



9th Conference of the European Pond Conservation Network

25th-26th May – via Zoom

Abstracts

Session 1: Patterns & Processes in Pondscales – CHAIR: Matt Hill

Plenary talk: Ponds and the three Cs – cores, cows and connectivity

Nigel Willby (Biological & Environmental Sciences, University of Stirling, UK)

Connectivity and landscape scale thinking have emerged as the new mantra of nature conservation and are embodied in processes such as rewilding. Connectivity is a quintessential property of aquatic systems, being the means by which energy, materials and genetic resources move within and between hydrological units of the landscape ('hydroscape'). Though we often celebrate the isolated nature of ponds, perhaps because they lack some of the more obvious forms of connectivity of other freshwater habitats – big catchments, significant surface water inputs, or large mobile water bird populations, for example – connectivity in the broadest sense is nevertheless important, as it is everywhere. I will discuss this with reference to some of the preliminary findings of the NERC Hydroscape project which emphasise the role of human driven-connectivity and the influence of the matrix in which water bodies are located.

The title reflects the fact that connectivity has multiple dimensions and we should not lose sight of these and the influence they have on pond ecosystems. The 'cores' part of the title reflects the fact that history and legacy matters, both in terms of the basin itself, and the surrounding landscape, but also highlights the importance of connectivity to the propagule bank, especially in intermittent ponds or after restoration. However, it also suggests that connectivity to a viable propagule bank or to contemporary populations in the wider landscape cannot be ignored when setting conservation objectives; without connectivity the past is not a guide to the future.

Dynamic processes, in which large herbivores (sometimes 'cows', possibly *Castor*) and management play a critical part, are also of more fundamental importance in small water bodies like ponds, which live and die by the sword of disturbance or the lack of it. Apart from being potent drivers of biodiversity and heterogeneity these processes introduce a component of local scale connectivity, both between ponds or other water bodies, and between ponds and their matrix, that is often overlooked.

Quantity, quality or connectivity; what matters most for freshwater biodiversity?

Alan Law (University of Stirling, UK)

Freshwaters are among the most globally threatened habitats and their biodiversity is declining at an unparalleled rate. In an attempt to understand this decline, studies have observed the effects of drivers at local and landscape scales. However, despite it being a fundamental component of freshwater ecosystems the effect of connectivity amongst waterbodies, and its potential interaction with stressors, is often overlooked.

In this talk we present the findings from an analysis of data on macrophytes, molluscs, beetles and odonates collected from 154 standing water bodies ranging from small ponds to large lakes nested in three contrasting landscapes in the UK; urban, upland and lowland agricultural, undertaken as part of the NERC Hydroscape project.

We consider numbers of species, rare species and invasive species as responses and then compare the sensitivity of these responses to area and other predictors, including a suite of novel connectivity metrics, across taxa and landscapes.

The mobile odonates and beetles were typically most diverse in small ponds. In contrast, richness of the more sedentary molluscs, and, to a lesser extent, macrophytes, increased with area, highlighting the importance for these taxa of habitat heterogeneity and opportunities for dispersal via hydrological processes and human or avian vectors. Consistent with this finding, invasive species were twice as frequent in lakes compared to ponds.

Our models highlight the need to consider mobility characteristics of focal taxa and stressor characteristics of focal landscapes when exploring such drivers of freshwater biodiversity, and suggest that there are constraints on generalising basic relationships across landscapes and taxonomic groups.

Rigorous rockpool recolonisation, or hitting rock bottom?

Andrea Francesca Bellia (University of Malta, Malta)

The aim of this study was to characterise recolonisation processes in temporary freshwater rockpools (TFR). Two pools were selected for this study, one of which had anoxic sediment. The experiment began with the removal, sterilization and replacement of sediment. The pools selected for this study were subsequently left undisturbed, allowing natural recolonisation processes to take place.

Both pools were monitored regularly for one wet season from September 2019 to February 2020. The communities in the two experimental pools were compared with those of nearby 'undisturbed' pools, and with the previous state of the pools prior to the start of the experiment. Within one week, both pools were colonised by ostracods and fairy shrimps, with the occurrence of a clam shrimp in one pool in the third week. Plant life was observed by the second week, although further colonisation occurred throughout the wet season.

Plant biomass and coverage towards the end of the wet season did not differ significantly across the 'anoxic', 'non-anoxic' and 'undisturbed' pools'. However, undisturbed pools had a higher floral species richness, presumably due to the storage effect of the sediment. Since no seed bank was present in the recolonised pools due to sterilization, any floral growth was due to incoming dispersal. Flora and fauna observed after recolonisation were subsequently compared with previous data for the pools monitored.

What determines the mollusc diversity in the isolated karstic lakes of central Albania?

