BU MATCH FUNDED STUDENTSHIPS 2024 PROJECT DESCRIPTION

PROJECT TITLE

Assessing the impact of pollution management on freshwater biodiversity

PROJECT SUMMARY

Rationale

Freshwater habitats comprise a small proportion of the world land surface area (2.3%), but support over 10% of global biodiversity [1]. However, freshwater biodiversity has significantly declined in recent decades, recording greater species losses than terrestrial and marine environments [1]. This is principally driven by the unsustainable use of freshwater by people (e.g., for waste removal, industrial and domestic uses, and modern agriculture) [2]. In particular, habitat degradation (such as pollution) is a long term and pervasive issue that has underpinned reduced ecosystem functioning and freshwater biodiversity losses globally [3]. Pollution events can be ubiquitous (e.g., eutrophication) or can be unique to a particular location, reflecting the composition of contaminants (including traditional and emerging pollutants) and the origin of the pollutants [4]. The consequences can be lethal or sub lethal, and their interactions with other pressures can result in unexpected consequences [4]. In the UK, the release of raw sewage and stormwater into rivers has been extensive in recent years, with combined sewer overflow (CSO) discharge events totalling 372,000 in 2021 [5]. This, combined with other stressors (fine sediment increases, habitat modification) have resulted in declines in water quality, and impacted faunal and floral communities in UK rivers [8]. The impact of pollution is not only limited to the main river channel but can be catchment wide, as during high flow events polluted water and sediment can move onto the floodplain degrading important habitats such as ponds and mires [9] and have been shown to detrimentally impact terrestrial species, particularly soil invertebrates [10].

Water pollution in the UK has become an important issue socio-politically [11], with water companies now committing to invest in increasing the sustainability of water management infrastructure and practice [12]. For example, many water companies are increasing storm water storage capacity at the largest wastewater treatment works in the New Forest through installation of holding tanks, and will be piloting local community initiatives to reduce surface water runoff. In addition, Freshwater Habitats Trust (FHT) are leading work to reduce point-source discharges in the New Forest, including from campsites, farms, and private residences. Despite the ubiquity of sewage impact, little is known about the environmental and ecological impacts of the planned improvements; our study provides a unique opportunity to evaluate this impact which will be of international relevance. The New Forest provides an excellent case study and a rare opportunity to examine the effects of mitigating discharges due to the absence of other stressors in the upper reaches of the main rivers. We hypothesise that improving water quality (by reducing CSOs and other point-source discharges) should have a demonstrable positive impact on aquatic biodiversity, returning communities to a comparable diversity to proximal unpolluted rivers. However, there remains a major gap in our knowledge of the patterns in recovery of freshwater ecosystems to an improvement in water quality.

Aim

This PhD aims to quantify ecological (macrophyte, macroinvertebrate and fish) and functional (decomposition) responses to reduction in CSOs and other stressors across three major river networks in the New Forest, incorporating both the main channel and adjacent floodplain habitats. By examining the impact of water quality improvement across a freshwater landscape, incorporating ecological and functional components, a more holistic catchment-wide assessment of ecosystem health can be obtained.

Objectives

O1. Quantify the long-term impacts of (1) episodic CSOs and other point-source, and (2) non-point discharges on environmental condition, and aquatic macrophyte, macroinvertebrate and fish communities in river and floodplain habitats.

O2. Examine the impact of new wastewater management practices (aimed at improving water quality by reducing CSOs and other point-source discharges), on environmental condition, and patterns of recovery by aquatic macrophyte, macroinvertebrate and fish communities in river and floodplain habitats.

O3. Determine the effects of water quality improvement on river ecosystem functioning, by comparing decomposition rates between managed, unmanaged and reference river catchments.

O4. Use data from O1 to O3 to develop catchment-scale management and conservation recommendations to enhance freshwater biodiversity which can be widely applied across the UK.

