

Urban freshwaters: the role of biodiversity for health and wellbeing-related ecosystem services
BESS workshop working paper
(Felicity Thomas, Sahran Higgins and Ben Goldsmith, May 2015)

Over half of the world's population now live in urban areas (United Nations 2008). It is generally accepted that urbanisation radically alters biodiversity (Dearborn and Kark, 2009; Faeth *et al.* 2011) and that alterations in ecosystem structure and function through changes in species composition, abundance, richness, and evenness may have important repercussions for human health and wellbeing (Dallimer *et al.* 2012; Lovell *et al.* 2014). Research has found that urban aquatic environments can bring positive health benefits (Volker and Kistemann 2011), yet the specific biological qualities that offer the greatest benefits to health-related ecosystem services remain poorly understood (Dallimer *et al.* 2012; White *et al.* 2010).

Green space literature is increasingly supportive of the health benefits obtained from exposure to the natural environment. However, knowledge on the nature of causal relationships between greenspace and human health and wellbeing is limited (Lee and Maheswaran 2011, and this is especially true of aquatic environments (Volker and Kistemann 2011. Furthering understanding in this area may have important co-benefits, improving human health and catalysing people to be more supportive of biodiversity conservation and management strategies.

This paper reports on the discussions that took place at a two-day interdisciplinary workshop held in London in April 2015 to progress understanding in this field and to initiate collaborative partnerships on urban aquatic biodiversity and health-related ecosystem service outcomes. Funded via the NERC-BESS programme, workshop participants came from a range of academic, practitioner, policy and user-group backgrounds (see Appendix 1). The first day focused on current knowledge about urban aquatic biodiversity, the relationship between aquatic or 'blue' space¹ and human health and wellbeing, valuations of blue space and the kinds of methodologies that have underpinned these understandings. The second day focused on group discussions relating to key questions identified by participants, and priorities in methodological development.

We start the paper with an overview of current knowledge on biodiversity and human health and wellbeing. Focusing on some of the key themes that arose from the workshop, we then identify some of the challenges involved in promoting aquatic biodiversity as a necessary or desired component for improved human health and wellbeing. In so doing, particular focus is placed on understanding the contested nature of 'good' biodiversity; factors influencing public perceptions and use/non-use of urban blue space; and the potential for different forms of appraisal to influence the valuation of blue space. In the final section of this paper, we discuss the relative (dis)benefits of uncoupling research and practice on green and blue space, emphasise the value of mixed methodologies and report on possible approaches that have the potential to further understanding of the links between urban aquatic biodiversity and human health and wellbeing.

Linking biodiversity with human health and wellbeing

In recent years, ecosystem service assessments have sought to formalise an understanding of the complex interdependent relationship between the natural

¹ Urban blue refers to 'all visible surface waters in urban areas' (Völker et al. 2013)

environment and human health and wellbeing (Daniel *et al.* 2012). Much of this work has focused on the potential of biodiversity in regulating ecosystem processes and functions, and on the provisioning goods and services that ecosystems provide. Direct links between biodiversity loss and human health are well recognised e.g. spread of zoonotic disease; loss of pharmaceutical opportunity (Lovell *et al.* 2014). But it is only more recently that attention has been paid to biodiversity's role as a determinant of enhanced health outcomes, and to cultural ecosystem services including the enhancement of wellbeing through aesthetics, recreation, and sense of place.

While evidence suggests that biodiversity is supportive of positive health and wellbeing (Fuller *et al.* 2007; Lindemann-Matthies *et al.* 2010; Curtin 2009), others have concluded that data to support this assertion is limited (Cardinale *et al.* 2012; Sandifer *et al.* 2015). With a few notable exceptions (e.g. Dallimer *et al.* 2012), research to date has focused on the potential for biodiversity-related human health benefits in green space. Whilst it is recognised that some of the issues raised in this literature are pertinent also to blue space, it was clear that this was an area in which further research and understanding should be prioritised.

What does 'good' aquatic biodiversity mean?

