FRESHWATER BLUE SPACE AND WELL-BEING: INVESTIGATING CO-BENEFITS AT DIFFERENT SPATIAL SCALES

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PhD

Environment

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July 2017

Abstract

There is increasing evidence that the natural environment is beneficial to human health and well-being. An initial scoping review indicated that studies have considered a range of health measures but generally treat the environment homogeneously, concentrating on green space, indicating a lack of integration of an ecological perspective. This thesis has used a mixed method approach to consider the role of the environment in benefiting human health and well-being and the potential to derive co-benefits from this relationship. At a national level, the benefits associated with a single environment type, blue space, were investigated. The majority of people derived psychological and social benefits from visiting blue spaces; nature was important in mediating the psychological benefits of these visits. At a local level, the role of nature, specifically ecological health, was considered, by evaluating the success of an ecological restoration project. An improvement in ecological health was seen as a result of the restoration whilst from a social perspective, users viewed the restoration positively and discussed obtaining psychological benefits from urban natural spaces. The use of qualitative methods allowed identification of issues surrounding place attachment which was disrupted by the restoration. A comparison of the views of local users, providers, and commentators further explored opinions regarding the management of urban natural spaces. Although providers and commentators were generally aware of the needs and preferences of local users, a mismatch was revealed regarding preferences for formal or wild natural spaces, with local users favouring a range of management regimes including wild spaces which providers believed they would find undesirable. The implications of these findings for planning and policy are considered as they indicate that the conservation and management of the natural environment offers opportunities to deliver co-benefits for the environment and health.

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Acknowledgements

Firstly, I would like to thank my supervisors Piran White and Hilary Graham for the opportunity to do this PhD and for their encouragement, support and advice all the way through. I am also grateful to the University of York for funding the project and to everyone who provided me with academic help along the way, including Stuart Jarvis for his statistical advice, the Health of Populations and Ecosystems (HOPE) project team and advisory groups, and everybody who helped me get my head around focus groups, interviews, and qualitative analysis.

I'd like to thank everyone at the Environment Agency who helped me find my case study but especially Jo Fraser for her enthusiasm and assistance in introducing me to the river Medlock. I'm grateful to everyone who gave up time to take part in my study, whether for a focus group, interview, or to help out with fieldwork: Sally Ann de Bell, Tom Holmes, Abi Sutton, Fran Falcini, Louise Best, Sarah Knight, Debs Sharpe, Jo Witton, Rosie Lennon, Tom Sloan, Stephen Lawlor, and Hannah Curzon. Hopefully no one was too scarred by their experiences with dead rats or ghostly bag-pipe players!

I've had some great opportunities to get involved with other projects alongside my PhD and I'd like to thank everyone who's been part of NRG BESS and GreenSTEMS for adding to the experience.

Finally, I want to thank my friends and family for their interest and encouragement, everyone here in York, Tom Denbigh, Rowenna Hallam, Cat McLaughlin, and the rest of the Effingham crew for providing an escape in Bristol when needed, and last but not least the de Bells.

Author's Declaration

Chapter 3 has been written in the style of *Landscape and Urban Planning* and has been accepted for publication. The contribution by co-authors was as follows:

Piran White and Hilary Graham: Supervision, review and editing.

Stuart Jarvis: Statistical advice and editing.

Chapters 2, 4, and 5 have been written as scientific papers in the style of various journals (as noted in the preface of each chapter). The contribution by co-authors was as follows:

Piran White and Hilary Graham: Supervision, review and editing.

I declare that the work contained in this thesis is my own and has not been submitted for an award at this, or any other, University. All sources are acknowledged as References.

Siân de Bell

Chapter 1 Introduction

There is increasing evidence that the natural environment is beneficial to human health and well-being but further research is needed regarding the role of different characteristics of the natural environment in this relationship. This thesis investigates freshwater blue space and the interactions between humans and ecosystems which result in benefits to people, considering the mediators of this relationship at different spatial scales. At the national level, it examines the benefits of visiting blue space whilst at the local level it explores the ecological and social benefits of the ecological restoration of blue space and the management of urban natural spaces. The introduction reviews the main evidence surrounding the relationship between the natural environment and health, highlighting the main topics relating to this thesis, and locates this research in the context of broader issues relating to ecosystems and human health. It discusses the main frameworks in this area before summarising research on the health benefits of the natural environment, which focuses mainly on the green space-health relationship. The importance of demographic factors, the use of natural spaces, and the role of environment type and quality in providing health benefits are considered. The broader context is then discussed and the need for further research into the nature-health relationship due to issues such as climate change and urbanisation. Finally, the importance of ecological restoration is considered alongside methods and approaches for investigating the nature-health relationship.

1.1 Defining health and well-being

The most widely used definition of health is 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO, 1948). In this definition 'health' and 'well-being' are defined in terms of one another. This creates difficulties in studying well-being as whilst disease and infirmity can be measured, a range of different indicators could be used in the measurement of well-being (Pretty et al., 2011). Further efforts have been made to define well-being, with agreement that it is 'the presence of positive emotions and moods (e.g., contentment, happiness), the absence of negative emotions (e.g., depression, anxiety), satisfaction with life, fulfilment and positive functioning' (Centres for Disease Control and Prevention, 2013). Wider definitions include the material needs for a good life, human rights such as freedom, as well as physical health and social relationships (MA, 2003). Although definitions vary, well-being is dependent on context: its standards are dependent on the situation in which a person lives (Tzoulas et al. 2007; MA, 2003). Due to the inclusion of well-being in its definition, health can be used as an umbrella term to refer to both health and well-being. For example, many models used to communicate the factors that determine health to policymakers include well-being as a component of health (Wilkinson & Marmot, 2003). This is the approach which will be taken in this introduction.

The definitions of health discussed above have referred only to the individual but health can be measured at different levels, from one person to the population. Population health is the health of a group of people, including the distribution of health within that group as this may differ between demographics such as age, sex, and ethnicity (Graham, 2007; Kindig & Stoddart, 2003). One of the first models used to communicate population health with policymakers was the Lalonde model which gave four types of determinant: lifestyle; environment; human biology; and healthcare (Arah, 2009). This was further developed by Evans and Stoddart (1990), whose model includes similar but expanded categories and emphasises the interrelatedness of these factors in influencing health, which is made up of different components including well-being and disease. There is no universally accepted model of population health; different models vary in their emphasis on different determinants and the causal relationships between those determinants (Friedman & Starfield, 2003; Kindig & Stoddart, 2003).

The social determinants of health model is the prominent framework for understanding health. Dahlgren & Whitehead (1991)'s model is the most widely used and gives social factors as the main determinants of health. The World Health Organisation (WHO) defines the social determinants of health as 'the conditions in which people are born, grow, live, work and age' (Marmot, 2010). These social determinants, from the lifestyle of the individual, to their network of social relationships, and living and working environment, interact and influence health; all of these factors are also affected by the broader socioeconomic and cultural environment (Ansari et al., 2003; Fig. 1).

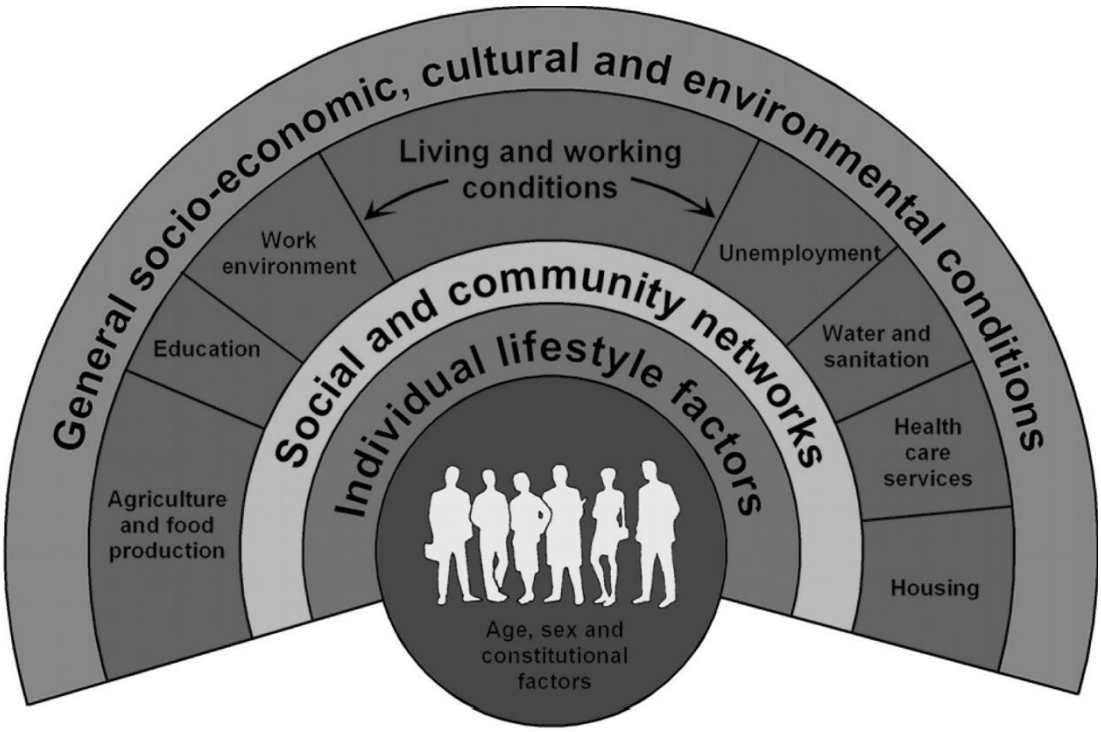

Figure 1 The main social determinants of health.
Dahlgren & Whitehead (1991)

1.2 The role of the natural environment in determining health

A common feature is seen in these models: the natural environment – 'all of the biotic (living) and naturally occurring abiotic (non-living) factors that act on a human or non-human organism, population, or community and influence its survival and development' (Ford-Thompson et al., 2014) - is relegated to a supporting role in determining health. The natural environment is also shown to be distant from the health of the individual (Fig.1). However, natural spaces have been recognised as beneficial to human health throughout history; as long ago as Ancient Rome there is evidence that people thought the countryside preferable to the pollution and noise of the city (Ulrich et al., 1991). This belief in the beneficial effects of nature can be seen in restorative gardens from the Middle Ages to hospital design between the 1600s and 1800s, and is still evident today, for example in German healthcare where nature walks and mud baths may be prescribed as part of a course of treatment (Bratman et al., 2012; Gobster et al., 2007).

The natural environment provides us with all of the fundamentals for life and these essentials can be thought of as services provided by the environment. Ecosystem services are defined simply as the benefits that individuals and society obtain from ecosystems and are divided into four main groups (Corvalan et al., 2005):

- Provisioning, for example food, wood, and water
- Regulating, for example climate and disease

- Supporting, for example nutrient cycling and primary production
- Cultural, for example aesthetic beauty and recreation.

Ecosystem service frameworks provide schematic representations of the movement of resources and benefits originating from ecosystems to society (Posthumus et al., 2010; Fig. 2). Although 'health' is generally used in ecosystem service frameworks to refer to both health and well-being, Fig. 2 uses a broad definition of well-being, displaying health as one of constituents of well-being alongside other factors such as good social relationships. Within this framework, the natural environment is shown to play a central role in determining health by supporting ecosystem services such as food provisioning and water filtration (Chan et al., 2012). The benefits of nature to humans exceed these subsistence requirements, with services such as disease regulation and cultural services playing a large role (Barton & Pretty, 2010; Tallis et al., 2008; Fig. 2). However, there is a lack of recognition of the potential for feedback between ecosystem services and health within ecosystem service frameworks (Ford et al., 2015). The environment can negatively affect health as factors such as human needs for food and clean water can impact the environment and its ability to supply ecosystem services.

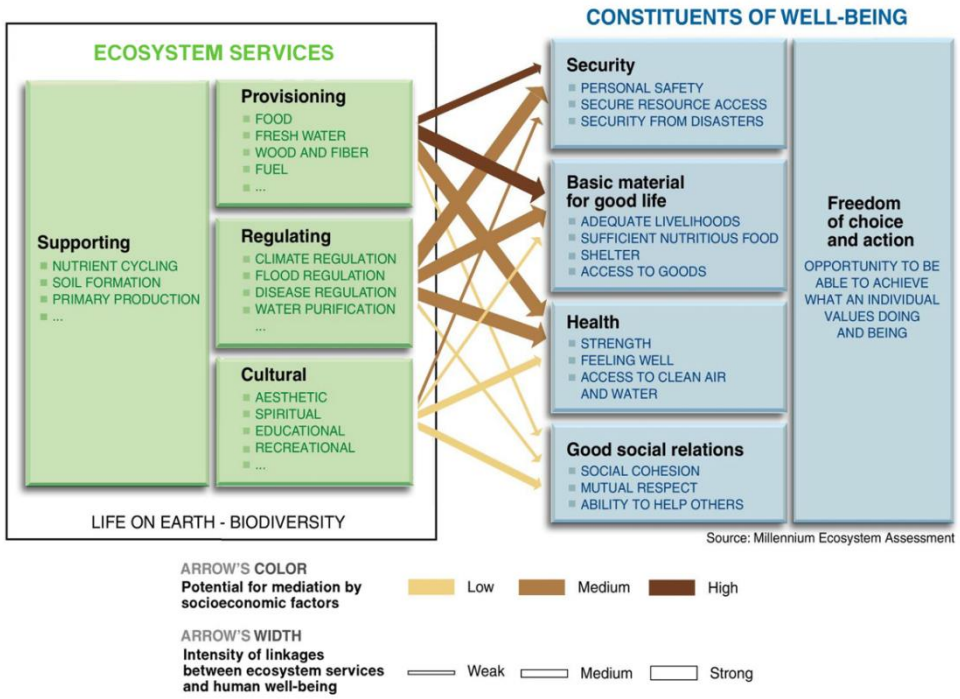

Figure 2 Ecosystem service framework showing the links between ecosystem services and components of human well-being. The strengths of these linkages are indicated as is the potential for mediation by socioeconomic factors.

Corvalan, C. F., Hales, S., & McMichael, A. A. J. (2005). *Ecosystems and human well-being: health synthesis*. World Health Organization.