Erika Lorencová (Masaryk University, Czech Republic)

Lakes and ponds in the Mediterranean karstic areas represent unique refugia for many species of stagnant waters. Although these ecosystems have faced notable degradation and eutrophication during the last few decades, only little is known about their malacofauna and the possible effect of these negative changes on molluscs. Therefore, we quantitatively sampled mollusc assemblages at 40 standing water bodies within a compact karstic area of central Albania. Besides, we also measured 35 environmental variables that may affect the studied mollusc communities. In total, we found only nine species of widely distributed mollusc species, including three non-native ones. The sites hosted notably species-poor assemblages, ranging between 0 and 6 species, with almost a half of the studied sites being mollusc free. The presence of molluscs was positively affected by the amount of littoral vegetation, the reed cover, fine organic material, and high-water transparency. By using the regression tree method, 40% of the total variability of species richness was explained. The species richness was driven mainly by the reed cover and the length of the shoreline. Water transparency and lake surface area explained 12.4% of the total assemblage composition variance. Our results showed that limited development of different types of littoral vegetation, changes of the landscape management during the second half of the 20th century, and natural isolation of sites, can be concluded as the major drivers for mollusc species presence and distribution in the studied network of isolated karstic lakes.

Water balance of ponds and a growing agglomeration: an example from Gdańsk, Poland

Włodzimierz Golus (University of Gdańsk, Poland)

Due to their small sizes, ponds are particularly vulnerable to growing landuse pressures and environmental change. Recently, climate change has also strongly affected small water bodies, depriving them of the previously certain fluxes of water. The terrain surrounding Gdańsk, Poland, represents a typical postglacial landscape characterised by ubiquitous small water bodies located on a moraine plateau. The environment there undergoes rapid modifications for city development. Over the last 10 years, pondscape, which has been part of the semi-natural mosaic of farmland and forest, has become restructured into a fast-growing suburban tissue. The water balance of ponds is affected by the dynamic changes in their catchments, the increased danger of drought and the global warming. A typical moraine pond is a permanent water body that is usually connected to small streams during the snowmelt season. In this period, its water balance is based on streamwater outflow and groundwater inflow. These fluxes prevail in winter and spring, whereas in summer and autumn, streams tend to dry out and the water balance is largely determined by precipitation, evaporation and groundwater inflow. While ponds in the suburbs are strongly affected by humans, little change to the components of water balance has been observed. Considerable and surprising changes have, however, been observed in ponds in the semi-natural landscape where drainage works have been done in the past to construct a bypass of Gdańsk. These water bodies are connected to a stream, as a result of which surplus water is easily drained from them. Additionally, the draught that occurred in the summer and autumn of 2018 resulted in the drying out of some formerly permanent ponds.

Pond insect responses to drought in the Cape Floristic Region, South Africa

Charl Deacon (Stellenbosch University, South Africa)

The Cape Floristic Region at the southern tip of Africa has recently experienced one of the most severe hydrological droughts on record. Droughts place substantial ecological pressure on freshwater species and the habitats they occupy. Due to their short generation times, high mobility and variable responses to ecological change, aquatic insects provide important information regarding the impacts of hydrological extremes. Using natural and artificial ponds, and a complement of aquatic insects, we investigated the effects of drought on aquatic communities, and whether artificial ponds play an additional role in maintaining aquatic insect populations. We found marginal vegetation cover as a primary driver of insect species richness, diversity and composition. Some physicochemical properties played an additional role in shaping local insect communities. Species shared between natural and artificial ponds were fewer compared to another biodiversity hotspot in South Africa, but interestingly, species only ever recorded from rivers were found to occupy artificial ponds during drought. Comparing our results to other pre-drought studies on aquatic insects in the region, we found that drought had little impact on overall species richness, despite immense water level fluctuation in most cases. Yet, overall insect abundance was substantially lower during drought, indicating that the taxa investigated here occupy artificial ponds at low density, which enables their survival into the next wet season. To ensure conservation of a range of aquatic insects, we recommend that a variety of ponds should be maintained, so to represent regional habitat heterogeneity and provide ecological resilience during extreme weather events.

Effects of landscape connectivity on movement and survival of a pond-dwelling freshwater turtle

Pedro Segurado (Universidade de Lisboa, Portugal)

Connectivity is a key landscape property affecting the persistence of populations occupying patchy habitats. When individuals need to cross hostile matrix among suitable habitats, landscape connectivity may be a critical limiting factor by influencing survival rates. This hypothesis has been rarely tested. We addressed this topic in a study of a population of European pond turtle, *Emys orbicularis*, inhabiting a temporary pond network in SW Portugal. The area has been subjected to agricultural intensification, along with a drastic reduction in the number of temporary ponds. We carried out a long term capture-recapture programme encompassing a drier period (2003-2005) and a wetter period (2010–2014). We computed connectivity metrics for each pond and leastcost path distances among ponds using a resistance surface. Multistate capture-recapture modelling was then used to assess how inter-pond movements and survival were related to landscape connectivity metrics, sex, age class, and the period (dry/wet). We captured a total of 221 pond turtles (89 juveniles, 58 females and 74 males). Survival was higher at ponds with higher connectivity measures, and this effect was more pronounced in juveniles. The probability of inter-pond movements decreased asymptotically with least cost distances, and tended to be higher during the dry period. Our findings confirmed the expected effects of landscape connectivity on both movement and survival rates of this patchy population. These results will be important to guide management actions for the conservation of European pond turtle populations in SW Portugal, especially to prioritise pond restoration aiming at maximising network connectivity.

