic Gd. This study is the first to explore both the toxic effects and the potential for phytoremediation of ionic gadolinium using free-floating freshwater plants duckweed *Lemna gibba* and water lettuce *Pistia stratiotes*. These plants can rapidly absorb and accumulate various pollutants, including heavy metals and rare earth elements, from their surrounding environment. Non-toxic (EC 10% 6.3-8.9 mg Gd L^{-1}) and toxic (EC 50% 10.2-12.8 mg Gd L^{-1}) concentration thresholds for Gd were determined, and the distribution of Gd between the water and plant biomass was analyzed to establish a mass balance. The accumulation of Gd in *Lemna* tissues increased proportionally with rising Gd concentrations in the water, achieving a bioconcentration factor of up to 1294 and tissue concentrations was as high as 6.5 g kg^{-1}. Although *Lemna* removed up to 95% of Gd from the water, only 17–37% of the initial Gd was stored in the biomass, with approximately 5% persisting in the water and 60–79% forming precipitates. Under semi-static experimental conditions, *Pistia* accumulated up to 50% of the total Gd present in the medium. The Gd concentration in the roots was approximately five times higher compared to leaves. When Gd exposed plants were transferred to a Gd-free nutrient medium, they released 32 % ionic Gd from their tissue back into the water. However, from *Lemna* and from *Pistia* ash 23.2 and 25.7 g Gd per kg can be recovered. These findings indicate that free-floating aquatic plants in constructed wetlands can effectively reduce ionic Gd levels in water, making them promising candidates for both bioremediation and recovery applications.

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Viktor Oláh, Muhammad Irfan, Zsófi Sajtos, Raja Amri, Sándor Szabó, Ilona Mészáros

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Department of Biology, University of Nyíregyháza, Hungary

Duckweed turions can be used as reference biomass in monitoring water pollution - Oral presentation

Spirodela polyrhiza is a worldwide-spread duckweed species that readily forms turions. Dormant turions can be stored over longer periods and can produce new biomass rapidly upon germination. We hypothesized that this biomass could be applicable in monitoring bioavailability of inorganic pollutants in freshwaters. As a first step, we tested this hypothesis in laboratory experiments with the following aims: 1. To determine the threshold metal(loid) concentration in the medium that could be detected in *S. polyrhiza* biomass after one week-long static treatments; 2. To test if metal(loid)s were still detectable in the biomass several days after a short-term, intermittent exposure; 3. To compare bioaccumulation capabilities of different *S. polyrhiza* genotypes. The experiments were conducted according to the OECD guidelines for *Lemna* tests: Turions were germinated for 7 days in Steinberg medium containing environmentally relevant metal(loid)s. To simulate exposure to industrial effluents, we used a mixture of As(V), Cd, Cr(III) and Ni. After 1 week, we harvested the biomass and analyzed for metal(loid) content. The metal(loid) concentration series followed geometric order, and was designed to not inhibit plant growth in static treatments even at the highest step used. In intermittent exposures, the germinating turions were treated with a mixture of As(V) (0.5 mg/L), Cd (0.005 mg/L), Cr(III) (0.05 mg/L) and Ni (0.025 mg/L) for either 1 or 2 days and then transferred back to a metal-free medium for 2 days. Bioaccumulation capabilities of 7 different European *S. polyrhiza* genotypes were compared after germinating them under static conditions in the same mixture as for the intermittent exposures. Our results showed that the applied metal(oid)s were detectable in the biomass after 1 week-long static treatments with 0.001 mg/L Cd, 0.013 mg/L Cr and Ni, and 0.4 mg/L As, respectively. Above those thresholds, internal concentrations correlated linearly with the external ones. After intermittent exposures, Cd and Cr were still detectable in the biomass, but not As or Ni, revealing certain limitations of turions in biomonitoring. Different *S. polyrhiza* genotypes showed somewhat distinct metal(loid) accumulation, but the differences were moderate. Based on these results, germinating *S. polyrhiza* turions can be suitable in monitoring bioavailability of metal(loid) pollutants in surface waters. Turions even from different genotypes can provide similar results supporting comparability of such assays across different regions.