There is increasing interest in the relationship between the natural environment and health due to the rapid changes which are being seen in the natural world. Globally, environmental change is placing pressure on the natural world and causing the degradation of ecosystem services (Myers & Patz, 2009). Although anthropogenic changes to the environment have so far been beneficial to human health, climate change is having unpredictable consequences, causing more frequent natural disasters such as famines and droughts as well as increasing the occurrence of many infectious diseases. Whilst the effects of changes in more tangible ecosystem services such as food production are obvious, much less is known about intangible aspects such as recreational benefits and other cultural ecosystem services and how these may be affected by environmental pressures (Luederitz et al., 2015). Health is also being affected by the lifestyles which are causing damage to the natural world. Urbanisation and fossil fuel use are two culprits, allowing us to live sedentary lifestyles which increase the prevalence of many chronic diseases as well as driving climate change (Kovats & Haines, 2005; McMichael, 2000). It is future generations who will bear the brunt of anthropogenic changes to the natural world caused by society today (Corvalan et al., 2005; Graham, 2012).

The relationship between nature and human health is both large and complex, operating at a range of spatial and temporal scales. Spatially the relationship can be seen at the local level in the health benefits individuals gain from experiencing biodiversity in their daily lives, to ecosystem level, and finally at the global scale, in the relationship between human populations and the ecosystems surrounding and incorporating them. Temporally, even short periods of time spent experiencing nature can result in health benefits, whilst environmental degradation can have no immediate effects but damage public health in the long term.

The natural environment and health are prioritised differently in environmental and public health research but to fully understand the effect of the natural environment on public health requires the assimilations of ideas and perspectives from both disciplines. Research is needed to determine how natural environments, from habitat type to ecological health, affect human health, considering spatial scale and possible differences in the benefits populations may receive from the natural environment compared to the relationship of individuals with nature. Further understanding of the links between nature and human health will inform the conservation and restoration of natural spaces and enable interventions with co-benefits for the environment and health (Ford et al., 2015; Tzoulas et al., 2007).

1.3 Evidence for the nature-health relationship

1.3.1 Physical and mental health benefits from the natural environment

Contact with nature can be divided into three main types of interaction (i) indirect (ii) incidental and (iii) intentional (Keniger et al., 2013). Whether the interaction is indirect, a view from a window for example, an incidental contact such as living near a park and walking through it to work, or an intentional exposure such as exercise, contact with nature has been found to have positive impacts on all aspects of individual health, from the physical to the psychological (Keniger et al., 2013; Ulrich, 1984).

Many studies have examined the relationship between the quantity of green space, the area in the neighbourhood or distance to the nearest space from a person's home, or the quality of green space, and health. Having a greater proportion of green space in the neighbourhood has been associated with reduced mortality; a recent systematic review found the effects of this positive relationship were greatest for cardio-vascular mortality (Gascon et al., 2016). Studies in the UK have found that increased green space is associated with lower mortality from circulatory diseases (Mitchell & Popham, 2008), and cardiovascular and respiratory diseases (Richardson & Mitchell, 2010), but not lung cancer. The major cause of lung cancer is an individual-level risk factor, cigarette smoking, so it is unlikely to be connected with green space exposure. A cohort study in Canada reported similar findings for respiratory disease (Villeneuve et al., 2012). However, a study from New Zealand found no relationship between green space and mortality (Richardson et al., 2010), so this association may be dependent on factors such as urban form which differs between countries.

There is also evidence that neighbourhood green space is associated with better physical health. Studies have found that neighbourhoods with more green space have a lower rates of Type 2 diabetes in the UK (Bodicoat et al., 2014), and Australia (Astell-Burt et al., 2014), whilst research measuring the cortisol levels of people in deprived communities has indicated that individuals living in greener neighbourhoods have lower stress levels (Roe et al., 2013; Ward Thompson et al., 2012). There have also been reviews which suggest that people living in greener areas are less likely to be obese (Lachowycz & Jones, 2011), and that contact with nature can lead to reduced heart rate and blood pressure (Pretty et al., 2011).

A large number of studies have investigated the association between green space and general and mental health. A review of green space and perceived general health by van den Berg et al. (2015) showed that quantity and proximity to green space were both related to positive health outcomes, whilst Gascon et al. (2015) found evidence that long-term exposure to green environments is linked to better mental health. At the neighbourhood level, higher areas of

green space have been associated with lower rates of anxiety and mood disorders (Nutsford et al., 2013), a lower risk of psychological distress (Francis et al., 2012), a greater ability to manage stressful life events (van den Berg, Maas et al., 2010), and better general and mental health (de Vries et al., 2003; de Vries et al., 2016). Although most studies are cross-sectional, there is some evidence from studies of longitudinal panel data; these have found that people from greener neighbourhoods have lower levels of mental distress and higher well-being (White et al., 2013a), and that moving to a greener neighbourhood leads to better mental health (Alcock et al., 2014).

1.3.2 Benefits of green space are dependent on demographics and use

Whilst there is increasing evidence that people who live near to green spaces are healthier than people who do not, it is difficult to separate causation and selection (de Vries et al., 2003; Ord et al., 2013). For example, house prices in greener neighbourhoods are higher than those in less green areas (Luttik, 2000), and health is related to socioeconomic position (Ansari et al., 2003), so healthier people may be living in greener areas but this does not mean green space is benefiting health. There are a range of factors such as age, gender, and socioeconomic position which need to be considered when investigating the benefits people derive from green space (Lachowycz & Jones, 2013).

It appears that green space may affect the health of men and women differently. Studies have found male cardiovascular and respiratory disease decreases as green space increases (Richardson & Mitchell, 2010), and that living in a greener neighbourhood is associated with lower cortisol and therefore stress levels only in women (Roe et al., 2013). This may be due to be due to differences in use of green spaces by different genders or other factors such as age. Astell-Burt et al. (2014) found in a longitudinal study that green space was associated with better mental health only for men, but that when age was considered, benefits emerged for older women.

Evidence also suggests that access to green space could reduce the impact of socioeconomic status on health. Greener neighbourhoods have lower levels of income-related health inequality for mortality (Mitchell & Popham, 2008), and mental health (Mitchell et al., 2015), and people with the lowest likelihood of having good general health benefit most from moving to a greener neighbourhood (Weimann et al., 2015).

Investigations of the health benefits of quantity of neighbourhood green space rarely measure whether spaces are visited by local residents, but the possibility of a dose-response relationship between nature and health has been proposed (Shanahan et al., 2015). Studies have shown that longer visits to nature are more restorative (White et al., 2013b), associated with lower rates of depression and high blood pressure (Shanahan et al., 2016), better mental and social health,

and increased physical activity (Cox et al., 2017a; van den Berg et al., 2016). A review by Bratman et al. (2012) has suggested there is a need for further investigation of the effects of visit characteristics on health outcomes. White et al. (2013b) found visiting natural environments with children led to a less restorative visit, but that activity type had no effect. There is some evidence that more vigorous activities such as running are linked to greater happiness than more sedentary activities such as gardening but this difference is very small (MacKerron & Mourato, 2013).

Although more evidence is needed regarding the effect of visit characteristics, a range of social and demographic factors affect the green space-health relationship. These have been incorporated into frameworks regarding the green space-health relationship (Lachowycz & Jones, 2013); they will be considered as confounding factors in this thesis when investigating the benefits people derive from visiting freshwater blue space at the population level.

1.3.3 The role of environment type and quality in benefitting health

Recently there has been interest in the environment beyond green space, including the role that different types of natural environment might play in benefiting health, the location of this space in the rural or urban environment, and the quality. Studies have even considered the benefits of incidental greenery, such as street trees, which have been linked to better general and mental health (de Vries et al., 2013).

Lovell et al. (2014) found in their review that although the evidence is currently limited, the biodiversity of the natural environment may affect the health benefits it provides. A positive relationship with biodiversity is present at a range of spatial scales: Wheeler et al. (2015) indicated that bird species richness was associated with good health at a national level, and at a neighbourhood level, well-being has been associated with species richness and abundance of birds, and density of plants (Luck et al., 2011). Studies of individual park users have had mixed results, whilst Fuller et al. (2007) found that plant and bird species richness was linked to psychological well-being, results from Dallimer et al. (2012) indicate that the biodiversity people perceived to be present was associated with their well-being but not the actual biodiversity of the space. Greater vegetation cover and afternoon bird abundances, natural characteristics that people are likely to experience, have also been associated with lower prevalence of depression, anxiety, and stress (Cox et al., 2017a), suggesting that aspects of nature which people perceive or experience benefit health. The complexities of human relationships with nature will be explored in this thesis through discussions with individuals regarding their experiences and opinions of nature.

Although most research concentrates on green space, there is evidence that different types of environment, including woodland, arable land, improved grassland, and blue spaces, are linked to better health (Wheeler et al., 2015). Whilst Alcock et al. (2015) did not find an association between environment type and mental health, they did find differences in mental health in people who moved to a coastal, mountain, or improved grassland environment during the study, suggesting different habitats might be providing different health benefits. There are also studies surrounding the health benefits of coastal blue space. Visible (coastal) blue space is associated with lower rates of psychological distress (Nutsford et al., 2016), whilst people living on the coast tend to be in better health (Wheeler et al., 2012; White et al., 2013c). Coastal visits have been found to be more restorative than visits to other natural environments (White et al., 2013b), whilst people visiting natural habitats, particularly coastal environments, are happier compared to those visiting urban environments, (MacKerron & Mourato, 2013). Investigation of coastal blue space indicates that benefits arise from visiting natural environments containing water. However, there has been little research into whether these benefits arise in freshwater environments, a topic which will be addressed in this thesis.

1.4 Mechanisms explaining the benefits of contact with nature

A range of mechanisms have been proposed to explain the relationship between the natural environment and health (Kuo, 2015). These can be divided into four main groups: environmental; physical activity; social; and psychological (Hartig et al., 2014).

Environmentally, green spaces are thought to improve the physical environment in which people live in a number of ways. Green spaces can reduce urban heat island effect, whilst the vegetation present in these spaces can improve air quality by reducing levels of pollutants, such as nitrogen oxide gases and particulate matter, in the air (Hartig et al., 2014; Kuo, 2015). There is also evidence that contact with green spaces exposes individuals to a wide range of microbes which are essential to ensure effective immunoregulation (Rook, 2013; Sandifer et al., 2015).

Physical activity in itself has physical and mental health benefits (Barton & Pretty, 2010), so by providing a space in which people can participate in exercise, green spaces are thought to benefit health. A meta-analysis found that, compared to exercise in other environments, exercise in green spaces improved self-esteem and mood (Barton & Pretty, 2010). There is also evidence that people who live in greener neighbourhoods exercise more (Coombes et al., 2010). Some studies have found that physical activity offers an explanation for the association between green space and mental health (Annerstedt et al., 2012; Astell-Burt et al., 2013), and physical health (Sugiyama et al., 2008). However, others have found that it plays no or only a small part as a mechanism explaining the relationship (de Vries et al., 2013; Richardson et al., 2013b).

Like physical activity, social interaction as a mechanism explaining the green space-health relationship considers the provision of space important. This mechanism proposes that green spaces provide areas in which people can interact with family and friends, gaining health benefits from these interactions. Whilst there has been far less study of social interaction as a mechanism (Hartig et al., 2014), there is evidence that it partly explains the green space-health relationship (Maas et al., 2009; Sugiyama et al., 2008).

Theories surrounding the psychological benefits of nature stem from the Biophilia hypothesis, first proposed by Wilson in 1984, which suggests that humans have a biologically based need to associate with nature and that this is essential for well-being (Kellert & Wilson, 1993). The central tenet, that humans evolved in the natural environment and are therefore evolutionarily adapted to prefer landscapes which offer them the best chance of survival, has been incorporated into several psycho-evolutionary theories (Bratman et al., 2012; Gobster et al., 2007; Ulrich et al., 1991).

These theories incorporate evolutionary thinking but focus on the restorative effect of nature. Attention restoration theory (ART) was developed by Kaplan and Kaplan (1989), and proposes that many activities in modern society need directed attention, which requires excluding other stimuli and over time leads to mental fatigue; contact with the natural environment alleviates this mental fatigue (Hartig et al., 1991). The second view was proposed by Ulrich et al. (1991) and is often known as psychophysiological stress recovery theory (PSRT) (White et al., 2013b). Ulrich et al. (1991) suggested that two responses to nature evolved in early humans, both involving the autonomic system, a restorative response following stressful activities, and a positive response to nature which favoured well-being and survival if they had not been under stress. Both theories postulate that the response to nature occurs without thought, but ART focuses on the cognitive response to the environment whilst PSRT focuses on the emotional and physiological responses to the natural world (Bratman et al., 2012).

Studies examining all the mechanisms have produced mixed results. Some have found that psychological benefits and social support are mechanisms explaining the green space-health relationship (Dadvand et al., 2016; de Vries et al., 2013), whereas Triguero-Mas et al. (2015) found physical activity and social interaction did not explain the relationship between green space and health. It is likely that a range of mechanisms, from environmental to psychological, are linked in causing the positive health outcomes seen from contact with nature (Hartig et al., 2014).

1.5 The ecological perspective

Humans have changed the environment throughout history in increasingly widespread and damaging ways: population growth, climate change, and changing land use have led to a deterioration of ecosystem services in many habitats, particularly over the last fifty years (Corvalan et al., 2005; Myers & Patz, 2009). Despite the degradation of the environment, in many countries people's well-being has increased (Raudsepp-Hearne et al., 2010). The reasons for this concern the social factors, particularly people's living and working conditions, which play a key part in determining health (Fig. 1). Technology allows the provision of services such as irrigation and flood control, and globalisation means that products such as food and timber can be imported from elsewhere (Raudseppe-Hearne et al., 2010). Societies are therefore insulated from the impacts of the degradation surrounding them.

However, this insulation is distributed unequally: less economically developed countries do not always have the resources to either import goods or implement technologies so are more likely to suffer the consequences of environmental change (Whitmee et al., 2015). Whilst it is likely that the first consequences suffered by societies currently insulated from environmental change will be economic, humans are still reliant on ecosystem services. If they continue to decline then people in more economically developed countries will be affected in other ways too.

1.5.1 Negative impacts of the environment on health

Many of the negative impacts of the natural world on human health are the result of events such as natural disasters and disease epidemics (Bratman et al., 2012; Whitmee et al., 2015). The impacts of these events extend beyond the immediate effect of the initial disaster and can cause long-term health problems (Aronson et al., 2016). Different groups of people may be affected in different ways; an individual's health may be directly impacted through injury or illness, or indirectly, through population displacement or economic disruption (Whitmee et al., 2015).