Session 2: Advances in Pond Monitoring – CHAIR: Helen Greaves

Plenary talk: High resolution remote sensing as chance for efficient research and monitoring of ponds and pondscapes

Marlene Pätzig (Leibniz-Centre for Agricultural Landscape Research (ZALF) e.V., Germany)

For a long time, small water bodies have been described as hotspots of biodiversity, representing valuable habitats especially in agricultural landscapes. In recent years, research has also increasingly focused on their importance for biogeochemical processes and their ecosystem services. Although knowledge about small water bodies has increased, there is a lack of upscaling of knowledge from field studies to larger spatial scales on the one hand, and the establishment of methods to obtain comprehensive information about small water bodies on the other hand. There are a number of modern methods that are promising for more efficient research and environmental monitoring of small waters, especially when combined. The technical developments in remote sensing represent a special potential. In this plenary talk I will present the advantages of unmanned aerial systems (UAS) for the investigation of small water bodies and give an outlook on the chances that have arisen with the latest satellite technologies for small water bodies. In doing so, I will exemplify my own work on vegetation detection, biomass determination and hydrological characteristics of small water bodies, which has been developed in cooperation with experienced colleagues in remote sensing and photogrammetry.

Improving the detectability of Dragonflies species in alpine ponds: with larvae, exuviae, adults or metabarcoding from environmental DNA?

Marie Lamouille-Hébert (HEPIA, HES-SO, Switzerland)

Current climate change has a strong impact on species distribution, especially in mountains where the species are pushed toward higher altitudes, in areas where they might be trapped by a lower habitat availability. To study these ongoing changes, we need to survey these species and to map their present distribution. This can nevertheless be a problematic task, for groups with a low detectability as boreo-alpine dragonfly species (Odonata). Our study took place in the Western Alps, in the region of Chamonix (France). We visited 125 wetlands on a 193 km² area situated above 1900 masl in 2017, 2018 and 2019. We assessed the presence of different species of dragonflies by combining several detection methods. Three methods focused on the detectability of the different life stages of the dragonflies: larvae, exuviae and adults. To improve the detectability we also used the metabarcoding of the free environmental DNA (eDNA) found in the water in a subset of 36 wetlands. Dragonflies have been detected in 43% of the 125 wetlands, and were represented by six species. Their presence has been highlighted by the exuviae (in 56% of the occupied sites), larvae (76%) and adults (74%). In 22 out of the 36 sites of the subset, we detected dragonflies with at least one of the four methods: the presence of dragonflies has been highlighted by metabarcoding in 14 sites, by exuviae in 12, by larvae in 18 and by adults in 17 sites, respectively. Discrepancies were evidenced, depending the method put into action. Several false negative records were obtained with all methods. Our study demonstrates that the four methods are complementary in order to improve the detectability of the six target species. The methodology linked with eDNA has nevertheless still to be improved to increase the detectability of the dragonflies.

Developments in environmental DNA (eDNA) monitoring approaches to inform non-native pond conservation management decisions – Practicing Professional

Phil Davison (Centre for Environment, Fisheries and Aquaculture Science (Cefas), UK)

Following its initial use to detect non-native and native amphibians, environmental DNA (eDNA) survey methods have shown considerable potential for monitoring pond communities. This communication will review the use of eDNA in pond conservation, with particular relevance to the use of eDNA to determine whether or not potentially invasive NN fishes are present, so as to inform management measures to eradicate invasive species. This type of application of eDNA methods requires a very high level of confidence in the demonstration of presence or absence, thus indicating the need, or not, for eradication measures. To achieve this high confidence level, a new highly-sensitive, nested-PCR analytical protocol was developed to assess the efficacy of operations to eradicate topmouth gudgeon *Pseudorasbora parva* from ponds in the London area. The nested-PCR analysis of water samples for eDNA of topmouth gudgeon was compared with conventional sampling surveys undertaken post-eradication in angling ponds at a commercial fishery in Kent and in an experimental study of ponds of various sizes in Hertfordshire. Additionally, this approach was used to applied in ornamental ponds of a park in London in order to determine whether or not any topmouth gudgeon survived the management operations to eradicate the species. The results of these studies will be discussed with regard to the potential applicability of eDNA methods as a monitoring and decision-support tool that can be used in combination with traditional sampling methods in the management of ponds in general, and of biodiversity conservation in particular.

Ecoacoustics: A novel tool for assessing pond restoration success?

Jack Greenhalgh (University of Bristol, UK)

Ecoacoustics is increasingly being used to monitor species populations and to estimate biodiversity in marine ecosystems, but the underwater soundscapes of freshwater environments remain largely unexplored in this respect. Few studies exist concerning the acoustic diversity of ponds but because many arthropods, such as Coleoptera and Hemiptera, are known to produce sound by stridulation, there is potential to use ecoacoustic techniques to monitor changes to biodiversity and conservation value.