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Manli Xia, Wei Li, Yu Cao, Yongwei Zhi

Wuhan Botanical Garden, Chinese Academy of Sciences, China

Impacts of rosette and canopy macrophyte communities on water quality and aquatic plant reproduction in shallow lakes - Oral presentation

Submerged macrophyte restoration is widely used for eutrophic lakes. In shallow lakes, restoration practices typically utilize two growth forms of submerged macrophytes: rosette and canopy types. The rosette-type macrophyte, characterized by densely clustered basal leaves forming a rosette-like structure, effectively absorbs nutrients from the sediment and are suited for deeper waters. In contrast, the canopy-type macrophytes have upward-growing stems and leaves that rapidly occupy the upper water column, maximizing light utilization for photosynthesis, making them ideal for shallow areas. Despite common restoration practice of combining these two growth forms to optimize spatial niches, submerged macrophyte communities often evolve into single-growth-form-dominated communities in the later stages of restoration. The impacts of rosette-type and canopy-type macrophyte communities on the water environment and other aquatic plant remain poorly understood. Here, we conducted an in situ mesocosm experiment with three plant community backgrounds (no macrophyte, rosette-type macrophyte community (RME), and canopy-type macrophyte community (CME)) to investigate their effects on the water environment and other aquatic plants (phytoplankton, epiphytic plants and six submerged plants. We found that (1) both RME and CME significantly reduced nitrogen and phosphorus concentrations while increasing water transparency. The water pH and dissolved oxygen in CME were lower than those in RME. (2) In the CME, plant cover reached 80%, shading reduced underwater light intensity, leading to decreased phytoplankton and epiphytic algae. (3) The community background of two growth forms inhibited the growth of six submerged macrophytes. Among these, sexual reproduction of three rosette-type macrophyte (*Vallisneria natans*, *V. spinulosa*, and *Ottelia alismoides*) was significantly inhibited in the rosette-type community, making them more susceptible to community background effects than the other macrophytes (*Myriophyllum spicatum*, *Potamogeton intortifolius*, and *P. wrightii*). Our study demonstrates that both growth forms of plant communities can significantly improve water quality. However, shading by canopy-type plants reduces light intensity, affecting the growth of phytoplankton and epiphytic algae, while sexual reproduction of rosette-type plants is significantly inhibited within rosette-type communities.

Xiumei Zhang, Wei Wang

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The effects of downward transportation of lanthanum-modified bentonite on phosphorus inactivation and submerged macrophyte growth - Oral presentation

Excessive phosphorus (P) is one of the key factors causing lake eutrophication. The combination of chemical phosphorus inactivation and submerged macrophyte transplantation has gained increasing attention in the restoration of eutrophic lakes. Chemical phosphorus inactivation agents may be transported to deeper sediment due to the sediment suspension induced by wind or bioturbation. However, the effect of the downward transportation of chemical phosphorus inactivation agents on the effectiveness in internal phosphorus loading control and submerged macrophyte growth is not clear. Hence, in this study, we investigated the effect of lanthanum-modified bentonite (LMB) in combination with submerged macrophyte (*Vallisneria denseserrulata*) on phosphorus inactivation and macrophyte growth in two scenarios, including capping on the sediment surface and mixing with the sediment. The results showed that the combination of LMB and *V. denseserrulata* improved water quality in both scenarios and LMB transformed mobile phosphorus (e.g., BD-P and NaOH-IP) to recalcitrant phosphorus forms in the sediments. However, LMB inhibited the clonal reproduction of *V. denseserrulata*, and the inhibition was further aggravated when LMB was transported to the deeper sediments. The uptake of La by *V. denseserrulata* inhibited the uptake of calcium, manganese, iron, and magnesium, while promoting chlorophyll synthesis. Though LMB inhibited the growth of *V. denseserrulata*, the formation of iron plaque on the roots increased, which may promote the migration of phosphorus from the surrounding sediment to the rhizosphere, thereby reducing the release of phosphorus from sediment. Our study indicated that combining LMB with submerged macrophytes can effectively reduce P release from sediment, even in scenarios where LMB was transported downward. Hence, we recommend minimizing sediment disturbance when implementing phosphorus inactivation agents and submerged macrophytes in lake restoration efforts.

Xiaolin Zhang, Te Cao

Institute of Hydrobiology, Chinese Academy of Sciences, China

Ecological functions of submerged macrophytes diversity and a case study of restoration in eutrophic plateau shallow lake - Oral presentation