Disasters such as earthquakes are unavoidable but extreme weather events and epidemics are affected by ecosystem services such as climate regulation and disease regulation (Corvalan et al., 2005). In recent years there has been an increase in extreme weather events which has been attributed to climate change, a trend which is likely to continue (Kovats & Haines, 2005). Estimations by the WHO suggest that one quarter of disease worldwide is caused by environmental change (Pattanayak et al., 2009; Keune et al., 2013), and it is thought that an increase in human diseases in the near future is likely (Corvalan et al., 2005; Keune et al., 2013). Biodiversity loss has already resulted in an increase in cases of Lyme disease in the north-eastern forests of the USA as alterations in species dynamics mean more people are exposed (Myers & Patz, 2009).

Even everyday exposure to the environment can be detrimental to health due to noise and pollution (Keniger et al., 2013). Many of these negative health outcomes are the result of contact with harmful substances, whether these have a natural or anthropogenic origin. Air pollution can cause asthma and other respiratory illnesses, its sources are wide-ranging and include pollen, bracken spores, and biogenic volatile organic compounds (BVOCs) from trees as well as emissions from industry and transport (Pretty et al., 2011). Industry and agriculture expose people to pollutants, whether in the air, soil, or water; prolonged exposure can lead to cardio-respiratory illness and other chronic diseases (Marmot, 2010; McMichael, 2000).

1.5.2 Urbanisation and disconnection from nature

Many anthropogenic changes only affect ecosystem services such as food production and water regulation in a visible way (Raudseppe-Hearne et al., 2010). However, although regulating and cultural aspects of ecosystem services are far less tangible, their disruption still has detrimental effects on public health (Corvalan et al., 2005; Chan et al., 2012). Urbanisation is an illustration of this point. Currently more than half of the world's population lives in an urban area, a proportion which is higher in developed countries, and predicted to increase worldwide (WHO, 2010). Urbanisation has led to lifestyle changes including increases in sedentary behaviour (Soga & Gaston, 2016; Tellnes, 2005), meaning urban residents are more likely to suffer from chronic and non-communicable diseases such as heart disease and obesity (Shanahan et al., 2015; Tellnes, 2005). Sedentary lifestyles and the resulting illnesses are thought to cost the NHS £8.2 billion annually (Allender et al., 2007). Increases have also been seen in the prevalence of mental illnesses such as depression (Alcock et al., 2014).

There has been a reduction in the direct contact people have with nature in their everyday lives due to urbanisation (Soga & Gaston, 2016). Studies show that a small proportion of people make the majority of visits to urban nature (Cox et al., 2017b) and that people are less likely to visit protected areas such as SSSIs than non-designated areas for recreational purposes (Hornigold et al., 2016). This lack of exposure is thought to be a contributing factor to the poor health of urban populations, as if people are not visiting natural spaces they cannot access benefits from these areas. Increasing urbanisation also threatens the ecological health of urban natural spaces and therefore their ability to provide cultural ecosystem services so may reduce the benefits people receive from these areas (Botzat et al., 2016; Ives & Kelly, 2015).

The poor quality of urban natural spaces raises the issue of a shifting baseline: people's expectations of the natural environment are defined largely when they are young so, if children are exposed to few or degraded natural environments, they will not expect high quality environments (Miller, 2005). There is concern that if people place little value on nature as adults

they will be less likely to support conservation and restoration or engage in pro-environmental behaviours that might prevent environmental degradation of spaces which are beneficial to them (Dunn et al., 2006).

1.5.3 Ecological restoration and its benefits for the environment and human health

Ecological restoration aims to return degraded natural environments to as near their natural state as possible. Although its aim is environmental, by ensuring the provision of ecosystem services, it offers the opportunity to benefit human populations. In urban areas, ecological restoration of remnant patches of natural habitat can provide areas of high quality nature within the living environment, allowing people to experience and connect with nature (Dunn et al., 2006; Miller, 2005). International organisations such as the United Nations Environment Program (UNEP) have made commitments to engage in ecological restoration (Baker et al., 2013). Freshwater blue spaces are particularly vulnerable to damage from human activities, in both rural and urban environments (Pander & Geist, 2013). In the UK there are examples of restorations around urban rivers including the river Don in Sheffield, river Mersey in Liverpool, and the rivers Tyne and Wear in Northumberland (Everard & Moggridge, 2011).

A culvert on the River Quaggy in London was removed in 2002 and its flood plain restored, along with the park surrounding it (The River Restoration Centre, 2009). A survey showed that three quarters of local residents used the park more after restoration and that it was important to the local community as a place for walking and as an area in which young people could play sport (Chartered Institution of Water and Environmental Management, 2012; The River Restoration Centre, 2009). Similar changes in patterns of use and perception of the space have been seen as a result of the restoration of the river Skerne in north-east England (Åberg & Tapsell, 2013), and the restoration of green space in Glasgow (Ward Thompson et al., 2013). However, it is possible that ecological interventions might have negative impacts on human health. Restoration changes the environment and environmental change can disrupt people's sense of identity and place; these values underlie various aspects of human health (Gifford, 2014). Ecological restorations are in themselves natural experiments, they provide the chance not only to investigate how improving the ecological quality of a space leads to social benefits, but also exploration of people's perceptions of other characteristics of the natural environment such as its management, and whether this changes the use or benefits provided by a space.

Through studying ecological restoration, this thesis aims to investigate both its ecological and social benefits. By concentrating on an urban restoration, it will also explore how problems resulting from urbanisation and disconnection from nature could be addressed using urban natural spaces.

1.6 Methods and approaches for exploring the role of the environment in benefitting health

Although there is increasing evidence demonstrating that the natural environment is beneficial to human health, there is still much about this association which is not understood. Currently, studies of the green space-health relationship tend to use quantitative and cross-sectional methods (Lachowycz & Jones, 2013), whilst most experimental studies take place in laboratory settings, which imposes a limiting factor as there is no exposure to actual nature. Research into the association between the natural environment and health is inherently interdisciplinary and needs therefore to utilise the range of methods employed by these different disciplines (Kabisch et al., 2015). Alongside quantitative methods, qualitative approaches can provide valuable information, particularly when investigating the benefits of the natural environment to the individual, as relationships may be complex and involve social and cultural as well as health factors (Maxwell & Lovell, 2017).

Studies of the association between nature and health have paid more attention to health outcomes than the role of the environment in shaping these outcomes, and the effects of environmental characteristics such as the type or quality of these spaces (Douglas, 2012; Jorgensen & Gobster, 2010; Sandifer et al., 2015). Studies indicating the importance of biodiversity and environment types beyond green space demonstrate the need for investigation of the benefits provided by different types of natural environment (Lovell et al., 2014; Wheeler et al., 2015). There is increasing evidence of the benefits of coastal blue spaces, which suggests that the presence of water in the natural environment may benefit health, but water has received little attention in freshwater settings.

Spatial scale needs consideration when investigating both ecological restoration and the role of different types of environment in benefitting people. Whilst patterns may be seen at the population level, individuals' interactions with natural spaces occur within a wider socio-environmental setting which affects their perceptions of the environment and means the benefits received from it differ from person to person (Conradson, 2005). The complexities of people's relationships with nature at an individual level may mean that the effects of interventions, such as increasing access to ecologically healthy green space, are small but these could translate into large benefits at the population level (Pett, et al., 2016).

1.7 Summary of thesis aims and structure

The research in this thesis aims to explore characteristics of the natural environment and their role in providing benefits for human well-being at different spatial scales. Specifically it investigates the benefits that people obtain from freshwater blue space at the national and local level, whether these benefits differ according to the ecological health or management of these

spaces, and the potential to derive co-benefits for the environment and health from this relationship.

Chapter Two is a scoping review of quantitative studies investigating green space and health. Socioeconomic position is a determinant of both living near green space and of health so this review determines whether socioeconomic status has been considered as a confounding factor in studies and the relationship found between green space and health where it has been included in analyses. Green space was the focus because most studies of the nature-health relationship investigate green space and it is often used to refer the natural environment more generally so encompassed blue space studies. The review also examined the measurement of green space and health in existing studies.

Chapter Three investigates the benefits people obtain from visiting freshwater blue space at a national level, through quantitative analysis of a commissioned module on visits to freshwater blue space in a UK-wide survey. Three benefits: physical activity; social interaction; and psychological benefits; are examined, each relating to a mechanism thought to explain the health benefits of visiting the natural environment. Logistic regression models are used to explore the sociodemographic factors which determine the frequency, location, and benefits people derive from their visits to blue space, as well as the importance of nature to their visit.

Chapters Four and Five concentrate on the local level, using data I collected from an ecological restoration project, an urban river restoration in a large UK city. Chapter Four evaluates the success of this project from an ecological and social perspective through comparison with an unrestored river. Macroinvertebrate data is used to determine the ecological health of the river and whether it has been improved by restoration. Focus groups with local users discuss the benefits they feel they derive from the natural space around the restoration as well as their concerns regarding the project.

The views of local users are supplemented in Chapter Five, by data collected from providers, people who manage or ensure the provision of natural spaces, and commentators, who deliver the evidence surrounding the health benefits of natural environments. Framework analysis is used to compare and contrast the views of these different groups regarding urban natural spaces and how the management and presence of built features within these environments can connect people with nature.

The discussion (Chapter 6) brings these components together and identifies common themes, making recommendations for areas of further research. It discusses the contribution of this research to understanding how the natural environment can benefit human health and well-

being, and the implications regarding opportunities to derive co-benefits for the environment and health.

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Chapter 2 Does socioeconomic position explain the association between green space and health?

Preface

Research shows that exposure and access to green space is beneficial for human health (Hartig et al., 2014). Studies providing evidence for this relationship come from a range of disciplines which has led to the use of a variety of methods and study designs as well as diverse definitions of green space, encompassing everything from local parks to the wider ecosystem (Gascon et al., 2015; Tzoulas et al., 2007). Despite these differences between studies it is important that they consider socioeconomic position as a confounding factor as it is a major determinant of both whether a person is likely to live in a greener neighbourhood and their health. This chapter uses a scoping review to identify literature on the green space-health relationship, investigate whether they have considered socioeconomic confounding and, if so, the relationship found between green space and health. It also investigates how existing studies measure green space and health.

This chapter is written as a short communication for submission to the journal *Health and Place*.

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Abstract

Evidence that exposure to green space is associated with better health has important policy implications. As a factor related both to health and to use of green space, *socioeconomic position (SEP)* may confound the association; it may also moderate its effect. We found no review of this key issue. Our scoping review of published studies therefore investigates whether the green space-health association is robust to adjustment by SEP. One hundred and seventy-one studies published between 1980 and 2017 were identified through electronic databases (Web of Science and PubMed) and citation searches. Information was extracted on the measurement and control of SEP and the association between green space and health reported post-adjustment for SEP. Over 65% of studies adjusted for SEP; the majority of these (68%) reported a positive association between green space and health. Our analysis provides further evidence of the health benefits of green space.

2.1 Introduction

There is a growing body of evidence that suggests living in a neighbourhood with a higher proportion of green space is associated with better physical and mental health (Gascon et al., 2015; Lee & Maheswaran, 2011; Lovell et al., 2014; van den Berg et al., 2015). A positive relationship between green space and health offers the potential for health co-benefits for policies to promote and protect green space. Countries including the UK, Denmark, and Germany have implemented green space management policies in urban areas which aim to utilise the health benefits of these spaces (ten Brink et al., 2016). In Scotland, the NHS Greenspace initiative provides an example of collaboration between public health and environmental organisations, including NHS Scotland and Forestry Commission Scotland, which conserves green space to benefit public health. Since being established in 2007 this project has improved areas of NHS estate and successfully encouraged their use by patients to facilitate physical activity and contact with nature (Forestry Commission Scotland, 2014).

Whilst the link between green space and health has important implications for policymaking the evidence needs to be assessed to determine whether the association is robust. Reviews have identified various limitations of current research and suggested the application of a wider variety of methods and measures including the use of natural experiments and longitudinal studies to add to the evidence base (Lovell et al., 2014; Lee & Maheswaran, 2011). The association may also be explained by other factors, particularly those associated both with an individual's exposure to green space and with their health. As a major determinant of health that is also related to access to and use of green space, SEP may confound the association or moderate its effects (Mitchell & Popham, 2008). Analyses of the association between green space and health

should therefore take account of SEP, reporting whether they measured SEP and whether they adjusted for SEP, to ensure that positive associations between green space and health are not the results of socioeconomic confounding (van den Berg et al., 2015).

Lee & Maheswaran (2011) noted in their review that many studies failed to consider confounders, and whilst the importance of considering SEP has been highlighted by recent systematic reviews (Gascon et al., 2015; van den Berg et al., 2015), the numbers of studies including SEP as a confounding factor has not been discussed or considered as the focus of any review. Scoping reviews provide a preliminary assessment of research fields (Arksey & O'Malley, 2005), so are a suitable method to address this issue. Our scoping review of published studies investigates whether the green space-health association is robust to adjustment by SEP.

2.2 Methods

A scoping review, based on methods detailed in Arksey & O'Malley (2005), was undertaken. We searched electronic databases Web of Science and PubMed for studies published between 1980 and 2017, using key terms relating to public health, green space and nature; nature was included as widespread usage of green space to refer to a green living environment is relatively recent. Further relevant studies were identified from citation searches of systematic reviews located during the database search (Lovell et al., 2014; Lee & Maheswaran, 2011; Gascon et al., 2015; Gascon et al., 2016; van den Berg et al., 2015).

Inclusion criteria were quantitative studies of adults in high-income countries, published in English, which included (i) a measure of green space, whether as a category, quantity, or quality (ii) access and/or exposure to green space and (ii) physical and/or mental health as a primary outcome.

Relevant data were extracted from the studies (research question, country, location, population, green space measure, health measure, SEP measure and adjustment, green space-health association) by one reviewer (SDB) and a random sample was then checked by other members of the team (HG, PW).

We grouped the green space measures into broad categories: 'quantity' refers to the percentage or area of green space; 'distance' to the distance to green space from a residence; 'urbanity' refers to where a green space is placed on a scale from urban to rural, normally measured by the number of dwellings in a given area; 'type' refers to land use type, for example park, field, or woodland; 'setting' refers to specific green space locations, such as those used by an experimental study; and 'quality' refers to biodiversity or assessment of environmental characteristics including maintenance and naturalness. Where specific audit tools, such as the

Scania Green Scale (SGS) were used, or data came from a known source, for example the General Land Use Database (GLUD), this is indicated.

We extracted information on the instrument or scale used to measure health when this was a validated measure; if a standard measure was not used the category of health measured, for example 'psychological', was given along with a description of its measurement.