Biodiversity is defined by the Convention on Biodiversity as 'the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems' (UNEP 1995). While the research literature on biodiversity has included a level of academic debate in terms of ecological functioning, there has been little critical analysis of what effective outcomes might mean across different disciplines. This is surprising given that the language of biodiversity now permeates the literature on ecosystem services and has a strong presence in UK policy documents (Lawton *et al.* 2010; UK NEA 2011; Natural England 2011). Whilst not wishing unnecessary prevarication to divert attention away from core issues, it was clear from the workshop discussions that the concept of 'good' biodiversity had different meanings across academic disciplines and practitioner/policy groups. Acknowledging these differences is vital if interdisciplinary working is to result in effective outputs, particularly when the outcomes prioritised across different fields may seem, at least on the surface, to be at odds.

Varying priority outcomes were most apparent between those from ecological backgrounds and those from health and wellbeing backgrounds. For the former group, good biodiversity equated most closely with the Convention on Biodiversity definition, with not only species richness but also species *appropriateness* considered vital for robust ecosystem functioning. For the latter group, biodiversity was equated primarily with species richness and aesthetic value, and seen as one possible avenue through which human wellbeing could be enhanced.

Whilst recognising the inherent value of robust ecosystem functioning, it was agreed that the ecological concept of good biodiversity did not necessarily cohere with positive outcomes for human health and wellbeing. A species-poor blue space site for example, might hold an important health function if it is a place where regular physical activity is undertaken, or where therapeutic wellbeing is experienced. Conversely, a species-rich site may harm wellbeing if, as a result of its immense ecological value, access is restricted, or people feel that they are no longer able to access it. It was also recognised that for some people, the mere knowledge of the existence of a particular blue space was enough for it to impact upon wellbeing, even if more tangible or visual forms of interaction with it were rare. At the same time

however, people's expectations relating to biodiversity were felt to be associated with particular places and contexts e.g. parks, wild spaces, with encounters considered 'too close for comfort' e.g. within private gardens, potentially unsettling for human wellbeing.

Questions were raised over the temporal nature of values placed upon biodiversity. One concern for example, related to a perceived short-termism in the way that people view natural environments, with a felt tendency for individuals to be satisfied with present day levels of biodiversity, rather than aspiring to either levels attained in the past or to potential future gains. It was also agreed that perceived resource scarcity could both foster public demand for blue space preservation and increase its perceived value.

As has been suggested elsewhere (Dallimer et al. 2012; Hassall 2014) there is often a mismatch between people's *perception* of, and *actual* species richness. However, it was acknowledged that while people may not recognise ecological biodiversity, there were aspects of it that they appreciated in terms of wellbeing gains. The role of charismatic species (e.g. swans, ducks, water lilies, fish) with which people felt able to connect in a tangible or emotional sense, as well as more highly valued species such as kingfishers, otters and dragonflies, was felt to play a particularly key role in urban blue space, where it was generally perceived that people had a more limited understanding of ecological functioning than with terrestrial environments. It was also recognised that different blue space user groups may have greater knowledge of particular species and may be inclined to view their abundance more positively than other user groups - anglers for example, would likely be especially satisfied with high levels and diversity of fish. It was felt that while particular species were likely to provide an important function for human wellbeing, more research was needed to examine causation, and to assess if and how these benefits were experienced by people from diverse social groups and at different stages of the life course. Whilst there was some reluctance to embrace the contribution to diversity of non-native or invasive species, it was generally agreed that addition of carefully selected charismatic species e.g. water lily cultivars, could provide a potential compromise if it meant that the more 'natural' biodiversity lying unseen below the water surface could be left untouched.

There was general agreement that intervention was needed to prevent the spread of invasive species for both ecological and economic reasons. However, the relative role of native and non-native species for biodiversity and for human health and wellbeing was less clear-cut. It was agreed that although non-native (but non-invasive) species are often viewed positively from an aesthetic perspective, their ecological value was questionable. There was a general consensus amongst workshop participants from an ecological background, that non-native species should gradually be replaced by native species. However, it was also recognised that people's wellbeing may be bound up with the familiar sight and sound of particular (non-native) species e.g. Canada geese, common carp, and that any intentional reduction of these species might be detrimental to human wellbeing if not undertaken sensitively and accompanied by appropriate forms of interpretation.

The role of education in alerting the public to the potential ecological issues associated with non-native species was debated. One concern raised related to the possibility of public disengagement with nature if information provided was deemed didactic or if discussion relating to the relative merits of native and non-native species was perceived to be judgemental and overly complex. However, it was also argued that with carefully targeted educational initiatives and better provision of access to resources (e.g. through leisure, public participation and engagement),

people could be better placed to re-engage with, and appreciate the value of, native species.