Amongst a background of anthropogenic impacts, eutrophication is still an important stress to freshwater ecosystems. It is important to understand how submerged macrophytes maintain ecological functions under increasing eutrophication stress. In the extensive field survey of 49 lakes (reservoirs) on the Yunnan-Guizhou plateau, we sampled and monitored the community structure of aquatic vegetation together with water environmental characteristics in a hierarchical strategy. Species richness, coverage, and also biomass of aquatic plants were analyzed together with functional traits of each species gathered from a well-built dataset. We found that submerged macrophyte species richness, functional diversity, and β diversity had positive effects on ecosystem functioning, even under eutrophication. Functional diversity was a stronger predictor of community biomass than species richness and β diversity, while species richness explained higher coverage variability. This suggests that species richness was a reliable indicator when valid functional traits cannot be collected. With increasing eutrophication, the mechanisms underlying biodiversity-ecosystem functioning evolved from “niche complementarity” to “selection effects”, as evidenced by decreased species turnover and increased nestedness. Based on the niche studies of submerged macrophytes, we attempted a restoration of aquatic vegetation in a seriously degraded plateau shallow lake, the Caohai Lake in Guizhou, China. This shallow lake has suffered from a rapid aquatic vegetation decline starting from 2009. Till 2021, the submerged aquatic vegetation coverage dropped to below 10%. We analyzed the reason for the vegetation decline and started restoration of submerged vegetation for an area of 7 hectares in the lake. However, the restoration pathway is not just the reverse of degradation. During the degradation, there is a positive feedback among the relationships of benthic-omnivorous fish, herbivorous fish, submerged macrophytes, turbidity and phytoplankton, which was triggered by water level and strong wind. While in restoration, the overwhelming submerged vegetation coverage and biomass were more important,and should also be accompanied by fish and turbid control measures. After 3 years of restoration works, the coverage in the restoration area reached almost 85%, and the biodiversity of aquatic plants is also much higher. We hope the case of restoration could provide some experience for reference.

Luke Huffman, Gavin Dehnert

Nelson Institute for Environmental Studies, University of Wisconsin-Madison, United States of America
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Using the asterisk survey method to examine effects on macrophyte and macroinvertebrate biodiversity in Wisconsin lakes - Oral presentation

Native macrophytes and macroinvertebrates provide invaluable services to waterbody health, yet some species can be negatively impacted by aquatic invasive species (AIS) and aquatic plant management (APM) methods. Herbicides are one of the most common management methods; however, they can sometimes lead to negative impacts on aquatic ecosystems. Therefore, we analyzed the effects of exposure to an aquatic herbicide, florpyrauxifen-benzyl, on aquatic biodiversity by measuring macrophytes and macroinvertebrates. We developed a new survey method, the Asterisk Survey Method (ASM), for rapid identification of different species presence/absence, and to optimize the collection of biodiversity with limited points. We conducted ASM surveys on three Wisconsin water bodies that had florpyrauxifen-benzyl treatments for invasive species and determined species levels pre-treatment and post-treatment over three months for two years. Our results indicate that all lakes together exhibited an increase in macrophyte biodiversity per point from pre-herbicide to post-herbicide application, and a decrease in macroinvertebrate biodiversity from year one to year two ($P<0.0001$ and $P<0.05$, respectively). We also found that the target macrophyte species (Eurasian watermilfoil and Hybrid watermilfoil) declined over time ($P<0.001$), while the following non-target species appeared more often: *Najas* spp. ($P<0.01$), *Potamogeton* spp. ($P<0.05$), and *Vallisneria americana* ($P<0.05$). Finally, locations that previously hosted the target species had significantly higher species-per-point compared to those that did not for both years, even after the herbicide reduced the target species ($P<0.0001$). Our results indicate that florpyrauxifen-benzyl can effectively reduce *Myriophyllum*, and that native macrophyte species may increase due to this reduction. This study provides crucial insight into best management practices for aquatic herbicide use and instruction for a new method of standardizable transect surveys in an ecosystem.

Małgorzata Gałczyńska, Jacek Wróbel, Adam Tański, Agata Korzececka-Orkisz, Krzysztof Formicki

West Pomeranian University of Technology in Szczecin, Poland

Multiple stress effects of static magnetic field and heavy metals on the growth of *Ceratophyllum demersum* - Poster presentation