We recorded the green space-health associations as 'positive' or 'negative' where they were, respectively, positive or negative for all the health domains investigated in the study and 'no relationship' when no associations were reported between green space and health. Where some associations were positive and some negative or showed no relationship, we recorded the studies as 'inconclusive'.

2.3 Results

One hundred and seventy-one studies with data on green space and health, reported in 169 papers, were included in the review (Appendix 1). Four studies were published between 1980-2000, 19 from 2000-2009 and 148 since 2010, indicating increasing interest in this area.

The majority of studies were based in the UK (35 studies), USA (31 studies), Australia (18 studies), and the Netherlands (15 studies). Other study locations included Denmark, Finland, Japan, New Zealand, and Sweden. Of the 171 studies, 84 used an urban setting; other settings included rural, or both urban and rural, settings, and locations such as a laboratory or hospital.

Most studies (129) used an observational study design, 115 of these were cross-sectional and 14 were longitudinal. The remainder used experimental or quasi-experimental designs (42). The most common objective was to examine associations between neighbourhood green space and a dimension of health; accordingly, local residents were the most widely-studied population.

Green space was generally measured as a quantity, 104 studies measured quantity, for 63 it was the sole measure of green space; other methods included surveys of species richness, or using indices of quality such as the SGS. Health was most often measured using established survey instruments, such as the General Health Questionnaire (GHQ-12), and self-assessed general health; physiological assessments such as heart rate and blood pressure were also used. Most studies measured both physical and mental health (80); of those that measured only one kind of health, 44 measured mental health and 47 solely physical health.

Most studies (100) used either one or two measures of health, 61 used three to five different measures, 9 studies used five to eight measures and one used 10 measures. Studies measuring both physical and mental health were the most likely to use a range of measures, 33 used four

or more. Of the studies which measured mental health none used more than four measures and 28 used only one measure.

SEP was measured in 129 (75.4%) studies, the majority at either individual or area level. Forty studies considered both, using measures such as education level and area-level deprivation. Overall, 118 (69.0%) studies adjusted for SEP (Table 1). Thirty-seven of the 42 experimental studies did not measure and adjust for SEP. Sixteen of the observational studies either did not measure it or did not control for it.

Most studies (118, 68.4%) reported a positive association between green space and health (Table 1). Fourteen studies (8.2%) found no association and 36 (21.1%) were inconclusive. Four studies (2.3%) found a negative association.

Of the studies reporting positive associations, 56 measured physical and mental health, 31 mental health only and 30 physical health only. Similarly, of the 36 inconclusive studies, 10 measured both physical and mental health whereas half (7) of the studies which found no association measured physical health. Fifty-four of the 71 studies using three or more measures of health reported a positive association between green space and health.

All studies reporting a negative relationship, 10 of the 14 studies reporting no relationship and 24 of the 36 inconclusive studies adjusted for SEP. Of the 118 studies controlling for SEP, 80 (67.8%) reported a positive association between green space and health. Studies which controlled for SEP and reported a positive association measured both mental and physical health primarily (34) whilst 22 measured mental health only and 24 solely physical health.

Table 1 Summary of characteristics and findings of papers considered in the scoping review (n=171).

	Number of papers	Percentage
Study Design		
Experimental or quasi-experimental	42	24.6
Cross-sectional	115	67.3
Longitudinal	14	8.2
Setting		
Urban	84	49.1
Rural	2	1.2
Both	67	39.2
Other	18	10.5
Measurement of SEP		
Yes	129	75.4
No	42	24.6
Type of Measure		
Individual	60	46.5
Area	29	22.5
Both	40	31.0
Adjustment for SEP		
Yes	118	69.0
No	53	31.0
Relationship		
Positive	117	68.4
Inconclusive	36	21.1
No relationship	14	8.2
Negative	4	2.3
Relationship Post-Adjustment		
Positive	80	67.8
Inconclusive	24	22.9
No relationship	10	8.5
Negative	4	3.4

2.4 Discussion

Although nature has been considered beneficial to human health for centuries, the relationship was thought to be too subjective to measure (Jorgensen & Gobster, 2010). Early studies of the green space-health relationship drew on psychology and used experimental approaches. We found that the majority of studies used observational study designs, which is indicative of the move to investigate whether the association between nature and health uncovered by early research persists in community settings using epidemiological approaches (Table 1).

Disciplinary orientation and study design influence the selection of co-variates. Adjustment for SEP is standard practice in public health research but less firmly established in psychology where experimental designs and non-representative samples, like students and patients, are used more widely (Keniger et al., 2013). This group of studies was least likely to report post-adjustment associations between green space and health.

Some studies gave limited information on the measures used, for example, the source of admin data was not always indicated. Studies differed in their definitions and measurement of green space and health; green space measures included measures of biodiversity, upkeep (e.g. maintenance, littering), and continuous measures such as urbanity. The lack of consensus on definitions within the field has been raised as an issue: green space itself has no standard definition, it varies between studies; the broadest definition includes natural and semi-natural areas, from streetscape greenery to parks and forests, found in urban and rural environments (Lachowycz & Jones, 2013; Mitchell & Popham, 2008).

Health was mostly self-reported, using questionnaires or scales such as the GHQ, for both general and psychological health; researcher-assessed measures such as blood pressure and heart rate were used less frequently. The number of health measures used by studies deserves consideration as although the majority of studies used few measures of health those which used several were more likely to report a positive green-space health relationship.

The majority of studies considered socioeconomic confounding. A range of socioeconomic measures were used, and concerns about measurement quality and precision have been noted by researchers in the field (Adams & White, 2003). Despite this, post-adjustment associations between green space and health were found across studies using different measures (Appendix 1), giving confidence that associations are not a measurement artefact. That the positive association between green space and health is independent of SEP is also supported by the fact that all longitudinal studies in the review considered SEP and the majority found a positive relationship between green space and health.

The use of a scoping review may be considered a limitation as strategies for searching, study appraisal, and analysis therefore lack the rigour of a systematic review. However, they are well-suited for emerging areas of research, particularly those spanning disciplines and study designs (Arksey & O'Malley, 2005; Levac et al., 2010), so were considered appropriate for an initial assessment of this growing body of evidence.

2.5 Conclusions

An individual's SEP influences their health, their access and exposure to green space, and the health benefits they may derive from it (Lee & Maheswaran, 2011; Mitchell & Popham, 2008). SEP may therefore attenuate, in whole or in part, associations between green space and health reported in unadjusted analyses. We found that most studies took account of SEP; in the majority of these studies, a positive relationship between SEP and health remained after adjustment. It appears that associations between green space and health are independent of SEP-green space and SEP-health associations. Our analysis provides further evidence that green space has important benefits for health.

Policies which aid the conservation of the natural environment have the potential for health co-benefits as they can lead to improvements in public health. Studies have demonstrated that green space has greater health benefits for those with lower SEP than those with higher SEP indicating opportunities for green space policy to reduce social inequalities in health (van den Berg et al., 2015; Mitchell & Popham, 2008). Successful green space-health policies have already been implemented by a range of countries but there is scope for further development (ten Brink et al., 2016; Forestry Commission Scotland, 2014).

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Chapter 3 The importance of nature in mediating social and psychological benefits associated with visits to blue space

Preface

Studies investigating the relationship between the natural environment and health have concentrated on green spaces, but there are a wide range of environment types which could provide health benefits. People have been found to derive benefits from visiting coastal blue spaces (MacKerron & Mourato, 2013; White et al., 2013), suggesting environments with water are beneficial to human health. However, there has been little investigation of freshwater blue space. This chapter uses data from a UK-wide survey is to investigate the characteristics of visits to freshwater blue space, the benefits that people derive from visits to freshwater blue space, and the importance of nature to these visits.

This chapter is written in the style of the journal *Landscape and Urban Planning* and has been accepted for publication (4 June 2017).

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Abstract

There is increasing appreciation of the benefits associated with exposure to natural environments. However, most of the evidence relates to green space with much less on blue space. Drawing on data from a British survey of adults, we describe the characteristics of visits to blue space and investigate whether the benefits reported in studies of green space - physical activity, social interaction, and psychological benefits – are evident with respect to blue space. We also examine the importance of nature to people's visits to blue space and investigate the sociodemographic predictors of visit frequency and location, the benefits received, and the importance of nature to the visit. Social interaction and psychological benefits were the most important benefits obtained from visiting blue space. Socioeconomic status was a predictor of both frequency and location of visits and was also associated with identifying social interaction as the most important benefit. Respondents who reported psychological benefits as the most important benefit were more likely to find nature very important to their visit. The importance of nature in underpinning these benefits was relatively greater for older people compared with younger people. These findings highlight the social and psychological benefits obtained from visits to blue space, and provide new evidence on the importance of the natural environment in underpinning these benefits and enriching people's lives.

3.1 Introduction

Exposure to the natural environment can have a range of social and psychological benefits and contribute to physical and mental health (Gascon et al., 2016; van den Berg et al., 2015). This paper will investigate the benefits associated with visiting a specific environment type, freshwater blue space. Research has concentrated on green space, with studies tending to focus on the quantity of green space in people's living environment (van den Berg et al., 2015). A range of health benefits have been associated with living in a greener neighbourhood, including better perceived general health (de Vries et al., 2013), mental health (Richardson et al., 2013), happiness (van Herzele & de Vries, 2011), lower rates of cardiovascular disease (Richardson et al., 2013), and lower death rates (van den Berg et al., 2015; Villeneuve et al., 2012).

3.1.1 Mechanisms by which the environment affects health and associated benefits

A number of mechanisms have been proposed to explain the association between green space and health (Kuo, 2015). Many relate to environmental conditions, for example improvements in air quality and microclimate regulation, resulting from the presence of green spaces in the living environment (Kuo, 2015). In terms of people's visits to green spaces, three main mechanisms have been suggested which link activities in these areas to specific health-related benefits (de Vries et al., 2013; Hartig et al., 2014).

- Green spaces give people an area in which to be physically active, and people may also be more likely to exercise in these environments as they are aesthetically pleasing (de Vries et al., 2013; Maas et al., 2008; Richardson et al., 2013). This provides a health benefit of physical activity.
- Green spaces provide people with a space in which they can socialise with family and friends (de Vries et al., 2013). This provides a health benefit through social interaction.
- Green spaces facilitate relaxation, mental restoration and stress reduction (de Vries et al., 2013; van Herzele & de Vries, 2011). They therefore provide psychological benefits for health.

Of the three mechanisms and associated benefits, a review of the literature suggests the role of green space in facilitating relaxation and stress reduction (psychological benefits) appears to be most important in explaining the green space-health relationship (Hartig et al., 2014). Visiting green space more frequently has been associated with achieving the recommended amount of physical activity (Flowers et al., 2016), but physical activity does not appear to mediate the association between green space and health (Hartig et al., 2014). There is some evidence that socialising (social interaction benefits) may also be a mediator; for example, de Vries et al. (2013) found that perceived social cohesion and stress reduction mediated the relationship between streetscape greenery and health, but there are a limited number of studies which have investigated this (Hartig et al., 2014).

Whilst research has concentrated on the provision of green space and its proximity to the dwelling, recent studies have investigated the importance of the quality of this green space in providing benefits (Dallimer et al., 2012; van den Berg et al., 2015). Quality can refer to both the amenity value of green space, such as the maintenance and the provision of paths and other facilities including benches and play areas, or its biological attributes, for example the presence of wildlife or the biodiversity of the space (Lovell et al., 2014; van den Berg et al., 2015).

With respect to amenity value, studies suggest that residents in neighbourhoods in which green spaces have more amenities have better mental health (de Vries et al., 2013; Francis et al., 2012). Regarding the biological quality of the space, evidence indicates that, although the general public are fairly poor at accurately gauging the biodiversity of green space, the biodiversity they perceive is associated with their mental well-being (Dallimer et al., 2012). Studies have also found a link between objective measures of biodiversity, particularly plant and bird communities, and better mental well-being (Fuller et al., 2007; Luck et al., 2011). The majority of studies have focused on the psychological benefits of experiencing biodiversity but there is some evidence of increased physical activity in more biodiverse environments (Lovell et al., 2014).

The benefits obtained from natural environments may also depend on the type of natural environment (Hartig et al., 2014; Wheeler et al., 2015). Freshwater blue spaces - areas of standing or running water, such as rivers, lakes, and canals – are one type of environment which has been identified as needing further research (Foley & Kistemann, 2015; White et al., 2010). Our study aims to address this need by investigating the benefits of visiting freshwater environments.

3.1.2 Blue space, health and well-being

Qualitative studies have highlighted the value that people place on both freshwater and coastal blue spaces: water is associated with psychological benefits as well as having aesthetic value, providing a place for recreation and physical activity (Foley & Kistemann, 2015; Völker & Kistemann, 2011). However, a recent scoping review found that quantitative studies of the relationship between freshwater blue space and health are scarce (Gascon et al., 2015).

Studies from the UK and the Netherlands have shown that freshwater blue space availability is associated with better psychological and general health (de Vries et al., 2003; Wheeler et al., 2015), and, using a validated mental health scale, lower prevalence of mood and anxiety disorders (de Vries et al., 2016). There is some evidence that the distance of blue space from the home may affect this association, with water more than 1km from the home having a positive health effect but water less than 1km having a negative effect (de Vries et al., 2003).

One problem that studies of freshwater blue space have encountered is that of scale. Compared to green space, blue space is small in area and forms less than 2% of land cover in the UK (Gascon et al., 2015; White et al., 2013a). In comparison, Richardson & Mitchell (2010) found the average area covered by green space in urban areas in the UK is 46.2%. This makes it difficult to determine any effect blue spaces may have on health and well-being in large-scale studies and has often led to the inclusion of freshwater blue space with green space in analyses (Gidlow et al., 2016; Triguero-Mas et al., 2015).

The coastal environment covers a much larger area and, as a result, there is a greater range of evidence relating to health benefits of coastal blue space. Living near the coast has been found to be positively associated with both general and mental health in studies using cross-sectional and longitudinal survey data (Wheeler et al., 2012; White et al., 2013), and higher proportions of visible coastal blue space have been linked with lower rates of psychological distress (Nutsford et al., 2016).

Studies in England investigating coastal blue space and health have used data from the Monitor for Engagement with the Natural Environment (MENE) survey. Running since 2009, the MENE

survey collects data on visits to the natural environment, asking participants to concentrate specifically on their last visit and their activities, motivations, and attitudes to visiting natural spaces (Natural England, 2015a).