Methods

Long-term environmental and ecological datasets (1980s-present) will be examined to quantify the long-term impacts of CSO and other point-source discharges, and non-point discharges, on freshwater biodiversity across rivers in the New Foret (01). To quantify the effect of future wastewater management changes on freshwater communities and ecosystem functioning (02 and 03), seasonal sampling of aquatic macroinvertebrates, macrophytes, fish, and decomposition will be undertaken for at least 3 years. Fieldwork will focus on the Beaulieu, Lymington and Dark Water Rivers, as different stretches of these rivers are subject to different stressors, and can be subdivided as (i) no anthropogenic input, (ii) CSO and other point discharges only, and (iii) surface runoff pollution (non-point sources). In addition, the timing of CSO discharge mitigation works at different sites on these rivers will vary within the timeframe for data collection, allowing assessment of temporal change to physical and ecological parameters. Alongside the main river channels, environmental and ecological sampling will also occur in corresponding freshwater floodplain habitats (ponds and wetlands). Aquatic macroinvertebrate [13,14], macrophyte [15] and fish [16] communities will be sampled following standard methodological procedures. Environmental data collection will include a suite of water chemistry parameters, physical habitat, and spatial parameters. Decomposition will be measured using standardised cotton strips, which will be placed in sample sites for different lengths of time each season (21, 37, 50 days). Cotton strip tensile strength will be quantified and used as a proxy for decomposition.

Outcomes

The project is highly novel and timely, given there is a critical need to understand the long-term impacts of water pollution at a multi-habitat scale (most previous research has focussed pollution impacts within a single habitat type), and how wastewater infrastructure and management changes may influence freshwater communities across different trophic levels (previous studies focus on single faunal and floral groups). A consideration of ecosystem functioning (decomposition) alongside biodiversity, will ensure that the effects of new wastewater management practices on overall ecosystem health can be quantified, and the conclusions of this PhD will establish holistic catchment-wide management recommendations. This project will be collaborating with several organisations (Southern Water, FHT, Wild New Forest) and will encourage local community engagement with the project. Given the multi-habitat and large-scale approach to assessing the ecological effects of wastewater management practices, this work will result in at least four scientific publications.

References

[1] Reid et al. 2019. Biological Reviews, 94, 849-873. [2] Albert et al. 2021. Ambio, 50, 85-94. [3] Stendera, 2012. Hydrobiologia, 696, 1-28. [4] Dudgeon 2019. Current Biology, 29, R960-R967. [5] The Guardian 2022 [last accessed 21/11/2023]. [6] Whelan et al. 2022. Science of the Total Environment, 843, p.157014. [7] Haase et al. 2023. Nature, 620, 582-588. [8] Peipoch et al. 2015. BioScience, 65, 1057-1065. [9] Tockner and Stanford 2002. Environmental conservation, 29, 308-330. [10] Klok and Kraak 2008. Science of the Total Environment, 406, 455-461. [11] BBC Sewage web pages [last accessed: 21/11/2023]. [12] Water UK. 2023. Water companies propose largest ever investment. [last accessed: 21/11/2023]. [13] Everall et al. 2017. Ecological indicators, 78, 437-448. [14] Action, P., 2000. A guide to monitoring the ecological quality of ponds and canals using PSYM. [last accessed: 21/11/2023]. [15] UKTAG 2014. UKTAG River Assessment Method Macrophytes and Phytobenthos [last accessed: 21/11/2023]. [16] Macnaughton et al. 2015. River Research and Applications. 31: 1040-51.

ACADEMIC IMPACT

This research will provide critical evidence for sustainably managing wastewater and develop fundamental knowledge of how wastewater infrastructure investment and management adaptations can influence freshwater ecosystems at a catchment-scale. As a result, the findings of this PhD are of wide international interest, reflecting the pervasiveness of freshwater pollution across most continents, and will also be of specific interest to communities and stakeholders across the UK and locally in the New Forest. The studentship will result in at least four published articles (one article per objective).