Civilization development has an impact on aquatic ecosystems. Unused artificial fertilizers flow into waters as a result of surface runoff from agricultural fields. Industrial and municipal sewage and mine waters containing, among others, biogenic compounds and various metals are also a major problem for water reservoirs. There is also an increase in the number of various electrical devices and industrial equipment present in the aquatic environment. Currently, in the assessment of surface water quality, in addition to the concentration of physicochemical parameters, their impact on the development of living organisms, such as fish or macrophytes, is taken into account. The experiment with *Ceratophyllum demersum* collected from the environment was conducted in glass containers (approx. 20 g per container) in SIS nutrient solution (4 dm^3) under controlled conditions of temperature (20 °C) and lighting (16 h, mean PPFD values were 400 µmol m^{-2} s^{-1}). After 1 week of acclimatisation of the hornwort to new growth conditions, stress factors were applied: addition of copper ions (5 mg·dm^{-3}) and zinc (5 mg·dm^{-3}) separately, and static magnetic fields (0.3 - 0.8 mT) generated by magnets. The experiment was conducted in a randomised complete block design with six treatments: control (C), Cu stress (Cu), Zn stress (Zn), static magnetic fields stress (SMFs), Cu stress + SMFs stress (Cu + SMFs) and Zn stress + SMFs stress (Zn + SMFs), 3 replicates. The plant's response to stress factors after 7 days was assessed by measuring the mass and concentration of photosynthetic pigments in individual experimental variants. Additionally, changes in the concentration of nitrogen and phosphorus compounds in the medium, pH and electrolytic conductivity were analysed after the end of the experiment, and the content of zinc and copper in the plant was determined. It was found that both in SMFs and in C, the average value of the relative growth rate for hornwort was the same. *Cerathophyllum demersum* responded differently to the combined stress factors, i.e. in contrast to the Cu + SMFs variant, in the Zn + SMFs variant, there was virtually no decrease in biomass. Without the presence of SMFs, the greatest decrease in biomass was noted for the variant with Cu (27%) and Zn (15%). The presence of SMFs did not affect the concentration of copper in the plant. However, approximately 7-fold higher zinc concentrations were found in the hornwort in the variant without SMFs.

Welcome reception

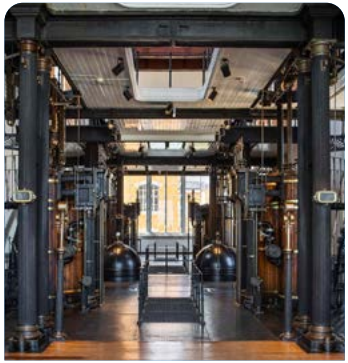
Welcome reception **Monday, 15th September**

We are pleased to be welcomed by the Water Museum for the Symposium's Welcome Reception, which will take place in its historic setting at the garden and buildings of the Barbadinhos Steam Pumping Station.

The Water Museum, held by EPAL, SA – Empresa Portuguesa das Águas Livres, is made up of four spaces scattered throughout the city of Lisbon, all of them buildings related to the supply of water to the city of Lisbon, dating from the 18th and 19th centuries: the Águas Livres (Free Waters) Aqueduct, the Mãe d'Água das Amoreiras Reservoir, the Patriarcal Reservoir and the Barbadinhos Steam Pumping Station.

In 1990 the Water Museum was awarded the Council of Europe prize and is the only Portuguese museum to hold such a distinction, which contributes to the understanding and knowledge of the European cultural heritage, as well as raising awareness of its identity.

The history of the Barbadinhos Station is closely tied to a pivotal moment in Lisbon's urban development. As the city's population grew, the existing Águas Livres (Free Waters) Aqueduct could no longer meet the increasing water demand. To address this, the Alviela Aqueduct was built between 1871 and 1880 to transport water from the Olhos de Água springs, 114 kilometres north of Lisbon. The water was stored in the Barbadinhos Reservoir, located within a former Franciscan convent that had once been occupied by the Barbadinhos religious order. To ensure efficient distribution of this new water supply, a steam pumping station was constructed next to the reservoir and began operating on 3 October 1880. This complex now forms the historic core of the Water Museum. The Barbadinhos Steam Pumping Station operated from 1880 to 1928. It currently has the former steam machines and respective pumps, wealthy testimonies of industrial archaeology. In 2010, the pumping station building was classified as a Set of Public Interest.



Excursion

Mid-Symposium Field Excursions

17/11 Wednesday

Field trip 1
River Sado freshwater and coastal vegetation

Organizers: Patrícia Rodríguez-González (Instituto Superior de Agronomia, Universidade de Lisboa, Portugal) & **Ana Caperta** (Instituto Superior de Agronomia, Universidade de Lisboa, Portugal)

This field trip will combine ecological and cultural highlights in the downstream area of the Sado river basin, located in Southern Lisbon and around one hour by car. The area is protected under Natura 2000 Network (ZPE Açude da Murta PTZPE0012 and ZPE Estuário do Sado PTZPE0011 under Birds Directive; ZEC Comporta/Costa da Galé PTCON0034 under Habitats Directive); and includes one Ramsar site (7PT007 Estuário do Sado).

We will begin our field trip by crossing the 25th of April Bridge over the Tagus River. The itinerary includes visiting representative spots of the tidal marsh vegetation communities dominated by halophyte plants (e.g., *Sarcocornia* spp., *Spartina* spp.), the freshwater wetland forests dominated by hygrophytes (e.g., *Salix atrocinerea, Thelypteris palustris*), and dune communities rich in several endemic species (e.g., *Juniperus navicularis, Thymus capitellatus, Armeria rouyana*).