Evidence from the survey indicates that visits to the coast are perceived to be more restorative than visits to other natural spaces, such as urban parks and playing fields, and that people living nearer the coast are more likely to meet physical activity guidelines (White et al., 2013a; White et al., 2014). However, the questions asked in the MENE survey limit the scope of the analyses which can be undertaken. The survey does not have a question which includes all three benefits - physical activity, social interaction, and psychological benefits – as outcomes of the visit.

We found only one study which has explored whether the mechanisms affecting green space and health also apply to blue space. Triguero-Mas et al. (2015) found no relationship between freshwater or coastal blue space and health but did find that access to these blue spaces was associated with increased social interaction.

Existing studies of both freshwater and coastal blue space and health have considered the contribution of social factors, including age, gender, socioeconomic status, household composition, and urbanity (de Vries et al., 2016; Triguero-Mas et al., 2015). The green space literature also indicates that factors such as socioeconomic status (Mitchell & Popham, 2008), age and gender (Astell-Burt et al., 2014; Richardson & Mitchell, 2010), influence the relationship between the natural environment and health.

Our study investigates whether the benefits associated with the mechanisms thought to mediate the green space-health relationship are evident in people's visits to freshwater blue space. The pathways between time spent in blue space and these benefits are represented in Figure 1. We considered sociodemographic factors known to influence the relationship between the natural environment and health and their effect on the characteristics of visits to blue space, the benefits people received from their visit, and the value people placed on nature when visiting blue space (Fig. 1).

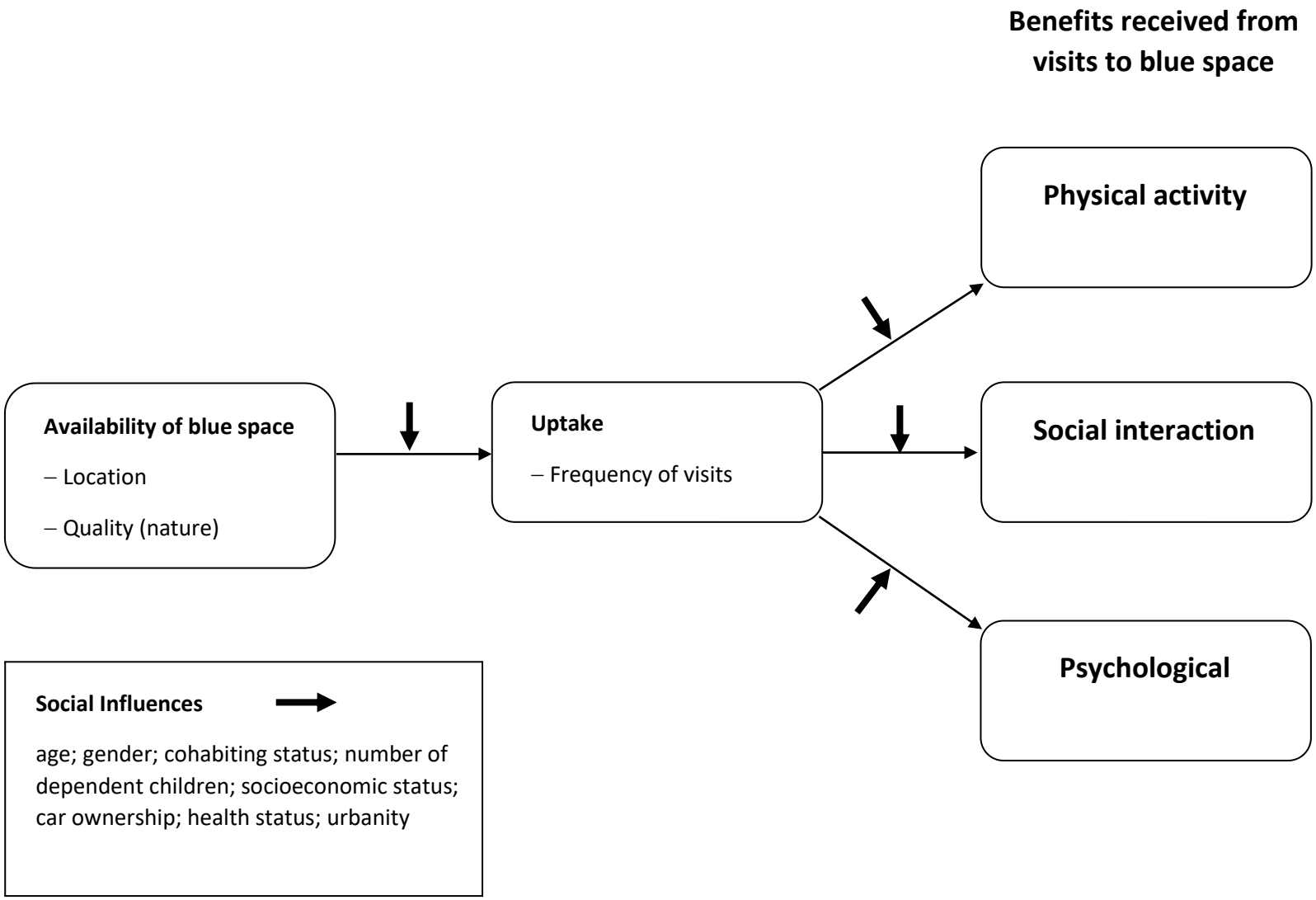

Figure 1 Conceptual model showing the benefits obtained from visiting blue space and possible influences on the relationship, adapted from Hartig et al. (2014).

3.1.3 Study objectives

We had three objectives: (i) to describe the characteristics – frequency and location - of visits to freshwater blue space; (ii) to investigate which benefits identified in studies of green space are evident for blue space; and (iii) to examine the importance of nature in enhancing the benefits derived from visits to blue space.

3.2 Methods

3.2.1 Sample

Our cross-sectional study was based on the Office for National Statistics (ONS) Opinions and Lifestyle survey, a British survey containing standard socio-demographic questions, together with modules commissioned by government organisations, academic institutions, and charities. Modules are designed with the Opinions and Lifestyle survey team to meet ONS quality standards. Data access is governed by the ONS Code of Practice, Protocol on Data Access and Confidentiality and Microdata Release Procedure (UK Statistics Authority, 2009).

The survey covers Great Britain, excluding the Isles of Scilly and the Scottish Highlands and Islands and is based on a random probability sample of private households stratified by region and socio-demographic profile (ONS, 2014). Each month, 2010 addresses are selected and one person over 16 in each household is designated as a respondent for the address (ONS, n.d.). Trained interviewers conduct face-to-face interviews, interviewing only the selected respondent at the address, and returning at least 8 times to each address at different times of the day and week to achieve as many responses as possible. Response rates are typically between 50% and 60% (ONS, n.d.). The survey runs for eight months of the year; we commissioned a module in the May 2015 survey for which the response rate was 56%, resulting in a sample of 1043.

The sampling structure of the survey, selecting first households and then one individual within a household, means that the likelihood of an individual being chosen for the survey differs depending on household size (individuals living alone in a household are certain to be selected if their household is selected; individuals in a family of four in a household only have a 25% chance of selection if their household is selected). As household size may vary based on other demographics, this has the potential to bias results. In addition, some groups are less likely to agree to respond to the survey than others. These factors mean that weighting is required to make the gathered sample representative of the general population. The ONS provides an individual analysis weight for each case which accounts likelihood of selection and non-response bias. In calculating percentages of individuals choosing each option to a question, raw response numbers were multiplied by the weighting to make them nationally representative (ONS, n.d.).

3.2.2 Survey questions

To address our three objectives, our module asked four questions relating to people's visits to freshwater blue spaces. These were defined for study participants as 'areas such as rivers, canals and lakes and their immediate surroundings, including river paths, canal paths and lakeside walks' and therefore excluded coastal blue spaces such as beaches.

We based our questions on those asked by the MENE survey to enable us to compare our data on visits to blue spaces to information from the MENE survey on visits to other natural environments. The MENE survey asks respondents to think about their last visit to a natural environment. We used the same format as we considered respondents would give clearer answers than if asked about visits to blue spaces in general. We also adapted some of the MENE questions to provide data on the mechanisms affecting the blue space-health relationship and the importance of nature to visits to blue space.

The first question asked the respondent how often they visit blue spaces, with possible answers being: *every day; once a week; once a month; once every few months; two or three times a year; once a year or less; never visit*. Respondents who answered '*never visit*' were asked no further questions from our module. Respondents who had visited blue space were then asked to think about their last visit to a blue space and report the location of this visit (either *countryside* or *built up area*).

To investigate mechanisms, we asked respondents to indicate the single most important benefit they experienced during their last visit to a blue space, the options being: *exercise or keeping fit; spending time with friends or family; relaxation or stress reduction*. Respondents were also given the option of answering '*other*' in which case they were asked to describe the benefit.

The final question asked respondents to assess the importance of nature in enhancing their visit, with options being: *very important; quite important; not important; not at all important*.

3.2.3 Variables

Sociodemographic and health information was collected as part of the ONS survey. We used data on factors that other studies have found to be related to green and blue space use as predictor variables in our analyses. These factors were: age; gender; household composition (cohabiting status, number of dependent children); socioeconomic status (highest educational qualification); car ownership; health status (limiting long-standing illness); and urbanity of the respondent's dwelling, with 'urban' being defined as more than more than 10,000 people in the settlement and 'not urban' as less than 10,000 (Table 1).

Table 1 Social profile of the sample (n = 1043)

	N	Weighted %
Gender		
Male	468	44.9
Female	575	55.1
Age		
16 to 24	116	11.1
25 to 44	338	32.4
45 to 64	349	33.5
65 and over	239	23.0
Cohabiting status		
Married/cohabiting	636	61.0
Single	238	22.8
Widowed	63	6.0
Divorced/separated	106	10.2
Dependent children		
Yes	386	37.0
No	657	63.0
Car ownership		
Yes	835	80.1
No	208	19.9
Level of higher education		
Degree or equivalent	298	28.6
Below degree level	439	42.1
Other qualifications	122	11.7
None	184	17.6
Limiting long-term illness		
Yes	211	20.2
No	832	79.8
Urbanity		
Urban	894	85.7
Not urban	149	14.3

3.2.4 Statistical analyses

For some questions, numbers for certain responses were small, requiring response categories to be merged to allow robust statistical analysis (Table 2). For frequency of visits, responses were combined to form three categories: frequently (≥ once a month), infrequently (< once a month), and never visit. For the importance of nature to the visit, the majority of respondents answered 'very important' so this was considered the appropriate category for comparison and 'quite

important', 'not important', and 'not at all important' were merged into one group 'less important'.

Table 2 Visits to blue space (n=1040)

	N	Weighted %
Frequency of visits		
Frequently (≥once a month)	520	50.0
Infrequently (<once a month)	362	34.8
Never	158	15.2
Missing	3	
Location of visits		
Built-up area	402	45.6
Countryside	479	54.4
Missing[1]	161	
Visit benefits		
Exercise or keeping fit	151	17.1
Spending time with family or friends	292	33.2
Psychological benefits	349	39.6
Other	89	10.1
Missing[1]	161	
Importance of nature		
Very important	500	56.7
Less important	382	43.3
Missing[1]	161	

[1]includes respondents who have never visited a blue space

A logistic regression model was run to examine the sociodemographic and health factors predicting whether respondents visited blue space frequently or not frequently (infrequently or never). Pearson Chi-squared tests were used to determine if there were differences in the sociodemographic and health profiles of those who visited blue space (frequently or infrequently) and those who never visited.

Users who had never visited a blue space (n=158) were then excluded from further analyses. Logistic regression models were used to investigate the association between the sociodemographic and health factors and each outcome: visit location; visit benefits; and the importance of nature to the visit.

A logistic regression model was run to predict the sociodemographic and health factors associated with the location of the respondents' last visit to a blue space (built-up area or countryside).

A multinomial logistic regression model was run for visit benefits, to investigate the sociodemographic and health predictors of selecting 'exercise or keeping fit', 'spending time with family or friends', or 'other' rather than 'relaxation and stress reduction'.

The sociodemographic and health predictors of the importance of nature in enhancing the respondent's last visit to a blue space were investigated; reporting that nature was very important rather than less important was modelled.

Finally, a second multinomial logistic regression model was run to identify sociodemographic and health factors associated with choosing 'exercise or keeping fit', 'spending time with family or friends', or 'other' rather than 'relaxation and stress reduction'. The importance of nature was added as a predictor to determine whether the likelihood of choosing a particular benefit was associated with the importance placed on nature during the visit.

Statistical analyses were carried out in SPSS Version 22. Nagelkerke's R^2 is displayed to indicate the goodness of fit of the model. Results are presented as adjusted odds ratios (OR) (OR calculated taking into account the effects of all the other variables in the model) with 95% confidence intervals (CI) (these are Wald CI and relate to the adjusted odds-ratios estimated by SPSS in the logistic regressions). Only variables which were significant predictors in the multivariable models are displayed in the paper, the full models are available in Appendix 2.

3.3 Results

Table 1 describes our study sample.

3.3.1 Frequency of visits and location of last visit to freshwater blue space

Half (50%) of respondents visited blue space frequently (≥ once a month) although 15% had never visited a blue space (Table 2). Those who had never visited blue space were significantly different to those who had in age, cohabiting status, number of dependent children, car ownership, level of higher education, and long-term limiting illness (Table 3). Table 3 describes the social profile of people who never visited blue space; 37% were 65 and over and 42% had no educational qualifications.

Table 3 Social profile of respondents who never visited a blue space (n=158), who had visited a blue space (n=885), and differences in sociodemographic and health factors between these two groups (* marks variables for which the difference is significant)

[1]p-values based on Pearson Chi-squared tests

	Never visited		Visited			
	N	Weighted %	N	Weighted %	X^2	p-value[1]
Gender						
Male	64	40.5	404	45.6	2.59	0.108
Female	94	59.5	481	54.4		
*Age**						
16 to 24	18	11.5	98	11.1	33.46	<0.01
25 to 44	37	23.6	301	34.0		
45 to 64	44	28.0	305	34.5		
65 and over	58	36.9	181	20.5		
*Cohabiting status**						
Married/cohabiting	71	44.9	565	63.8	31.62	<0.01
Single	45	28.5	193	21.8		
Widowed	21	13.3	42	4.7		
Divorced/separated	21	13.3	85	9.6		
*Dependent children**						
Yes	53	33.5	333	37.6	5.14	0.023
No	105	66.5	552	62.4		
*Car ownership**						
Yes	97	61.8	738	83.3	65.13	<0.01
No	60	38.2	148	16.7		
*Level of higher education**						
Degree or equivalent	19	12.1	279	31.5	96.67	<0.01
Below degree level	49	31.2	390	44.0		
Other qualifications	23	14.6	99	11.2		
None	66	42.0	118	13.3		
*Limiting long term illness**						
Yes	62	39.2	149	61.8	47.74	<0.01
No	96	60.8	92	38.2		
Urbanity						
Yes	142	89.9	752	85.0	3.80	0.051
No	16	10.1	133	15.0		

Of those who had visited blue space, a larger proportion (54%) had visited a built-up area on their last visit to a blue space than had been to the countryside (46%).