This study compares the underwater soundscapes of recently restored open-canopy ponds and unmanaged highly terrestrialised ponds in an arable agricultural landscape of North Norfolk, UK in order to assess the benefits of farmland pond restoration. In addition, the stridulations of three diving beetle species (Dytiscidae) were recorded in tank studies to document local acoustic diversity. Six acoustic indices were also calculated to assess soundscape biodiversity.

Sound richness and stridulation abundance were significantly higher in the restored ponds compared to the highly terrestrialised ponds. Acoustic indices ACI, AR, AEI and BI were shown to positively correlate with both sound types richness and stridulation abundance. The index NDSI was positively correlated with stridulation abundance, but negatively correlated with sound type richness. The index ADI was negatively correlated with both sound type richness and abundance.

The three Dytiscid water beetle species recorded in a tank were found to produce distinctive and recognisable sounds, indicating potential to create an audio reference library that could be created and used for the automatic acoustic monitoring of freshwater arthropods.

Pond soundscapes are rich in biological information and this study suggests that automated passive ecoacoustic monitoring could be an effective non-invasive monitoring technique for assessing conservation value and restoration success.

Species monitoring of ponds in Flanders: Odonata as an example

Geert De Knijf (Research Institute for Nature and Forest, Belgium)

Every six years, European member states have to report on the conservation status of Natura 2000 species in the framework of the Habitats Directive. This reporting should be based on statistically sound data and should be able to detect a population decline of about one quarter within a period of 24 years. Moreover, the Flemish Government mandates to monitor additional species which are considered to be of regional importance and evaluate the policy measures taken for their benefit at a regional level. To assess the population status and trend of aquatic animal species (amphibians, molluscs, fish and for ten species of dragonflies) in Flanders (northern Belgium), standardised monitoring schemes were developed. Sampling strategy and basic field methodology are described in several protocol documents. Transect or site counts of dragonflies are made by trained volunteers and started in 2016. For the rarest species, with less than 30 populations, all sites are monitored. For the more widespread species, a statistical (GRTS) approach is used to select localities in order to obtain a spatially balanced sample across the Flemish region. We present the framework, the different methodologies and give the results of the first four years of monitoring for dragonflies confined to lentic aquatic habitats.

Generating and testing ecological hypotheses at the pondscape with environmental DNA metabarcoding: a case study on a threatened amphibian

Lynsey Harper (University of Illinois at Urbana-Champaign, USA)

Environmental DNA (eDNA) metabarcoding is revolutionising biodiversity monitoring, but has unrealised potential for ecological hypothesis generation and testing. We validate this potential using vertebrate community data generated by eDNA metabarcoding of 532 UK ponds. We test biotic associations between the threatened great crested newt (*Triturus cristatus*) and other vertebrates, and abiotic factors influencing *T. cristatus* detection at the pondscape. Furthermore, we test the status of *T. cristatus* as an umbrella species for pond conservation by assessing whether vertebrate species richness is greater in ponds with *T. cristatus* and higher *T. cristatus* Habitat Suitability Index (HSI) scores. *T. cristatus* detection was positively correlated with amphibian and waterfowl species richness. Specifically, *T. cristatus* was positively associated with smooth newt (*Lissotriton vulgaris*), common coot (*Fulica atra*), and common moorhen (*Gallinula chloropus*), but negatively associated with common toad (*Bufo bufo*), common carp (*Cyprinus carpio*), three-spined stickleback (*Gasterosteus aculeatus*) and ninespine stickleback (*Pungitius pungitius*). *T. cristatus* detection was negatively correlated with mammal species richness, and *T. cristatus* was negatively associated with grey squirrel (*Sciurus carolinensis*). *T. cristatus* detection was negatively correlated with larger pond area, presence of inflow, and higher percentage of shading, but positively correlated with HSI score, supporting its application to *T. cristatus* survey. Vertebrate species richness was significantly higher in *T. cristatus* ponds and broadly increased as *T. cristatus* HSI scores increased. We reaffirm factors reported to influence *T. cristatus* detection, but also provide novel insights. Our findings demonstrate the prospects of eDNA metabarcoding for ecological hypothesis testing at the pondscape.

Faecal pollution hotspots in urban lakes and ponds: causes of high spatial heterogeneity

Zarah Pattison (Newcastle University, UK)

Faecal pollution is an overlooked but potentially common stressor in waterbodies, particularly in urban environments. Concentrations of waterborne faecal indicator organisms (FIOs), e.g. *E. coli* and intestinal enterococci, which together with microbial pathogens such as *Campylobacter* spp., can provide a measure of faecal pollution. The extent of microbial pollution depends upon surrounding land-use, coupled with the potential for physical (e.g. hydrological run-off) and biological transfer (e.g. waterfowl input). Restoration of freshwater environments often focuses on increasing connectivity between waterbodies however, the implications of the spatial variance of FIO concentrations within and between lakes and ponds, in relation to connectivity and stressors, is still largely unknown.