The importance of recognising the heterogeneous nature of blue space was also discussed. Hypotheses suggesting biotic homogenisation within urban areas have been challenged, and it is now generally recognised that most types of urban blue space (ponds, lakes, canals, rivers, fountains) perform potentially important ecosystem service functions. The nature and proportionality of these functions is known to vary widely across water bodies but can include pollutant retention, air cooling, moderation of flood hazards, storm water retention, recreation and food supply amongst others. Better understanding of the causes and complementarity of these variations was felt by workshop participants to be important in future research.

Blue space, health and wellbeing

Research has demonstrated a link between people's interactions with aquatic environments and their health and wellbeing, with evidence emerging that blue space is amongst people's most preferred places for restoration and relaxation (White et al. 2013). While most of this research has focused on coastal settings, a small but growing body of research suggests that urban blue space can support health and wellbeing outcomes through masking traffic noise (Jeon et al. 2010; You et al. 2010), mitigating summertime temperatures (Völker et al. 2013), providing high levels of restorativeness (White et al. 2010; Thomas *in press*), and providing spaces for physical activity, social interaction and recreation (Völker and Kistemann 2013; *in press*), the latter of which may include the pursuit of natural history interests (e.g. birdwatching).

Research has also found a link between people's interaction with natural environments and people's interest in, and knowledge of, its ecological worth (Caissie and Halfpenny 2003). This was reiterated amongst workshop participants involved in citizen science initiatives that require active participation towards an end goal. This included schemes such as Fixing Broken Rivers, the Riverfly Monitoring Initiative, Canal and Rivers Trust fish rescues, and the South East Rivers Trust Pollution Assessment Volunteer Scheme. Importantly, it was agreed that most common forms of blue space use for recreation (angling, swimming, canoeing) and relaxation were unlikely to interfere significantly with ecosystem functioning and biodiversity as long as the ecosystem was sufficiently robust. Whilst this assertion has significant implications in terms of maximising both biodiversity and health and wellbeing outcomes, it also raises several important questions relating to blue space perception, access and use.

First, as with much of the literature on the salutogenic potential of green space, knowledge on the health and wellbeing impacts of blue space tends to be underpinned by an assumption that where people have such settings nearby they will use them. Research within this area also tends to be based on the experiences of those already using such spaces, paying far less attention to those who are *not*. This is an important oversight, not only in terms of data bias, but also from the perspective of health inequalities. An emerging body of research within the social sciences is beginning to acknowledge the ways in which urban natural spaces can become embedded with a range of socio-political associations and narratives that code them and their usage in particular ways in relation to factors including race (see Bryne and Wolch 2009), age, and body shape (see Thomas *in press*). Whilst better understanding of these issues is clearly not of direct relevance to aquatic biodiversity *per se*, understanding why people avoid such spaces does have potentially important repercussions both in terms of well-distributed health-related ecosystem services and

in maximising the potential for diverse groups of people to place value upon (and ultimately seek to protect) blue space.

A second, related question concerns the distribution and accessibility of good *quality* blue space. Literature on urban green space has emphasised how people living in areas with low socio-economic status often have relatively poor access to high quality natural environments (Mitchell and Popham 2007). It is likely that this is also the case with urban blue space, although research is needed to confirm this assumption. If this is the case, it again raises important questions over the potential for blue space to provide universal health and wellbeing benefits, and throws doubt on the likelihood of people necessarily connecting in a positive way with such blue space environments.

Understanding how governance structures influence the ways in which decisions are made about environmental and public health interventions and the interactions between them is important if the health and wellbeing benefits associated with urban blue space are to be realised.

Valuing blue space

Economic assessments have demonstrated the value accorded to blue space recreation. Angling for example, is thought to generate around £3.5 billion a year in economic activity (Brown 2012). Research has demonstrated that people tend to place a high economic value on residential and business locations near blue space (Sander & Zhao 2015) and this value is typically reflected in property and land prices. However, hazards such as flooding mean that assessing the risks and dis-benefits associated with urban blue space also forms an important component of any valuation. A long-term perspective on the value for money and economic returns on investment through blue space development/restoration can be taken into account through economic cost-benefit analysis. Importantly, it was recognised that economic valuations of blue space could conflict with other perspectives and priorities – a blue space with high economic value (e.g. through recreation) may be deemed to be of low ecological value and vice versa, suggesting that the relationship between biodiversity change and blue space use may in some circumstances and locations be weak.