Both the frequency of visits and the location of a respondents' last visit were predicted by their personal and social circumstances. Compared to people with a degree, people with below degree level qualifications were less likely to visit a blue space frequently (OR 0.71, CI 0.51-0.98). People were more likely to visit blue spaces frequently if they lived in a rural area than a built up area (OR 3.01, CI 1.91-4.76) (Table 4).

Table 4 Logistic regression analysis estimates for visiting a blue space frequently (≥once a month) rather than infrequently or never (pseudo-R^2 = 0.05)

	Frequency	
	Adjusted OR[1]	95% CI
Level of higher education		
Degree or equivalent	1	
Below degree level	0.71	0.51-0.98
Other qualifications	0.91	0.56-1.46
None	0.66	0.43-1.02
Urbanity		
Urban	1	
Not urban	3.01	1.91-4.76

[1]adjusted for gender, age, cohabiting status, number of dependent children, and car ownership

People with a degree were more likely to have visited a blue space in an urban area on their last visit to blue space than those with other (OR 0.53, CI 0.32-0.88) or no qualifications (OR 0.52, CI 0.32-0.86; Table 5). Those who did not own a car were also more likely to have visited a blue space in an urban area on their last trip to a blue space than those who owned a car (OR 1.73, CI 1.16-2.57), as were respondents who lived in an urban area rather than a rural area (Table 5).

Table 5 Logistic regression analysis estimates for visiting a blue space in a built-up area rather than the countryside, excluding respondents who have never visited a blue space (pseudo-R^2 = 0.10)

	Adjusted OR[1]	95% CI
Level of higher education		
Degree or equivalent	1	
Below degree level	0.73	0.52-1.02
Other qualifications	0.53	0.32-0.88
None	0.52	0.32-0.86
Car ownership		
Yes	1	
No	1.73	1.16-2.57
Urbanity		
Urban	1	
Not urban	0.23	0.14-0.37

[1]adjusted for gender, age, cohabiting status, number of dependent children, and long-term limiting illness

3.3.2 Perceived benefits received from visits to freshwater blue space

Most people reported that spending time with friends or family (33%) or psychological benefits (40%) was the single most important benefit they received most from their visit, 17% identified exercise or keeping fit whilst 10% responded 'other' (Table 2). Respondents who choose 'other' referred mostly to using blue space for a specific activity such as walking with friends, fishing, dog walking, or as a route to another activity such as work. Other benefits discussed included enjoying the fresh air and seeing wildlife. There were no sociodemographic or health factors which predicted selecting other as the most important visit benefit (Table 3 in the Appendix 2).

Health status was a predictor of choosing physical activity as a visit benefit. Respondents who did not have a limiting long term illness were more likely to report physical activity than psychological benefits as the most important benefit received from their last visit to blue space (OR 2.49, CI 1.36-4.54) (Table 6).

Table 6 Multinomial logistic regression analysis estimates for the most important benefit received on the respondents' last visit to blue space (compared with psychological benefits), excluding respondents who have never visited a blue space (pseudo-R^2 = 0.17)

	Exercise or physical activity		Spending time with family or friends	
	Adjusted OR[1]	95% CI	Adjusted OR[2]	95% CI
Age				
16 to 24			1	
25 to 44			0.86	0.44-1.67
45 to 64			0.48	0.23-1.00
65 and over			0.34	0.14-0.80
Dependent children				
Yes			1	
No			0.40	0.27-0.59
Level of higher education				
Degree or equivalent			1	
Below degree level			1.35	0.91-2.02
Other qualifications			0.76	0.41-1.43
None			1.97	1.09-3.57
Limiting long term illness				
Yes	1			
No	2.49	1.36-4.54		

[1]adjusted for gender, age, cohabiting status, number of dependent children, car ownership, level of higher education, urbanity

[2]adjusted for gender, cohabiting status, car ownership, limiting long-term illness, urbanity

Socioeconomic circumstances were a predictor of choosing social interaction as a visit benefit. Compared to respondents with a degree, those with no qualifications were nearly twice as likely to identify spending time with family or friends than psychological benefits (OR 1.97, CI 1.09-3.57) as the key benefit of their visit to blue space (Table 6).

Household composition was also a predictor. Compared to respondents with children, those without children were less likely to report social interaction than psychological benefits (OR 0.40, CI 0.27-0.59) as the most important benefit of their visit to blue space (Table 6).

Finally, those aged 65 and over were less likely to report socialising as the single most important benefit of their visit compared to young adults (OR 0.34, CI 0.14-0.80, Table 6).

3.3.3 Importance of nature on visits to freshwater blue space

The majority (57%) of respondents considered nature very important to their most recent visit to a blue space (Table 2).

Table 7 describes the social patterning of those who found nature very important. Women were more likely than men to value nature (OR 1.28, CI 1.05-1.82). The likelihood of finding nature important increased with age; compared to those aged 16-24, those aged 45-64 were over twice as likely (OR 2.43, CI 1.31-4.51) and those aged 65 and older were over three times as likely (OR 3.48, CI 1.70-7.11) to find nature very important. Socioeconomic status was also a predictor. Compared to people with a degree or equivalent, those with no qualifications were less likely to find nature important (OR 0.55, CI 0.34-0.90).

Table 7 Logistic regression analysis estimates for whether people found nature to be very important when visiting a blue space, excluding respondents who have never visited a blue space (pseudo-R^2 = 0.06)

	Adjusted OR[1]	95% CI
Gender		
Male	1	
Female	1.38	1.05-1.82
Age		
16 to 24	1	
25 to 44	1.54	0.87-2.71
45 to 64	2.43	1.31-4.51
65 and over	3.48	1.70-7.11
Level of higher education		
Degree or equivalent	1	
Below degree level	0.79	0.57-1.10
Other qualifications	1.07	0.65-1.76
None	0.55	0.34-0.90

[1]adjusted for cohabiting status, number of dependent children, car ownership, limiting long term illness, urbanity

The likelihood of selecting different visit benefits differed depending on how important the respondent found nature to their visit (Table 8). Respondents who found nature less important were more likely to select exercise (OR 2.80, CI 1.83-4.28) or spending time with family and friends (OR 1.69, CI 1.21-2.37) than psychological benefits as the most important benefit of their visit in comparison to those who found nature very important.

Table 8 Multinomial logistic regression analysis estimates for the most important benefit received on the respondents' last visit to blue space (compared with psychological benefits), excluding respondents who have never visited a blue space (pseudo-R^2 = 0.20)

	Exercise or physical activity		Spending time with family or friends	
	Adjusted OR[1]	95% CI	Adjusted OR[2]	95% CI
Gender				
Male	1			
Female	1.51	1.01-2.26		
Age				
16 to 24			1	
25 to 44			0.82	0.42-1.61
45 to 64			0.44	0.21-0.92
65 and over			0.30	0.12-0.71
Cohabiting status				
Married/cohabiting	1			
Single	0.48	0.24-0.98		
Widowed	1.57	0.65-3.79		
Divorced/separated	0.75	0.38-1.48		
Dependent children				
Yes			1	
No			0.41	0.28-0.61
Level of higher education				
Degree or equivalent			1	
Below degree level			1.39	0.93-2.08
Other qualifications			0.78	0.41-1.47
None			2.10	1.16-3.82
Limiting long term illness				
No	1			
Yes	2.66	1.45-4.89		
Importance of nature				
Very important	1		1	
Less important	2.80	1.83-4.28	1.69	1.21-2.37

[1]adjusted for age, number of dependent children, level of higher education, car ownership, urbanity

[2]adjusted for gender, cohabiting status, car ownership, limiting long-term illness, urbanity

When the importance of nature was included in the model, both gender and cohabiting status became predictors of identifying physical activity as the most important benefit of the visit. Women were more likely to select physical activity than psychological benefits as the single most

important benefit of their visit compared to men (OR 1.51, CI 1.01 – 2.26). Single respondents were less likely to report exercise than psychological benefits as the most important benefit of their visit compared to those who were married (OR 0.48, CI 0.24 – 0.98).

3.4 Discussion

3.4.1 Frequency and location of visits to freshwater blue space

While the majority of respondents visited a blue space at least monthly, access to blue space was socially patterned. Socioeconomic status and living in an urban area were predictors of both the frequency and location of visits to blue space whilst car ownership was also a predictor of visit location.

Evidence on the importance of accessibility to natural spaces is varied. Most visits to green spaces are to those closest to the home but, whilst White et al. (2013b) found that people living nearer the coast are more likely to visit than people who live further away, frequency of visits to specific landscape features such as forests, beaches, or lakes appears to be less affected by distance (Schipperijn et al., 2010a). Our results suggest area of residence is a predictor of visit frequency and location. Users from urban areas were more likely to visit blue space in a built-up area while respondents from rural areas, with perhaps more access to blue space, visited more frequently. As those without a car were less likely to go to rural blue spaces, the individual's ability to access the space also appears to be a factor affecting visit frequency and location.

3.4.2 Perceived benefits received from visits to freshwater blue space

The main benefits people identified as receiving from their visits to blue space were social interaction and psychological benefits (Table 2). Social disadvantage was associated with increased odds of identifying social interaction as the most important benefit as was household composition. Age was an additional predictor: older respondents were less likely to identify spending time with family or friends as the most important benefit of their visit than younger respondents. Health status was a predictor of reporting physical activity as the most important visit benefit.

We asked our respondents to identify the most important benefit they felt they received from visiting blue space. Our results are similar to findings from green space studies, where social interaction and psychological benefits have been identified as particularly important (de Vries et al., 2013; Hartig et al., 2014).

These results differed from the MENE survey which, in 2014-15, found that almost half of people visited the natural environment for health and exercise whilst 29% reported their motivation for visiting was 'to relax and unwind' (Natural England, 2015b). This may be because MENE asks

respondents about their reasons for visiting rather than the benefits resulting from their visit; people's intentions before visiting may not be the same as the outcome of the visit (Natural England, 2015a). MENE also asks about a range of natural environments, not just blue and green space, so it may be indicative of differences in the use and benefits received from these spaces.

People may access different benefits from natural environments simultaneously (Hartig et al., 2014). For example, some respondents who answered 'other' identified 'walking with a friend' as a benefit, which could provide physical activity and social interaction benefits. It should also be noted that many answers in the 'other' category were recreational pursuits, which can provide benefits in themselves (Völker & Kistemann, 2013). Although people identified these activities as the most important benefit of their visit, most could be placed in one of the three categories provided, for example, dog walking as physical activity.

An individual's socio-demographic characteristics affected the benefits they felt they received from visiting the space. We found that respondents who were older and who had a limiting long-term illness were more likely to report psychological benefits as the single most important benefit they received from visiting blue space. Both are user groups who may have problems with mobility and accessing blue space, so provision of these spaces with appropriate amenities, such as paths and benches to allow ease of access and use, is essential to enable them to derive these benefits (Finlay et al., 2015; Schipperijn et al., 2010b).

Socioeconomic status was a predictor of identifying social interaction as the single most important benefit received from visiting blue space. Studies of green and blue space have suggested that these areas may moderate some of the effects of socioeconomic inequality on health (Mitchell & Popham, 2008; Wheeler et al., 2012). This may be because people from different socioeconomic groups are using these spaces in different ways and therefore gaining different benefits from them. This is supported by research on relational encounters which suggests that the benefits people receive from natural spaces are a result of interaction between individuals and the wider socio-environmental setting (Conradson, 2005).

For some people, or in some situations, visiting a natural space may not be beneficial due to the interaction or relationship of the individual with the environment (Plane & Klodawsky, 2013). We found that one in six people never visited blue space; many of these respondents were elderly or in poor socioeconomic circumstances. They may not access these spaces because they are physically unable or due to time or financial limitations, but in some cases, it may be because blue spaces are perceived negatively as unhealthy places for them (Finlay et al., 2015; Plane & Klodawsky, 2013). More deprived neighbourhoods often have less access to natural spaces, and those that are present are more likely to be of poor quality (Mitchell & Popham, 2008; Rigolon,

2016), so these groups may have both fewer opportunities and little incentive to visit these spaces. As these respondents do not visit blue space, they are unable to access any benefits from spending time there.

3.4.3 Importance of nature on visits to freshwater blue space

The majority of our respondents found nature to be very important to their visit. Current evidence regarding the impact of water quality on recreational visits to blue space is mixed. Some research has found that people are more likely to choose to visit blue spaces with good water quality (Doi et al., 2013), however, work by Ziv et al. (2016) suggests that water quality does not affect whether people use blue spaces for recreation. These differences may reflect variation in people's perceptions of what is natural, as nature is regarded differently by different people, and is even situation-dependent, with people expecting spaces to be more or less managed depending on whether they are rural or urban (Cooper et al., 2017).

There is some research indicating that people prefer the natural environment to have a degree of naturalness rather than being excessively managed, a view that seems to be stronger in women than men (Lindemann-Matthies & Bose, 2007; Southon et al., 2017; Strumse, 1994). This preference for nature may be a factor in why people in rural areas were more likely to visit blue space frequently; more extensively modified by human activity, blue spaces in urban areas are less likely to 'look natural' (Wild et al., 2011).

Valuing nature showed social patterning: respondents who were female, older and socially advantaged were more likely to regard nature as very important to their last visit to blue space. This is in line with studies of pro-environmental behaviours which found that people engaging in these behaviours tend to be older and female although a recent meta-analysis of nature connectedness found no effects of age or gender (Capaldi et al., 2014).

Our results suggest that finding nature important when visiting blue space increases the likelihood of identifying psychological benefits as the main benefit of the visit. This may be indicative of the respondents' own biases – those who value nature highly may be more likely to gain psychological benefits from their visit. However, research on visits to green space indicates that there is a link between biodiversity and the psychological benefits of the space (Fuller et al., 2007), and that spaces with higher actual and perceived biodiversity are more restorative than those with less biodiversity (Carrus et al., 2015; Hoyle et al., 2017). A review of the health benefits of blue spaces also highlights the significance of features related to quality such as the movement, colour, and clarity of water to users (Völker & Kistemann, 2011), so the nature present in blue space may be important in providing psychological benefits.