To assess the spatial variation of FIOs in waterbodies, ~1000 sediment cores and overlying water samples were taken during the winter across 15 lakes and ponds. Waterbody size varied from 0.5 - 89 ha, and included a range of surrounding land-uses and degrees of connectivity. FIO concentrations were generally highest in areas of increased bird activity and areas vulnerable to overland flow from agricultural land or sewage overflow. However, some hotspots had no obvious local source point. High spatial resolution data such as this also offers the potential for 'spatial risk maps'. In shallow waterbodies with greater public use, the opportunity for resuspension of FIOs and pathogens from the sediment may increase. Focusing on the origins of these hotspots within the sediment can inform management actions vital for public health and identify potential exposure routes.

Session 3: Urban and artificial ponds – CHAIR: Richard Walton

Plenary talk: Urban ponds and their multiple ecosystem services: is biodiversity forgotten?

Beat Oertli (University of Applied Sciences and Arts Western Switzerland, , Switzerland)

The density of ponds is often high in the urban matrix. These artificial waterbodies are either created for their landscape value (parks, gardens), for their potential to reduce the risk of flooding, for their capacity to purify water, for their offer of leisure activities (as fishing, swimming, boating), or for their contribution to well-being of walkers (microclimate, contact with nature). The nature contributions to people offered by this blue network are today taking an increasing value, especially in the context of climate change. Fresher areas are procured during summer heatwaves, and sudden storm flooding events can be buffered by ponds. Nevertheless, their supply of habitats for biodiversity often takes a back seat. Biodiversity potential is however present and has been frequently demonstrated. Furthermore, appropriate, inexpensive management would easily make it possible to increase the biodiversity, for the benefit of citizens. For example, the design, and particularly a vegetated shoreline can effortlessly be promoted, without impeding the provided services. New pond creation in the urban matrix is sometimes hindered by potential issues such as the drowning risk, the presence of biting insects, or of exotic species. But here also appropriate management can easily reduce these potential problems. A densification of the urban blue network is therefore an achievable goal, and small ponds can easily find a place between buildings, green spaces, and even fallow land. These Nature-based Solutions will contribute to our adaptation to climate warming in the cities, also providing a chance for biodiversity.

Garden pond diversity: opportunities for urban freshwater conservation

Matt Hill (University of Huddersfield, UK)

Urbanisation is increasing globally, degrading terrestrial and freshwater habitats and reducing faunal and floral richness. Whilst the potential for garden ponds to serve as important biodiversity resources in urban areas has been documented, quantifying the contribution of garden ponds to urban freshwater diversity has been largely neglected. This study aims to quantify the taxonomic richness, community composition and conservation value of aquatic macroinvertebrates in domestic garden and non-urban ponds. Taxonomic richness was significantly lower in garden ponds than non-urban ponds at an alpha and gamma scale. A greater richness of Odonata, Coleoptera, Gastropoda and Hemiptera were recorded in non-urban ponds. Garden ponds were found to support compositionally different macroinvertebrate communities compared to non-urban ponds, influenced by variation in water depth and conductivity. A total of 30 taxa were recorded from garden ponds only. Non-urban ponds were of a significantly higher conservation value compared to garden ponds (87% of garden ponds were of low or moderate conservation value, while only 35% of non-urban ponds were in these categories). Although urban garden ponds currently support a limited macroinvertebrate diversity and have reduced conservation value, they do contribute to the regional species pool and their potential to limit future urban biodiversity loss is significant. Given their high abundance and popularity within the urban landscape, clear guidance is required for pond-owners on how to best manage garden ponds to support and sustain biodiversity. For this to be achieved, greater research is required to increase fundamental understanding of urban pond ecology, and the development of evidence led garden pond management practices.

Pondlife: documenting the unicellular life of New York City

Sally Waring (Earlham Institute, UK)

I'm a research scientist and filmmaker who has been documenting and studying microbial eukaryotes for the past five years. In 2015 I started a project called Pondlife (www.pondlifepondlife.com) that documents the microbes living in the urban ponds in New York City. Using a camera attached to a microscope, I was able to capture the behaviours and beauty of the city's microbial life to share with a general audience. I have just relocated to the United Kingdom to work on a project sequencing the genomes of eukaryotic microbes in the United Kingdom, and am keen to continue my documentary work alongside my research endeavours. My talk will showcase some of my film and documentary projects aimed at getting general audiences excited about microbial life, particularly in urban settings.