This project will likely generate significant impact as it will provide critical management and conservation recommendations to contributing organisations to further support freshwater biodiversity across the New Forest and the UK. Results will be presented at international conferences to further increase academic impact and the PhD Student will integrate into the research and scientific community at BU and at the collaborating partners.

SOCIETAL IMPACT

Understanding the long-term effects of water pollution, and the impacts of new wastewater management on multi-trophic and multi-habitat patterns in biodiversity has (i) ***environmental impacts*** as it will improve ecosystem heath and the development of more effective freshwater conservation practices (ii) ***economic impacts*** as it may facilitate the sustainable use of freshwaters, (iii) ***cultural impacts*** as an improvement in freshwater quality will be enjoyed by local communities and (iv) ***policy influence*** as this research can provide the underpinning evidence required to establish-larger scale wastewater management change.

Public interest and engagement in water pollution across the UK is exceptionally high and this PhD research is anticipated to generate both local and national interest. There has been significant recent media coverage of sewage outflows and this has raised awareness and concern amongst the local community. We anticipate holding several workshops with the general public to provide updates from the research and encourage engagement with scientific data collection and monitoring within the New Forest, including higher trophic levels such as birds.

PGR DEVELOPMENT OPPORTUNITIES

- Freshwater sampling: The sampling of aquatic macrophytes, macroinvertebrates and fish requires standardised field sampling procedures. Sampling the abiotic environment of freshwaters requires training in how to measure physicochemical and spatial characteristics using standardised methods. The successful candidate will receive training in all relevant sampling methods.

- Statistical analysis: The PhD research will involve advanced statistical analysis. The supervisory team will provide the student with training in univariate and multivariate statistics in the R environment, and they will benefit from dedicated departmental and gradual school level training courses. The PhD candidate will also be trained in spatial data analysis (in the R environment and GIS).

- Research ethics: The project is working on live fish which requires regulated procedures under current legislation. Thus, the successful candidate will receive training in research ethics and animal welfare in order and be trained in all techniques. This includes supporting their training and competency development to enable them to obtain their Home Office personal licence for working on live vertebrate animals under the co-supervisor project licence.

- Research and professional skills: formal and informal training will be provided on writing systematic reviews, scientific writing, disseminating science, time management, and networking.

SUPERVISORY TEAM	
First Supervisor	Dr Matthew Hill
Additional Supervisors	Professor Rob Britton, Dr Naomi Ewald, Professor Russell Wynn
Recent publications by supervisors relevant to this project	Dominguez Almela, V., South, J. and **Britton, J.R.,** 2021. Predicting the competitive interactions and trophic niche consequences of a globally invasive fish with threatened native species. *Journal of Animal Ecology*, *90*(11), pp.2651-2662. **Britton, J.R., 2023.** Contemporary perspectives on the ecological impacts of invasive freshwater fishes. *Journal of Fish Biology*, *103*(4), pp.752-764. Parker, B., **Britton, J.R.,** Pabortsava, K., Barrow, M., Green, I.D., Almela, V.D. and Andreou, D., 2022. Distinct microplastic patterns in the sediment and biota of an urban stream. *Science of the Total Environment*, *838*, p.156477. Dominguez Almela, V., Palmer, S.C., Andreou, D., Gillingham, P.K., Travis, J.M. and **Britton, J.R.,** 2022. Predicting the influence of river network configuration, biological traits and habitat quality interactions on riverine fish invasions. *Diversity and Distributions*, *28*(2), pp.257-270. Siqueira, T., Hawkins, C.P., Olden, J., Tonkin, J., Comte, L., Saito, V.S., Anderson, T.L., Barbosa, G.P., Bonada, N., Bonecker, C.C., Cañedo-Argüelles, M., Datry, T., Flinn, M.B., Fortuño, P., Gerrish, G. A., Haase, P., **Hill, M.J**., Hood, J.M., Huttunen, K., Jeffries, M. J., Muotka, T., O'Donnell, D.R., Paavola, R., Paril, P., Paterson, M.J., Patrick, C.J., Perbiche-Neves, G., Rodrigues, L.C., Schneider, S. C., Straka, M. and Ruhi, A. **2023**. Ecological stability propagates across spatial scales and trophic levels in freshwater ecosystems. *Ecology*. **Hill, M.J.,** Wood, P.J., White, J.C., Thornhill, I., Fairchild, W., Williams, P., Nicolet, P. and **Biggs, J**. 2023. Environmental correlates of aquatic macroinvertebrate diversity in garden ponds: implications for pond management. *Insect Conservation and Diversity*. **Hill, M.J**., Thornhill, I., Tiegs, S.D., Castro-Castellon, A., J. Hernández-Avilés, S., Daw, A., Salinas-Camarillo, V.H. and Hobbs, S. 2022. Organic-matter decomposition in urban stream and pond habitats. Ecological Indicators, 142, 109232.