3.4.4 Limitations and further work

Because our study formed part of a wider national survey, we were able to include a wide range of sociodemographic factors in our analysis, and use established measures of socioeconomic position (based on education), health status and household composition. However, some limitations of our study should be noted. The low pseudo-R2 values indicate that there is a large amount of variation not explained by the models, probably due to unmeasured factors, and the cross-sectional nature of the study meant that conclusions could not be drawn about causality. We were therefore unable to investigate whether the perceived benefits of visits to blue space mediated potential health effects of exposure to blue space. In addition, like other studies of the benefits of exposure to natural environments, our study relied on self-reported measures. Thus, although freshwater blue space was defined, there may be differences in people's perception and recall of visits to areas such as rivers, canals and their surroundings. However, to explain the social differences we found in frequency, location and benefits of visits to blue space, such perceptual and memory differences would need to be socially patterned. We consider this unlikely.

Our study adds to evidence in an area where research is limited and is one of the first to examine whether the perceived benefits of spending time in green space were also evident for blue space (Triguero-Mas et al., 2015). Our findings suggest visits to freshwater blue space are important for users; their potential contribution to mental health and well-being requires further investigation and comparison with the benefits provided by coastal blue spaces to determine whether different types of blue space provide similar benefits.

3.4.5 Relevance for policy and planning

There is increasing policy recognition of the societal benefits of the natural environment, from the acknowledgment of the need for a biodiverse natural environment to meet social needs in the Welsh Well-being of Future Generations Act (2015) to the promotion of green spaces for exercise by Natural England (Natural England, 2009; Natural Resources Wales, 2015).

Our study indicates the importance of the natural environment beyond green space, showing that different groups of people experience a range of benefits from freshwater blue space. For example, we found that younger and older people derive different benefits, as do those in urban and rural areas. Evidence on such patterns can help inform local and national strategies to promote the use of public blue space; encouraging the use of freshwater blue spaces could both prevent overuse of coastal environments and allow people who do not live on or near the coast access to the benefits of blue environments.

Importantly, we found that one in six adults does not visit blue space. The social patterning of visiting blue space infrequently or not at all suggests inequalities in access to blue space – and therefore to the benefits that exposure to these spaces may provide.

Our findings also indicate the importance of protecting and improving blue space, particularly in urban areas. Whilst many are heavily modified or culverted, urban blue spaces often exist within urban green spaces or are present where green space has been erased through urbanisation (Völker etal., 2016; Wild et al., 2011). There are an increasing number of projects which aim to restore urban rivers including success stories such as that of the river Quaggy in London where restoration has improved the local environment and increased use by residents (Chartered Institution of Water and Environmental Management, 2012; The River Restoration Centre, 2009).

Blue spaces deserve consideration in urban planning as areas which can benefit people and support nature. To ensure the provision of good quality blue spaces for use by urban populations, the catchments upstream of settlements need management to ensure the quality of the water downstream (Neale & Moffett, 2016). Urban planners should also ensure that local communities are engaged with restoration projects, particularly in the planning stages, so that spaces are designed with their support and to meet their needs (Smith et al., 2016).

3.5 Conclusions

In our study, the majority of people had visited a freshwater blue space in the last year; these visits were split almost equally between urban and rural areas. The frequency and location of an individual's visits to blue space were socially patterned, and determined by people's circumstances and access to the space, whether due to car ownership or their urban location.

Freshwater blue spaces were perceived as important primarily as areas for social interaction and psychological benefits. This is consistent with evidence from the green space-health literature which has identified social interaction and psychological benefits as key mechanisms through which green space benefits health. Those who were most socially disadvantaged (as proxied by having no educational qualifications) were more likely to report social interaction as the primary benefit, pointing to the role that blue space could play in supporting social engagement and improving well-being among those at greatest risk of poor health. However, as noted above, we found marked social inequalities in use of blue space; the most socially disadvantaged groups were least likely to report visiting a blue space frequently.

The majority of people considered nature very important to their visit, with women and those aged 45 and over attaching greater importance to nature than men and younger adults. People

who considered nature very important to their visit were more likely to identify psychological benefits as the most important benefit of their visit. This suggests that the quality of the blue space may be integral to the benefits that people derive and points to potential synergies between protecting natural habitats and promoting public health.

The findings of our study are relevant to the design of natural spaces for use by local populations as well as more broadly for social and environmental policies. The factors related to people's use of these spaces, particularly socioeconomic and health status, need to be addressed to ensure that access to blue spaces benefits everyone and does not contribute to widening socioeconomic inequalities.

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Chapter 4 Evaluating dual ecological and well-being benefits from an urban restoration project

Preface

Studies of the nature-health relationship indicate that the biodiversity of a space may affect the benefits people derive from visiting the area (Dallimer et al., 2012; Fuller et al., 2007). Ecological restoration aims to improve ecological health so could deliver benefits for human populations through the provision of diverse natural spaces as well as being beneficial for the environment. However, its success is rarely considered from both perspectives. This chapter concentrates on the local level, evaluating the success of a restoration project in a large UK city from both an ecological and social perspective. Macroinvertebrate data were used to investigate ecological health whilst focus groups were conducted with local users of the restoration to determine the social success of the project.

This chapter is written in the style of, and will be submitted to, *Restoration Ecology*.

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Abstract

Many urban natural spaces are being degraded, reducing their ability to provide benefits to human populations. Restoration can improve the ecological health of these spaces and the benefits they provide but its success is usually considered from solely an ecological or a social perspective. This study evaluated the combined ecological and social benefits of an urban river restoration project relative to an unrestored river on the basis of the following four principles: increasing ecological integrity; benefitting and engaging society; taking account of the past and future; and sustainability. Ecological health at each site was assessed by analysing macroinvertebrate samples. The social benefits of the project were measured by conducting focus groups with local users of green spaces surrounding the restored and unrestored rivers and comparing their responses using framework analysis. The restoration increased the ecological health of the river and was viewed positively by users in terms of its effect on nature and as a space to visit for psychological benefits. However, these dual benefits were offset by some concerns over the erasure of the cultural heritage of the area and the long-term sustainability of the project. Our findings indicate that it is important to consider restoration success from both an ecological and a social perspective, particularly in urban areas, where small ecological improvements have the potential to provide many benefits for human populations.

4.1 Introduction

Ecological restoration is guided by cultural expectations and values which determine both the goals set for restoration and whether projects are judged to be successful (Gobster, 2001; Hobbs, 2007; McCormick et al., 2015). Whilst the primary aim of restoration is environmental – the improvement of degraded ecosystems - it offers the opportunity to deliver social and economic benefits alongside environmental benefits (Choi, 2007; Perring et al., 2015), since more biodiverse spaces have higher levels of recreational use (Doi et al., 2013) and a positive effect on mental well-being (Dallimer et al., 2012; Fuller et al., 2007; Luck et al., 2011). Geist & Galatowitsch (2016) show human benefit increasing as ecological health is restored in their model of ecological restoration and human benefits. More work is needed on the evaluation of dual benefits from restoration, since a focus on a single dimension risks false conclusions being drawn about the success of restoration (Smith et al., 2016). Recently four principles have been suggested when setting goals for restoration: increasing ecological integrity; benefitting and engaging society; taking account of the past and future; and sustainability (Suding et al., 2015). These principles provide a framework for assessing the success of ecological restoration from an integrated environmental and social perspective.

4.1.1 Increasing ecological integrity

The responses of biotic communities to restoration have been variable (Kail et al., 2015). Some studies suggest that restoration has limited (Verdonschot et al., 2016) or no effect (Violin et al., 2011), finding, for example, that although restoration increases habitat diversity, it does not change macroinvertebrate community composition (Jähnig et al., 2010). Achieving successful restoration in urban environments is complicated by the presence of multiple stressors which prevent restoration to pre-disturbance conditions (Hughes et al. 2014). Factors such as the presence or absence of ecologically healthy ecosystems upstream also influence restoration success (Ogren & Huckins, 2015), leading to suggestions that improvements are needed at the catchment level rather than individual sites (Leps et al., 2016; Lorenz & Feld, 2013). However, a recent meta-analysis found that fish, macroinvertebrates, and macrophytes are all positively affected by restoration, with increases in abundance and biomass being greater than increases in biodiversity (Kail et al., 2015). Studies indicate that restoration is successful when it involves hydromorphological changes such as the creation of habitats which were not present prior to restoration (Hering et al., 2015; Lüderitz et al., 2011), or causes improvements in the retention of organic matter, increasing the range of resources available for aquatic organisms (Kupilas et al., 2016).

4.1.2 Benefitting and engaging society

The majority of studies concerning potential social benefits of river restoration have focused on the acceptability of aesthetic changes resulting from the restoration. Studies from Finland (Marttila et al., 2016), the Netherlands (Buijs, 2009), the UK (Åberg & Tapsell, 2013), and New Zealand (McCormick et al., 2015), show that local users prefer restored river landscapes which are naturalised, attractive, and offer access to the river. Research also indicates that restored ecosystems with the best ecological outcomes are preferred by the public (McCormick et al., 2015), and that people find ecologically healthy riverine environments most aesthetically pleasing (Cottet et al., 2013; Petursdottir et al., 2013). While there has been some investigation of the educational benefits resulting from public engagement with restoration projects (Herringshaw et al., 2010), there has been little broader consideration of the social benefits of restoration (Åberg & Tapsell, 2013; Smith et al., 2016).

4.1.3 Taking account of the past and future

Westling et al. (2014) found that local users' perceptions of river landscapes were not always related to measurable outcomes of restoration but to broader cultural factors such as local history and memories of the river. Cultural values and place attachment can lead to opposition to restoration (Buijs, 2009). For example, Lejon et al. (2009) found that there is often opposition

to the removal of old hydroelectric dams in Sweden as people are attached to these built features, viewing them as part of the landscape and using them for a range of recreational purposes. Consideration of the past and future is also important when evaluating the ecological success of restoration as the previous state of the river may determine the goals set for the restoration or expectations for its condition in the future (Hobbs, 2007).

4.1.4 Sustainability

Whilst there are some studies demonstrating the long-term success of restoration from an ecological perspective (Friberg et al., 2014; Muotka, Paavola, Haapala, Novikmec, & Laasonen, 2002), societal support is essential for both the short and long-term sustainability of restoration projects. Social benefits, such as the provision of recreational space, are often opportunistic or result indirectly from projects which aim to improve the environment (Marttila et al., 2016; Smith et al., 2016). This lack of integration of social objectives, resulting in public opposition to restoration, is the main reason that many projects are not sustainable (Cottet et al., 2013; Smith et al., 2016). Conversely, research from the river Skerne in England, shows that providing attractive spaces for rest and relaxation, valued by local residents, can contribute to the long-term success of restoration (Åberg & Tapsell, 2013).

4.1.5 Case Study

This paper uses the restoration of an urban river as a case study to investigate the ecological and social benefits of ecological restoration. The river Medlock is a tributary of the river Irwell in Manchester, one of the largest cities in the UK. The Medlock has been heavily modified due to industrialisation and urbanisation and a 1.6km section was finally culverted following serious flooding in 1872, becoming known locally as the Red River due to the bricks used to line the river channel. A project was run by the UK's Environment Agency which restored a section of the Medlock over a nine-month period between September 2013 and May 2014; pictures of the river before and after restoration can be seen in Figure 1. The aim of the project was to re-naturalise the river as well as increasing access for local people. Restoration involved widening the channel, removing the bricks to allow the formation of riffles and pools with natural substrates, and the addition of footpaths.

Like the river Medlock, the river Irk is a tributary of the river Irwell and is part of the same catchment. It flows through a similar area with the same history of industry but has not had any restoration work. The Irk allows a space for time substitution by serving as a pre-restoration baseline against which the Medlock can be compared.

Both rivers are accessible via green spaces used by local communities. For the Medlock, these are Philips Park, which contains an unrestored section of the river, and Clayton Vale, the site of the restored section of river (Fig. 2). The Irk flows through Queen's Park and Blackley Forest in Manchester and has not been restored in either space.

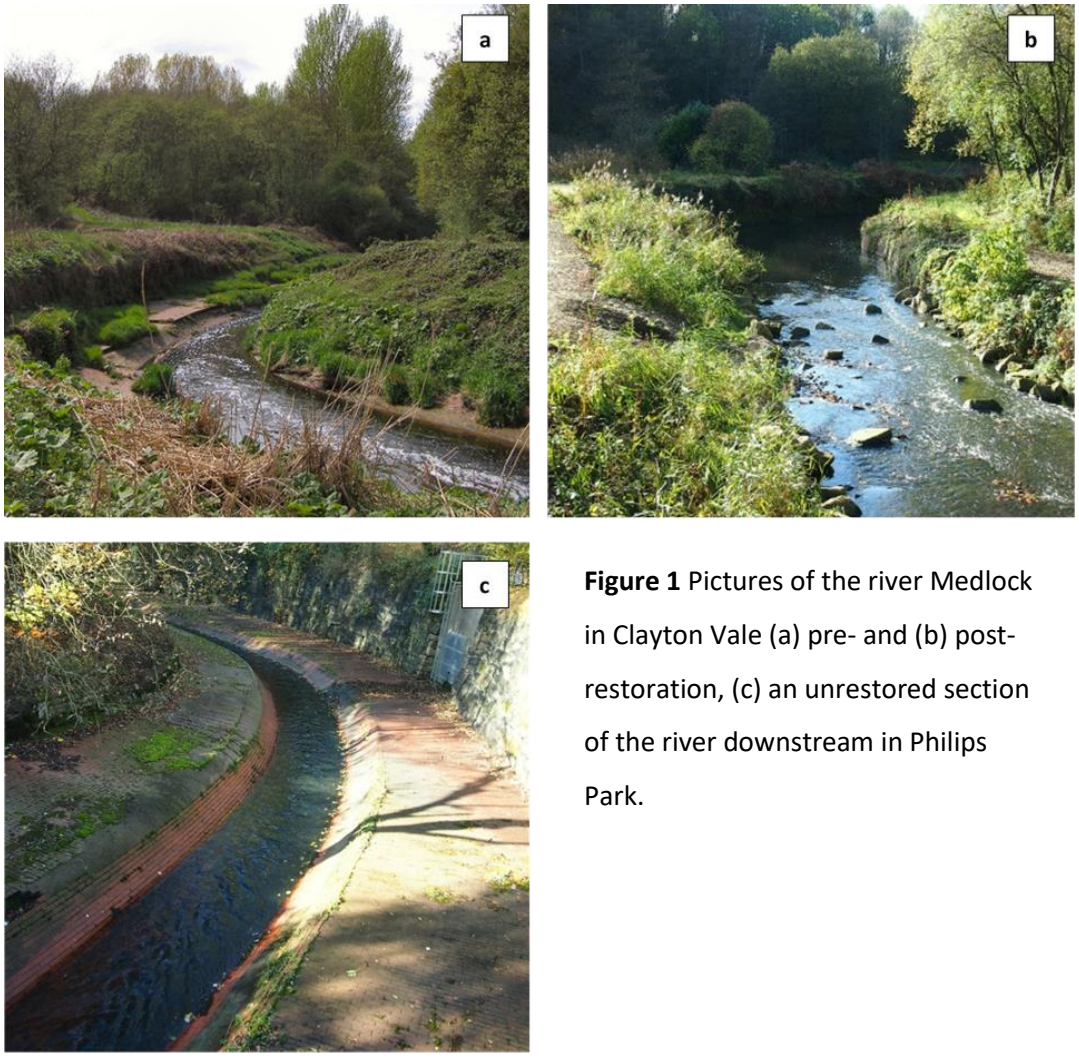

Figure 1 Pictures of the river Medlock in Clayton Vale (a) pre- and (b) post-restoration, (c) an unrestored section of the river downstream in Philips Park.