Artificial ponds can contribute to regional biodiversity conservation

Jose Manuel Zamora Marín (University of Murcia, Spain)

Artificial ponds are increasingly created around the world for a wide array of human purposes, rarely considering nature conservation. Knowing the potential of different types of artificial ponds for supporting freshwater biodiversity is a keystone to improve their design and management in face of the future human-dominated landscapes. We explored five different types of artificial ponds for their species diversity (alpha and beta richness; for gamma richness, see Part 2 of this communication) of three animal groups contrasting in their ecology: amphibians, freshwater beetles and snails. For that purpose, we used biodiversity data of artificial ponds located in Switzerland, France and Spain, including 38 gravel pit ponds (GP), 22 mountain watering ponds (MWP), 102 urban ponds (UP), 83 fishponds (FP) and 38 semi-arid watering ponds (SWP). We compared also selected pond types (GP, MWP and UP) with natural ponds located on the same region. Our results reveal that GP supported a high alpha richness, probably due to their natural pond features. On the other hand, natural ponds always held a significantly higher species richness than artificial ponds, particularly for freshwater snails. The invertebrate communities of both artificial and natural ponds were represented by a few common species, widely distributed, and by several rare species which occur in a small proportion of ponds. This aspect was also supported by the high levels of spatial turnover, which dominated the variation in species composition (beta-diversity). If well designed and managed, artificial ponds can make a great contribution to freshwater biodiversity.

Sound of the suburbs: exploring riparian soundscapes and conservation value of urban ponds

Rob Briers (Edinburgh Napier University, UK)

In comparison to the extensive work in marine ecosystems, understanding of the characteristics of the sound environment (soundscape) of freshwater ecosystems is relatively limited. Natural freshwater soundscapes are rich, but are also becoming increasingly dominated by anthropogenic sources in many areas. Characterising links between soundscapes and freshwater ecosystem health is an important area for research.

Ponds play a key role in supporting freshwater biodiversity in urban areas and such features are exposed to noise from the surrounding environment. Transmission of noise into the aquatic environment may have important direct effects on the organisms present. However, the characteristics of the riparian soundscape around sites may also reflect human pressures on freshwater environments and hence give an indirect indication of their status and potential value for conservation.

Using data derived from recordings from a series of urban pond sites in central Scotland here I explore the links between characteristics of the riparian soundscape and the biological diversity of invertebrate communities they support as a first step towards evaluating the potential of such data to act as an indicator of the biodiversity value of urban ponds and discuss areas for development.

Urban ponds and their multiple ecosystem services: is biodiversity also taken into account?

Marine Decrey, Eliane Demierre, Marie Meilland, Peter Gallinelli, Beat Oertli (HEPIA, HES-SO, University of Applied Sciences and Arts Western Switzerland, Switzerland)

Urban ponds are common in most cities. Their creation and their management are mostly linked to a single purpose such as aesthetic value, stormwater retention or recreation. Urban ponds could nevertheless provide several additional ecosystem services contributing to a better well-being of the population.

We took the example of Geneva to investigate urban ponds and their ecosystem services, in three steps: (i) inventory of ponds, with identification of the ecosystem services targeted by managers, (ii) enquiry in public parks to identify the expectation of citizens towards urban ponds, (iii) quantification of five ecosystem services (cooling of the microclimate, water purification, stormwater retention, habitats for biodiversity and carbon sequestration) in a selection of urban water bodies.

Our study evidenced that most urban ponds in Geneva were created and are managed for their aesthetic value. Other ecosystem services are less targeted. The survey evidenced that citizens recognize ponds as elements promoting their well-being. The aesthetic value and the refuge for biodiversity are the two most important ecosystem services mentioned by the public. They also expressed their preference for “natural and wild” ponds compared to artificial ponds.

The first results of the ecosystem services quantification demonstrate that Geneva's urban ponds aren't biodiversity hot spots. Climatic analysis showed that the thermal comfort is improved above the water body. Urban ponds also have a capacity to store a high amount of carbon especially through emergent plants (reeds, cattails and rushes). The ecosystem services of these ponds could nevertheless be easily enhanced through an adapted management.

Diving beetle (Coleoptera: Dytiscidae) diversity decreases with increasing urbanisation

Wenfei Liao, Stephen Venn, Jari Niemelä (University of Helsinki, Finland)

Blue infrastructure is a vital component of urban green infrastructure, which supports unique biodiversity in urban landscapes. Urban ponds, as part of urban blue, can harbour a wide range of aquatic macroinvertebrates. As yet, it is not clear how urban development affects macroinvertebrate diversity. Here, we use diving beetles (Dytiscidae), an indicator taxon of wetland biodiversity, to investigate how increasing urbanisation affects their diversity. We sampled dytiscids using 1-L activity traps in 11 ponds with fish and 14 ponds without fish, at ten sites in Helsinki, Finland. We extracted the percentage of impermeable surface in the pond surroundings within a radius of 500 m, as an indicator of how urbanized the pond surroundings were. We found that dytiscid species richness decreases with increasing impermeable surface, both in ponds with and without fish. Most dytiscid species become established in ponds with a level of urbanisation less than 36%, while good disperser species, such as *Agabus sturmii*,

seem to have adapted well to urban landscapes. Dytiscids have 80% higher species richness and 79% more individuals in fishless ponds than in ponds with fish, and medium to large-sized dytiscid species are more capable of coexisting with fish than small-sized species. Urban wetlands can support a diversity of dytiscids at the regional level, and the presence of fishless ponds can benefit the diversity of dytiscids and other fish-intolerant aquatic invertebrates. We recommend maintaining a diverse range of ponds and aquatic habitats to support aquatic biodiversity in urban regions.