During the journey, we will visit Carrasqueira, a small village beside the tidal marshes. This location includes the Palaphytic port **https://cm-alcacerdosal.pt/locais/cais-palafitico-da-carrasqueira/?lang=en,** a traditional port constructed with wood that allows access and storage of tools of the fishermen into the tidal marsh area for the culture of bivalves farming such as clams and oyster, and some of the remaining traditional marsh houses with the traditional vegetal roofs cover (made with *Scirpus lacustris/ Schoenoplectus lacustris*). The journey will also include a visit to the beach of Comporta **www.visitportugal.com/pt-pt/content/praia-da-comporta**.

Field trip 2
Paul da Goucha, a restored old lowland peatland

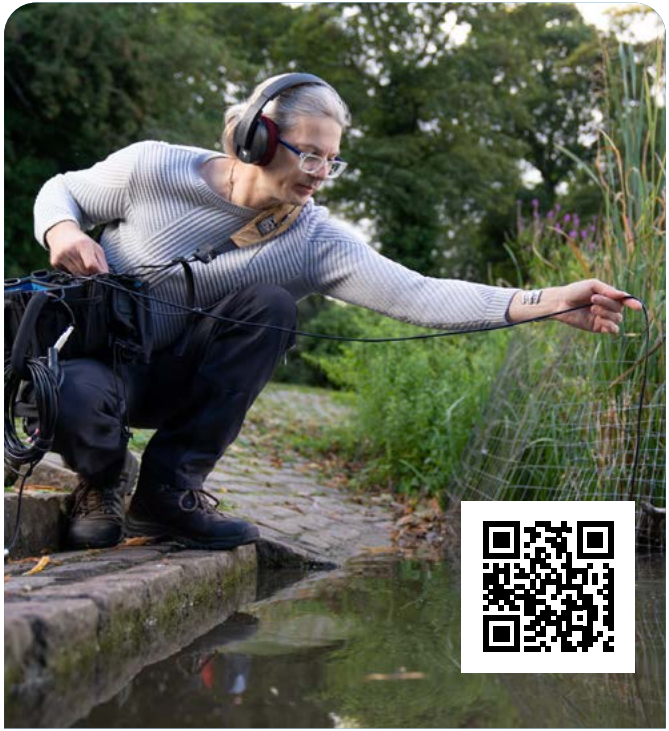
Organisers: Ana Mendes (MED - Instituto Mediterrâneo para Agricultura, Ambiente e Desenvolvimento, University of Évora, Portugal) & **Carla Pinto Cruz** (University of Évora, Portugal)

Just an hour's drive from Lisbon, this field trip takes you to a rare and unique old lowland peatland in central Portugal. Over time, the area has undergone hydrological changes, degradation, and, more recently, restoration efforts. An area of 140 hectares has been recently designated as a Local Nature Reserve and is home to one of the largest Salix atrocinerea forests in the Iberian Peninsula. It also features the 91E0 natural habitat, characterized by species such as the Iberian alder (*Alnus lusitanica*) and the ash (*Fraxinus angustifolia*). What makes Paul da Goucha unique lies beneath its soil, as in some areas we can find an exquisite 9-meter-thick layer of peat. The itinerary includes visits to key sites within freshwater wetland forests dominated by emergent plants such as *Typha latifolia, Phragmites australis, Iris pseudacorus,* and *Carex species*. It also features two restoration projects, one established 20 years ago and another currently in progress. You'll explore various restoration techniques and methods while discovering how this rare habitat persists in such southern regions of Europe.

We will start the day by visiting the Casa dos Patudos ('Web-footed House'), which was once a typical Portuguese manor house of the republican and diplomat José Relvas (who bequeathed his entire estate to the Alpiarça municipality, including an area of the Nature

Reserve), Santarém district. The field visit will begin at a viewpoint with a panoramic view of the entire reserve and the restoration project areas developed under Ripidurable (Interreg Europe) and REWET (Horizon Europe; **www.rewet-he.eu**).

There will also be the opportunity to join the Sonic Pond Dipping workshop, an arts-based approach to learning about freshwater ecosystems and acoustic ecologies **www.sonic-pond.net**. Led by underwater sound artist **David de la Haye**, the workshop invites you to listen beneath the surface of a local pond and become a citizen-scientist for the day. These small waterbodies, scattered across the landscape, contain the secret communications of amphibians, invertebrates, fish, and even plants. The recordings made during this short and informal session may contribute to ongoing ecoacoustic research. The awe and wonder of freshwater life await!



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