Urban aquatic plants as drivers of ecosystem services

Freshwater systems are among the most biologically and functionally diverse habitats known, ranging in size from the ancient Rift Lakes of Africa, to small, ephemeral water bodies present only during periods of heavy rain. From this huge diversity of form and function, many highly diverse and specialised plant and animal species have arisen, well adapted to the variable conditions and environments which freshwater habitats present. Complex interactions mediate these environments and species, facilitating a wide array of ecosystem services, including carbon capture and sequestration in peatbogs, bioremediation of excess nutrients via aquatic plants, and soil stabilisation and erosion prevention of bankside vegetation in riparian systems (Hill *et al*., 2017).

However, urbanisation and agricultural intensification over the last century have resulted in the drainage, damming, and degradation of many freshwater environments. Even throughout non-urban areas in the UK a considerable amount freshwater habitat has been lost. Current projections of urbanisation predict that between 2000 and 2030 the extent of urban areas will increase by an estimated 185%, representing a considerable threat to biodiversity and complex challenges for urban planners and conservationists alike (Hassall, 2014).

Figure 1: Extreme modification of catchments leads to complete loss of ecosystem services, reduction in habitat functionality, and may result in complete destruction of aquatic and other associated habitats.

Urban and cityscapes within the context of biodiversity are often likened to so-called biodiversity deserts, being depauperate, of little benefit to wildlife, and with limited ecological functionality. The flora and fauna of cities homogenises with increasing time and urbanisation, as only species tolerant of these intensely modified environments can establish. These urbanophiles become ubiquitous across cityscapes, as habitats are replaced by urban features, native species and their functionality from these areas are lost (McKinney., 2006).

Recent evidence, however, has shown that moderate levels of urbanisation support a greater diversity of plants, and that urban ponds sustain comparable numbers of invertebrate species and families compared to non-urban ponds, providing strong ecological evidence that these aquatic features may provide a promising avenue for supporting urban biodiversity (Hill *et al*., 2017). The majority of academic work focuses on terrestrial systems, considering habitat for pollinators and invertebrates, often by the creation of nectar resources. Considerably fewer resources are provided to the creation and study of aquatic habitats, due to the logistical difficultly and expenses associated with their management.

Figure 2: Various methods of bank stabilisation have been developed which facilitate the regeneration and establishment of vegetation in degraded environments, but to what extend do these influence aquatic plant composition and functionality whilst effectively providing nature-based solutions to the impacts of increased urbanisation? Importantly, do differing practices result in similar outcomes or are there trade-offs between treatments?

Much work has been done on the use of green-roofs, and their capacity to impede storm water surges and retain rainwater, showing how effective these green features can be as an addition to urban infrastructure, and provide observable biodiversity benefits in the form of dynamic floristically rich areas (Stovin *et al*., 2015). This project proposes to examine the various mechanisms by which cities, and the urban environment more broadly, influence aquatic plant distribution and function. Specifically with this project we aim to address two key topics.

1) Influence of urban environment of aquatic plant distribution and functional ecology

Urban aquatic plant distributions are determined by a combination of dispersal and habitat-level processes: can a species reach a new site, and can it establish once arrived? Theories about the niche/neutral processes underlying urban aquatic plant distributions will be tested using an extensive dataset of UK urban pond plant communities.

Land use changes have resulted in the fragmented and isolated patches of variable quality habitat for aquatic plant species in the urban landscape. The hard linear features of these landscapes such as roads, fences and hard flood defences limit the natural dispersal of species between already isolated habitat patches. Critically, evidence has shown that the reproduction barrier from the transition of casual to established populations is most strongly present in hybrid and novel ecosystems, environments which form the majority of urban greenspaces (Kowarik and von der Lippe, 2018).

Specific hypotheses will be tested, including: (i) biotic homogenisation, (ii) spatial structuring of communities, (iii) and the hump-backed relationship between urbanisation and plant species richness. From these hypotheses this project will demonstrate how these influences effect mechanisms of dispersal and persistence in aquatic communities. Furthermore, from these data functional plant traits, responses and their impacts may be inferred, providing insight into the functional traits our urban aquatic ecosystems currently exhibit.

Opportunities also exist to work with the Canals and Rivers Trust to incorporate canal ecosystems to study the effects of connectivity on plant communities at inter-city scales.

2) Mechanistic role of aquatic plants in the delivery of urban ecosystem (dis)services

Urban aquatic plants contribute both positively, through the enhancement of biodiversity, the phytoremediation of urban run-off, and the improvement of local aesthetics, as well as negatively, through their role as invasive species (e.g. New Zealand pigmy weed) or nuisance species (e.g. toxic algal blooms). The student can select from a variety of such services and disservices to apply an empirical approach to understand the mechanisms by which the plants influence the urban environment. Examples might include:

1. Experimental mesocosms to evaluate the capacity of particular plant communities to reduce pollution (e.g. nitrogen and phosphorous).
2. Field trials to study the impact of aquatic planting techniques (e.g. riparian, floating island) on the enhancement of invertebrate biodiversity, public engagement, and soil stabilisation.
3. Resilience and sustainability of different planting regimes in urban ponds and lakes, in terms of maximising ecological and utility benefits whilst minimising upkeep and associated negative impacts e.g. nuisance plant growth.
4. Socio-ecological survey work investigating the importance of aquatic plant communities on the perceptions of biodiversity value and engagement of local residents in urban parks.

Impact

The opportunities afforded by nature-based solutions to challenges in urban sustainability are considerable, but the evidence base is relatively poor. Urban greening and regeneration represent a key method for addressing urban challenges, but also a considerable potential expenditure for statutory bodies and organisations with responsibility for urban management. It is critical that a strong body of evidence is available, to inform best practice and demonstrate cost-effectiveness when designing, monitoring, and implementing management. This project will generate a preliminary body of such evidence with direct relevance to the management of West Yorkshire urban spaces, with application at a much wider scale.

Student Profile

Candidates considered for this studentship must demonstrate several key skills appropriate to this research topic and have a strong biological research background, with emphasis on aquatic plant ecology and freshwater biology:

- Strong quantitative skills and experience working with large datasets
- Understanding of ecosystem services and functions, particularly those of freshwater systems
- Familiar with core population ecology concept and dynamics
- Proficient in the identification of aquatic plant and macroinvertebrate species.

Desirable but not essential skills for this project include:

- Understanding of social science methods
- Experience monitoring aquatic biodiversity or working with mesocosm systems
- Previous experience working on nature-based solutions or urban infrastructure
- Knowledge of urban planning, urban engineering or water management
- Familiar with water management, urban planning, and conservation policy
- Experience with invasive species biology, management and policy.

References

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