Session 4: Pond conservation and management – CHAIR: Alan Law

Plenary talk: Making and managing ponds to protect freshwater biodiversity

Jeremy Biggs (Freshwater Habitats Trust, UK)

Ponds have long been both popular and misunderstood! They are a globally abundant freshwater habitat, inherently natural although often made by people. Until recently they have been largely ignored by science and policy makers.

In this presentation I want to briefly summarise how knowledge of the importance of ponds for biodiversity has grown over the last 25 years, and how protecting, making and managing ponds can play a major role in protecting freshwater biodiversity more widely.

Understanding the naturalness of ponds is essential to understand their ecology and management. Like all freshwaters, pond biodiversity is greatest where there is clean water – that is water that replicates natural conditions. However, ponds are also unusual amongst freshwater habits – they are enormously varied not just in their physico-chemical and hydrological characteristics – but also in their dynamism and longevity.

In all the modern landscapes where Freshwater Habitats Trust has looked, ponds have collectively supported a wider variety of plants and animals than other freshwaters, and more uncommon species, justifying the simplification - often needed by policy maker and practitioners - that ‘ponds support more species than other freshwaters’. The reason is partly their ubiquity and heterogeneity, but also because their small catchments mean that, in most landscapes, some ponds have clean water - now one of the scarcest natural resources in many parts of the world.

Our evidence is that protecting ponds is one of the cheapest and most effective tools for maintaining freshwater life in the landscape. Making new ponds is particularly valuable because it simulates ancient processes that have created ponds for millennia, and critically, because it can also add new clean water to landscapes.

Freshwaters are already amongst the most threatened habitats worldwide. At a time when climate change is set to further disrupt freshwater ecosystems on a massive scale, the not so humble pond is one of the few bright spots on the horizon: a habitat which can help us mitigate and adapt to climate impacts and protect freshwater biodiversity.

Once a pond in time: palaeoecological analysis of pond sediment aids in conservation efforts

Richard Walton (UCL/Newcastle University, UK)

Restoring highly terrestrialised farmland ponds combines the removal of woody vegetation and pond sediment and has been found to greatly enhance aquatic biodiversity. Many questions remain, however, regarding the historical precedent of pond restoration, and whether post-restoration aquatic communities resemble pre-terrestrialisation assemblages. Using a palaeoecological approach, sediments from a typical marl pit pond in North Norfolk, Eastern England, were analysed for changes to ecological structure throughout time and to compare aquatic plant communities found before and after restoration of the pond, using contemporary vegetation survey data, with plants and conditions found in the macrofossil record. Macrofossil evidence demonstrates that farmland ponds have a long history of undergoing canopy management. Abandonment of such management practices in the 1950s-1960s resulted in uninterrupted terrestrialisation. Furthermore, macrophyte communities arising after restoration of the pond exhibited

some resemblance to historical assemblages, but also contained some apparently new species, whilst some other aquatic plants now rare in the landscape did not return. As such, using palaeolimnological methods improves not only our understanding of the ecological history of ponds in agriculturally-intensive landscapes, but may also be a useful tool for informing restoration targets and practices for pond conservation.

The Normandy's action programme for ponds conservation (PRAM): knowledge enhancement, actions in the field and partnership with local stakeholders

Coraline Domingues (Le Conservatoire d'espaces naturels de Normandie, France)

Labelled by the French government and the Normandy region, the natural spaces Conservatory of Normandy is a non-profit association that protects, manages and promotes more than 200 natural spaces. The Conservatory also supports national and local environmental policies. The Conservatory runs several regional programmes, including the regional action programme in favour of ponds, since 2006: 750 listed species, 14 000 diagnosed ponds and 500 restored ponds.

Awareness of the need to protect these environments has gradually emerged among several stakeholders (intercommunal structures, local associations, ...). Many actions in favour of ponds were tried out. The stakeholders worked more or less concertedly with different specific objectives. By contrast, other territories did not have action plan.

The need to coordinate actions, to mobilise local stakeholders and to improve knowledge on ponds required the implementation of a regional action programme.

A three-year regional strategy was drawn up for the period 2019 to 2021:

- Axis 1: To develop, to animate and to support the network of stakeholders
- Axis 2: To maintain and to restore ponds networks
- Axis 3: To acquire, to organise and to share knowledge on ponds

Sharing our experiences, methods, tools, accomplishments and failures with the European community of ponds stakeholders is the ambition of our oral presentation.

This will be our first opportunity to present our 10 years of commitment to the preservation of ponds, to meet our European counterparts and possibly develop transnational European projects.