Non-economic valuations are also important, and can be influenced by the media, and by historical and cultural associations. It was felt that contemporary media representations of blue space were often negative, in large part because of the spate of flooding incidents in recent years. However, programmes such as *Three Men in a Boat* and *John Sergeant's Barging Around Britain* were seen to provide more positive portrayals.

Types of green space - particularly in the English countryside - have deeply ingrained and often romanticised associations with national heritage. Although biodiversity in itself has rarely been the central focal point of this, a range of flora and fauna have featured in well-known literature and art, and it is likely that this has had some influence on their perceived cultural value. The potential for exploiting cultural and historical associations to increase the valuation of urban blue space biodiversity was debated. Historically, much urban blue space in the UK was established for *recreational* purposes, with little attention being given to ecological biodiversity. This poses a potential challenge in terms of cueing in to positive cultural and historical associations to promote biodiversity. However, workshop participants agreed that the connections that people hold with such environments also represent an important opportunity to ensure that they maintain an interest in how it is managed. For example, forms of interpretation could be used to demonstrate to people how

previously sterile environments can be transformed into biodiverse blue space, and it is possible that this knowledge and the 'sense of place' engendered through this could in turn have positive impacts upon wellbeing. This was felt to be achievable across a range of blue space environments, and that in cases where regeneration was relatively recent (e.g. urban canals; Clapham Common Ponds) could also help foster a sense of civic pride and ownership.

Developing mixed methodologies

A diverse range of ecological, epidemiological and social science methods were discussed during the course of the workshop. Whilst practitioners are increasingly seeking to address a range of amenities through aquatic management, it was recognised that most blue space research to date has focused *either* on ecological functioning, *or* on human health and wellbeing, with fewer attempts made to examine both. Given the difficulties involved in providing rigorous evidence isolating and demonstrating a causal link between blue space biodiversity and health and wellbeing it was agreed that data demonstrating a 'plausible explanation' between them would be satisfactory. It was felt that this needed to encompass assessment of aquatic quality (defined via species richness and ecological appropriateness), microbial diversity, and the health and wellbeing benefits associated with this. However, the nature of the evidence required to unpick and explain the proximal and distal pathways shaping any such relationship was debated, and a number of methodological challenges were identified.

Techniques such as systematic review and meta-analysis, analysis of large scale longitudinal and panel data, qualitative interviews, focus groups primary biological and ecological data collection and a range of participatory methods are currently used successfully to help inform understandings of environment - human relations. Mixed methodologies using these techniques could also help to unpick particular exposure-outcome pathways to provide more specific insight into the relative role of biodiversity. Other techniques that have potential for this include eye-tracking and smartphone apps that focus on recording people's physical and emotional status whilst in particular environments. However, some workshop participants felt that there was a perceived expectation within elements of the public health sector for research considered sufficiently 'valid' to be driven by a fairly narrow range of experimental data collection techniques, such as those resulting from randomised controlled trials. Recent experience however, suggests that possibilities for considering the validity of a wider range of data are evident. The Landscape Institute for example, developed its position statement in collaboration with several Directors of Public Health and the Public Health Advisor for NHS Scotland. They have also held well-attended workshops for public health trainees to demonstrate the potential for landscape to improve health outcomes, suggesting that important opportunities for collaboration with public health specialists are available for take up.

A growing appreciation of the importance of considering life-course approaches to health and wellbeing also raises challenges. Comparing large-scale data sets across age cohorts is one way of measuring cumulative health and wellbeing impacts and change across the life-course. However, limits to such techniques exist: whilst data on population health is available over a number of decades, robust monitoring data on biodiversity has not been collected systematically in the UK, and where it exists, is rarely integrated or accessible in ways that make it useful to public health. Even where other potentially useful environmental data exist, e.g. standardised measurements of water quality, these are adjusted over time to incorporate new legislation and as such there are inconsistencies within what is measured and the methods used.

One suggested technique to examine biographical exposure data that could be used to assess the role of urban aquatic biodiversity for health and wellbeing involved use of a life-grid approach (see Berney and Blane 2003). Whilst not commonly used in environmental research, this approach offers opportunities for examining the ways that people perceive and 'place' particular spaces, emotions and events within broader social, economic, spatial and temporal contexts. Being able to prompt discussion on urban blue space biodiversity across significant moments of the life course or at key development periods in children would therefore likely elicit useful information that could feed in to inform a larger methodological body of work.