	Mathers, K.L., Doretto, A., Fenoglio, S., **Hill, M.J.** and Wood, P.J., 2022. Temporal effects of fine sediment deposition on benthic macroinvertebrate community structure, function and biodiversity likely reflects landscape setting. Science of The Total Environment, 829, p.154612. **Hill, M. J., Biggs, J., Ewald, N.** et al. 2021. Pond ecology and conservation: research priorities and knowledge gaps. Ecosphere, 12, p.e03853. **Hill, M. J.,** Wood, P.J., Fairchild, W., Williams, P., Nicolet, P. and **Biggs, J.** 2021. Garden pond diversity: opportunities for urban freshwater conservation. *Basic & Applied Ecology*, 57, 28-40. **Hill, M.J.,** Wood, P.J. and Mathers, K.L. 2021. Taxonomic and functional macroinvertebrate diversity of high-altitude ponds in the Macun Cirque, Switzerland. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 31, 3201-3214. **Hill, M.J.,** White, J.C., **Biggs, J.**, Briers, R.A., Gledhill, D., Ledger, M.E., Thornhill, I., Wood, P.J. and Hassall, C. 2021. Local contributions to beta diversity in urban pond networks: Implications for biodiversity conservation and management. *Diversity and Distributions*, 27, 887-900. Harper, L.R., Lawson Handley, L., Sayer, C.D., Read, D.S., Benucci, M., Blackman, R.C., **Hill, M.J.** and Hänfling, B. 2021. Assessing the impact of the threatened crucian carp (Carassius carassius) on pond invertebrate diversity: A comparison of conventional and molecular tools. *Molecular Ecology*, 30, 3252-3269. White, J.C., Fornaroli, R., **Hill, M.J.,** Hannah, D.M., House, A., Colley, I., Perkins, M. and Wood, P.J. 2021. Long-term river invertebrate community responses to groundwater and surface water management operations. *Water Research, 189*, p.116651.

INFORMAL ENQUIRIES
Please contact the lead supervisor on the following email for informal enquiries: mjhill@bournemouth.ac.uk
ELIGIBILITY CRITERIA
The BU PhD and MRes Studentships are open to UK, EU and International students. Candidates for a PhD Studentship should demonstrate outstanding qualities and be motivated to complete a PhD in 4 years and must demonstrate: • outstanding academic potential as measured normally by either a 1st class honours degree (or equivalent Grade Point Average (GPA) or a Master's degree with distinction or equivalent

- an IELTS (Academic) score of 6.5 minimum (with a minimum 6.0 in each component, or equivalent) for candidates for whom English is not their first language and this must be evidenced at point of application.

Candidates for an MRes Studentship should demonstrate outstanding qualities and be motivated to complete a MRes in 18 months and must demonstrate:

- outstanding academic potential as measured normally by an upper second class honours degree (or equivalent Grade Point Average (GPA)
- an IELTS (Academic) score of 6.5 minimum (with a minimum 6.0 in each component, or equivalent) for candidates for whom English is not their first language and this must be evidenced at point of application.

HOW TO APPLY

Please complete the online application form by **the deadline on the project webpage.**

Further information on the application process can be found at: www.bournemouth.ac.uk/studentships