“Variety is the Spice of Life”: restoring farmland ponds enhances landscape-scale aquatic diversity

Ben Siggery (Surrey Wildlife Trust, UK)

1. In agricultural landscapes ponds act as biodiversity hotspots within an otherwise species poor matrix. However, due to a decline in their traditional uses over the last 30-40 years, farmland pond landscapes in lowland UK have become overwhelmingly dominated by highly terrestrialised “late-succession” ponds, with open-canopy, macrophyte-dominated ponds relatively rare.
2. With the aim of increasing landscape-scale diversity, recent conservation movements have advocated restoration of late succession ponds to increase pondscape heterogeneity. There are, however, relatively few studies documenting the responses of farmland ponds to restoration interventions that have been undertaken in real-time and at the landscape scale.
3. In a Before-After Control-Impact study of ponds on a farm in Norfolk, eastern England, we investigated

short-term (2-3 years) responses of pond macrophytes, water beetles and amphibians to restoration by major removal of woody vegetation and sediment.

4. Major and significant increases in alpha and gamma diversity were observed following pond restoration. Species losses from the landscape were minimal whereas gains were substantial including several species of high conservation concern.
5. The study provides insights into early successional dynamics amongst restored ponds with a clear early (years 1-2 post-restoration) dominance of charophyte meadows and subsequent dominance of submerged plants such as *Ceratophyllum submersum* and *Potamogeton* species, as well as more prolific stands of emergent plants.
6. Our study clearly demonstrated that, through disturbance-initiated increases in pond landscape heterogeneity and in particular increased prevalence of aquatic macrophytes, pond restoration has major benefits for aquatic biodiversity in a relatively short amount of time.

Abiotic and anthropogenic effects on macroinvertebrate biodiversity in an agricultural pondscape

Camille Musseau (Freie Universität Berlin, Germany)

Kettle holes are small water bodies and remnants of the last glacial period. Abundant in young moraine landscapes of northern Europe, their density can reach 40 per km² in Northeast Germany where they are mostly distributed in agricultural landscapes and represent up to 5% of the arable land. Embedded in a rather homogeneous agricultural matrix, kettle holes are biodiversity hotspots, greatly threatened by intensive agriculture.

In this study, we aimed at understanding the effects of land use, physico-chemical parameters, hydroperiod and riparian vegetation on macroinvertebrate diversity and species coexistence. In total, we sampled 42 macroinvertebrate communities in the Uckermark region, which host a substantial number of kettle holes in Northern Germany. Our results showed that 1) alpha-diversity in those ecosystems responds to the combined effects of land use, canopy cover and hydroperiod, and 2) beta-diversity is strongly influenced by land use, fertilizers and canopy cover. These results highlight the roles of agricultural stressors in structuring macroinvertebrate communities living in small water bodies both at local and landscape scales. We will discuss the consequences of such impacts on the functional diversity and the associated ecosystem functions provided by these communities.

Already suffering from dramatic damages imposed by increasing human disturbances, small freshwater systems in agricultural landscapes challenge the scientific community to find a compromise between human demands and nature conservation.

Patterns of amphibian abundance and species richness in temporary ponds in agricultural landscapes

Janusz Kloskowski (University of Life Sciences, Poland)

Temporary and semi-permanent ponds, which are a critical habitat for amphibians in temperate European regions, have widely declined in numbers in recent years mainly due to agricultural intensification and climate change. In 2017-2018 we surveyed 91 natural open-canopy ponds in arable fields in western and eastern Poland for larval amphibian richness and abundance. No differences in species richness and occurrence patterns were found between the two regions. Landscape variables associated with land use strongly influenced amphibian diversity and abundance. The presence of fish in the ponds adversely affected amphibian richness. *Pelobates fuscus*, *Lissotriton vulgaris*, *Rana* sp. and *Pelophylax* sp. were the species most frequently occurring in the ponds. A large portion of the ponds dried up before the end of

June, this leading to considerable larval mortality by desiccation. The prevalence of species which have a prolonged larval period and/or undergo metamorphosis late in the season in temporary ponds indicates the shortage of fishless habitats with a hydroperiod long enough for successful recruitment [of these species]. Counteracting the ongoing decline of field ponds, including their destruction by land owners, represents a major conservation challenge in the Polish agricultural landscape.

Community assembly of cladoceran zooplankton in relation to pond age: an interplay of dispersal and the establishment of macrophytes and fish

Maria Peso (KU Leuven, Belgium)

Our understanding of local and regional factors in shaping community assembly is rapidly growing. In contrast, knowledge on the contribution of historical events to community structure is still limited. We here compare the local species richness and composition of cladoceran communities among two sets of ponds that differ in age. We observed that local cladoceran species richness was lower in recently constructed ponds than in older ponds. Older ponds with submersed macrophytes furthermore contained more cladoceran species than older ponds without vegetation, whereas ponds with fish always contained fewer species than fishless ponds. Most recent ponds lacked fish and macrophytes, which suggests that the difference in vegetation may be the reason for the lower cladoceran species richness in recent ponds. Cladoceran richness in the set of recent ponds was, however, also significantly lower than in older ponds that lacked vegetation and fish. The species found in younger ponds formed a subset of the species inhabiting this latter category of older ponds. This suggests that the lower species richness of recent ponds is also partly the result of dispersal limitation. We conclude that cladoceran richness gradually increases with pond age as species accumulate, but colonisation by plants and fish will ultimately determine how many cladoceran species will be able to settle and persist.