Case studies showcasing blue space restoration impacts on ecological functioning and on community health and wellbeing were felt to hold particular traction with policy makers. However, it was felt that they too often focus on celebrating an end product rather than exploring the processes via which such results had been achieved. Examining the complexities of these processes and exploring how barriers to progress had been overcome were deemed to be important. It was also recognised that successfully undertaking this kind of 'natural experiment' required researchers to have prior knowledge that the intervention was taking place and adequate notice to undertake baseline work. The complications and uncertainties involved in ensuring any such intervention went to plan requires that Research Councils be prepared to take risks to fund this type of innovative and longitudinal work.

It was also deemed important to consider the temporality of health and wellbeing outcomes from this type of intervention. For example, whilst the simple knowledge that an intervention is imminent may positively influence health and wellbeing for some people, others may not feel the benefits until several months or even years after it had been introduced. Economic evaluations of health and wellbeing outcomes were also discussed. Traditional economic measures focusing on the relationship between blue space (primarily seas and rivers) and health and wellbeing have examined both the cost to public health of risks such as algal blooms, as well as the public willingness to pay to reduce risks. Alongside this however, it is also possible to measure the revenue capture from health benefits that accrue from blue space development/restoration. While economic valuation tools exist for the health benefits of swimming and walking, there is considerable potential for further work to assess the specific benefits (or risks) of other forms of blue space recreation, and to examine the role that different types of incentives may play in encouraging healthy behaviour.

Underpinning discussion of methods was debate over the desirability of uncoupling green and blue space terminology, research and practice. Although there are exceptions, most urban blue space exists alongside, and within the wider context of, some form of green space (e.g. parks, towpaths). In some cases e.g. fish, it is clearly possible to disentangle blue and green space species biodiversity. However, in other cases e.g. birds, this is more difficult, and if taken more broadly to consider food webs, may in fact be unhelpful. Similarly with human health and wellbeing; while it may be possible to attribute health benefits brought about via physical activity to particular blue or green settings, disentangling the impacts of blue and green space exposure to feelings of wellbeing and restoration would be more complex. Recognising and understanding the inter-meshed relationship between blue and green space is therefore important.

However, it was agreed that blue space does hold particular functions and features for biodiversity and for health and wellbeing that distinguish it from green space. As

such, it is vital that these qualities are recognised and that the features that differentiate blue space do not become engulfed within broader, often homogenised, green space definitions. From an ecological perspective, it was felt important to think about biodiversity at a city or catchment-level, rather than a local scale, with blue spaces viewed as a network, or as corridors for biodiversity rather than as individual, isolated entities. The catchment-level work of the South East Rivers Trust for example, was deemed to encapsulate the idea of 'joined-up' biodiversity, and was also seen as a way of crossing potentially complex and contradictory administrative boundaries.

Summary

This paper has reported on the main discussions held at the BESS-funded workshop on urban aquatic biodiversity and human health and wellbeing. During the workshop, important points were made about the way that we think about aquatic biodiversity, and the priority outcomes associated with this. A key distinction was made between perceived and actual biodiversity, the role of charismatic species and the ways in which perceptions surrounding particular species are bound up with human health and wellbeing.

It was acknowledged that blue space can play an important role in enhancing human health and wellbeing. However, it was also recognised that the provision of blue space did not necessarily equate with its use. Ensuring that we promote research that seeks to understand who uses such spaces, as well as who does not, will promote understanding and action to better address health inequalities. Insight is also needed to better understand how and why people place particular (monetary, cultural) values on different types of blue space and what this might mean in terms of maximising biodiversity and health and wellbeing gains.

Mixed methods and approaches drawing on work within ecology, conservation, public health, epidemiology and the social sciences are needed to provide further insight into biodiversity - health and wellbeing links. Given the difficulties involved in providing rigorous evidence isolating and demonstrating a causal link between blue space biodiversity and health and wellbeing it was agreed that data evidencing a 'plausible explanation' between them would be sufficient. While the nature of the evidence required to do this was less clear-cut, it was felt that combining the existing methods used across key disciplines with demonstrative case studies, in-depth life course methods and innovative interactive techniques could provide important additional insights.

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Appendix 1: Workshop participant list

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