4.1.6 Aims and hypotheses

The improvements made to the river banks and bed of the Medlock would be expected to create new habitats beneficial for a range of aquatic organisms (Hering et al., 2015; Kail et al., 2015), as well as increasing resources in the aquatic environment (Kupilas et al., 2016). We therefore predict an improvement in the ecological health of the restoration site.

In terms of the social benefits, whilst people's emotional connections to places can result in alterations in the local environment being perceived negatively by the local community (Buijs, 2009), restoration can increase the value of sites by providing attractive spaces for recreation, relaxation, and nature encounters (Åberg & Tapsell, 2013). We expect a positive perception of

the project reflecting the dual aims of increasing ecological health and improving access to the site.

4.2 Methods

4.2.1 Ecological evaluation

We assessed ecological health by sampling macroinvertebrates. Macroinvertebrates are relatively sedentary, have life cycles of a reasonable length, and a range of responses to pollution (Extence & Ferguson, 1989), so are considered good indicators for assessing the ecological health of the aquatic environment (Mueller et al., 2014).

Three sites were sampled on each river (Fig. 2). One upstream site was sampled on each river (M/UC and I/UC) to give an indication of the initial ecological health of the river (Violin et al., 2011). The restored site (M/R), located downstream, was sampled on the Medlock, and an unrestored site (I/UR2), was sampled on the Irk. Two further downstream sites, one on the Medlock (M/UR), one on the Irk (I/UR1), neither of which had been restored, were then sampled to serve as comparison sites. These four sites – M/R, M/UR, I/UR2, I/UR1 - were all located in green spaces accessible to the public.

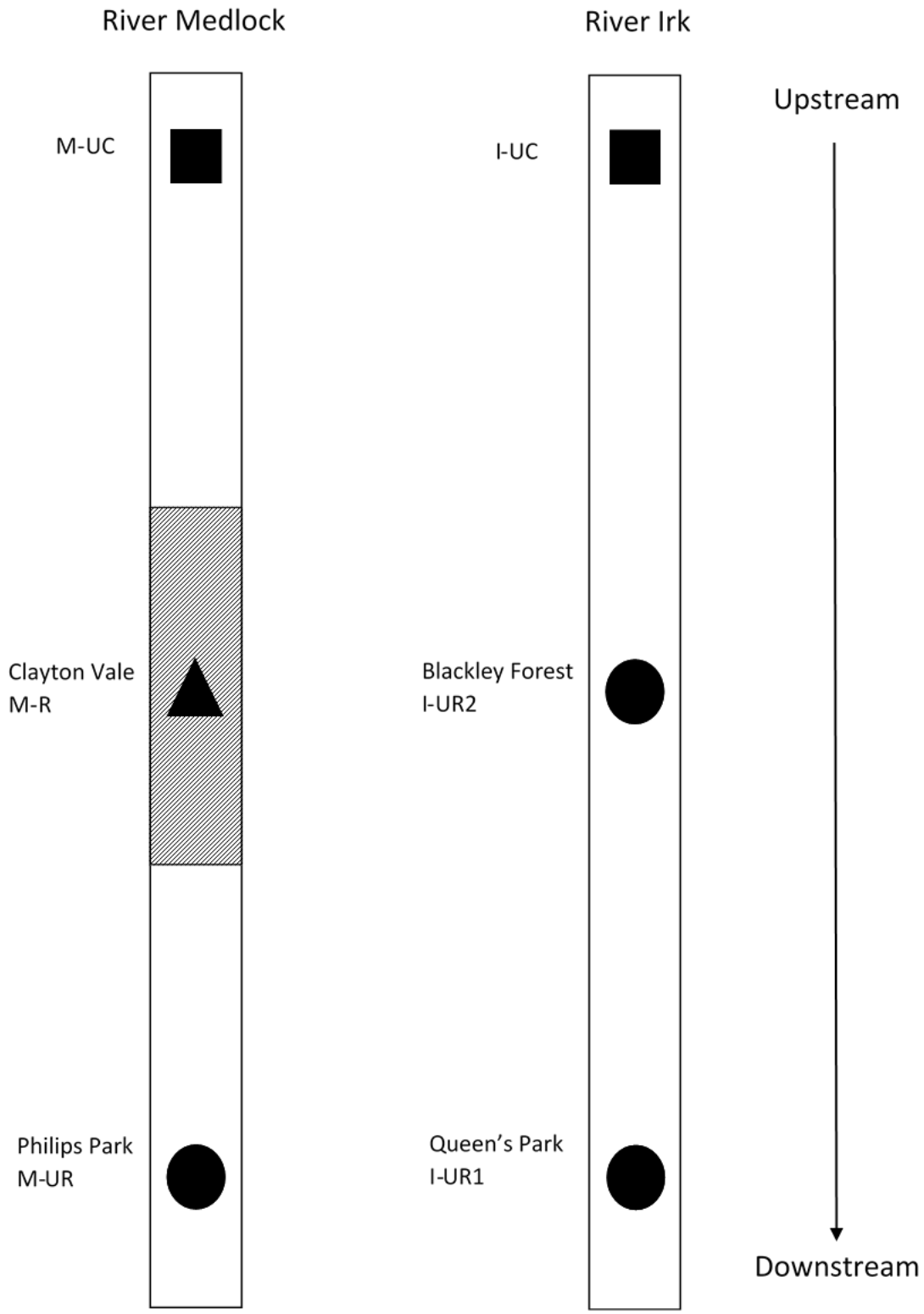

Figure 2 Schematic diagram showing the two rivers, the Medlock which has been restored, and the Irk, which has not, and the location of sampling sites in relation to one another. The squares represent the upstream comparison sites on each river, the triangle and dashed lines the restored site, and the circles show sites which have not been restored. Sites which relate to the focus group discussions are named.

The rivers were first sampled in spring 2015, one year after the completion of the restoration, then again in autumn 2015, and spring 2016. During each sampling season, all of the sites were visited and sampled three times. Macroinvertebrates were sampled using a Surber net. Four Surber samples were taken from a site on each sampling occasion (Brooks et al., 2002; Muotka et al., 2002); samples were taken over a 10 m stretch of river, encompassing the sides and middle of the channel as well as the different habitat types present at the site. When taking a Surber sample, large stones were brushed and the river bed disturbed to a depth of 5 cm for 1 minute (Muotka et al., 2002). Each sample was preserved using ethanol, prior to identification in the lab. Classification was performed at family level, apart from Oligochaetes (Herringshaw et al., 2010).

4.2.1.1 Data analysis

Macroinvertebrate community structure and diversity were expressed in a number of ways. In addition to total species richness and total abundance, Shannon diversity was calculated for each sample. The proportion of pollution-sensitive taxa found at each site was evaluated by calculating Ephemeroptera, Plecoptera, Trichopera (EPT) richness and abundance (Violin et al., 2011). To determine the overall pollution tolerance of the macroinvertebrate community at each site, the Biological Monitoring Working Party (BMWP) score was calculated for the site then divided by the number of scoring taxa found to give an Average Score per Taxon (ASPT) (Paisley et al., 2007).

To allow comparison between the rivers we quantified the differences between sites on the restored and unrestored rivers using Osenberg et al. (2011) response ratios:

$$\Delta r = ln\left(\frac{\bar{X}_R}{\bar{X}_D}\right)$$

with X_R being the restored site (M-R) on the Medlock, or unrestored site (I-UR2) on the Irk, and X_D being the unrestored downstream (M-UR and I-UR1) or upstream sites (M-UC or I-UC) (Table 1). A modified version of the formula from Verdonschot et al. (2016) was used to calculate response ratios for %EPT and %EPT abundance to account for 0-values in the data. Response ratios of >0 indicate a positive effect (an increase in diversity or abundance), whilst values of <0 indicate a negative effect, so Mann-Whitney U tests were first used to determine whether the response ratios for each metric differed significantly from zero. Mann-Whitney U tests were then employed to test whether there were significant differences in the response ratios for each metric between the restored and unrestored rivers (Table 1), using SPSS 22.

Table 1 Response ratios calculated for each metric on the two rivers, arrows show which response ratios were compared using Mann-Whitney U tests

Response ratio	Restored river		Unrestored river
Upstream	M-R : M-UC	↔	I-UR2 : I-UC
Downstream	M-R : M-UR	↔	I-UR2 : I-UR1

4.2.2 Social evaluation

We used qualitative methods to assess the social impacts of the restoration as they allowed exploration of the benefits local users felt they received from the restoration (Gill et al., 2008). Focus groups were chosen as the data collection method as study participants are often more comfortable talking in a group setting than engaging in an individual interview (Kitzinger, 1995).

4.2.2.1 Focus groups

Participants were recruited from users of the green spaces around the rivers, Philips Park and Clayton Vale on the restored Medlock, and Queen's Park and Blackley Forest on the unrestored Irk (Fig. 2). Posters and flyers were displayed around the four green spaces and at local venues including shops, libraries, and community centres. Local user groups were also contacted including Friends of Philips Park, Friends of Clayton Vale, Friends of Blackley Forest, and the Big Local Initiative at Queen's Park as well as the regular walking groups at Philips Park, Clayton Vale, and Blackley Forest. Focus groups were conducted until views had been collected from local users of all four green spaces.

Each focus group began by welcoming participants and asking them how often they used their local green space, their activities in the space, and areas they liked and disliked. This was followed by a photo-elicitation exercise (Harper, 2002). Photo-elicitation is the display of images - usually photographs although any visual media can be used - in a focus group or interview in order to prompt discussion. Images can trigger responses and encourage participants to consider different perspectives on a topic, so can elicit both more and different information to verbal discussion alone (Harper, 2000). In this instance, photographs of parks containing different natural elements such as trees and flowers under either natural or formal management regimes were used to encourage discussion of participants' preferences in green and blue space, when visiting for either exercise or stress reduction, and the importance of nature to their visits.

The second part of the focus group focused on the restoration. A photo-elicitation exercise using photographs of the river pre-, during, and post-restoration were used to prompt discussion of the restoration. Participants from the restored river were asked about their preferences before and after restoration, how they used the space, and if they had felt impacted by the process of

restoration. Local users of the unrestored river were asked about their preferences of the river pre- and post-restoration and prompted to discuss restoration of the unrestored river. Both groups were then asked about the restored and unrestored sections of river and their views on these areas. A focus group guide is available in Appendix 3.

4.2.2.2 Study participants

Five focus groups were conducted during October 2015, one and a half years after the completion of the restoration: one at Philips Park, one at Clayton Vale, two at Queen's Park, and one at Blackley Forest. They lasted between 20 minutes and one hour 40 minutes and were all conducted by a single author, SDB. There were 12 participants in total. Of these, there were ten female participants and two male, all were 45 years or older, six had been residents of the area for their entire lives, four for more than five years, and two between one and five years. Five were members of groups associated with the green spaces whilst seven were local users who were not associated with these groups.

4.2.2.3 Analysis

All focus groups were recorded and fully transcribed, and then analysed using framework analysis. Framework analysis is a systematic form of thematic analysis which allows the comparison of views both between different groups of participants and within groups (Furber, 2010). It has five distinct stages in which themes, patterns or ideas which are seen consistently in the data (Braun & Clarke, 2006), are identified and compared. The first stage of analysis involved familiarisation with the data set, through listening to audio-recordings of the data and reading the transcripts. Following this, themes were identified that were consistent with the four principles suggested by Suding et al. (2015): (i) increasing ecological integrity; (ii) benefitting and engaging society; (iii) taking account of the past and future; and (iv) sustainability. The second stage of analysis involved creating a theme-based framework by locating sub-themes identified during familiarisation under these four main themes. In the third and fourth stages, the data were coded using this framework in NVivo 11, and then charted, which involved summarising the views of users of the restored river and unrestored river for each sub-theme. Finally, interpretation of the data set was undertaken; the themes were compared and contrasted both within and between the two groups of local users.

4.3 Results

4.3.1 Increasing ecological integrity

On the Medlock, the restored site (M-R) has better ecological health than the unrestored downstream site (M-UR). Four out of six metrics differed significantly from zero: richness; total

abundance; EPT abundance; and Shannon diversity; were higher at the restored site (M-R) indicating increased diversity, abundance, and pollution tolerance (Fig. 3; Table 2). However, the ecological health of the restored site (M-R) was lower than that of the upstream site (M-UC), with richness, abundance, EPT richness, ASPT, and Shannon diversity differing significantly from zero; all apart from abundance were lower at the restored site (Fig. 3; Table 2).

Table 2 Mean response ratios for each metric, standard error in parentheses. P-value calculated using Mann-Whitney U test and indicates a significant difference from zero.

	Restored river				**Unrestored river**			
	M-R:M-UR	**p-value**	**M-R:M-UC**	**p-value**	**I-UR2:I-UR1**	**p-value**	**I-UR2:I-UC**	**p-value**
Richness	0.63 (0.08)	<0.001	-0.46 (0.05)	<0.001	0.14 (0.04)	0.014	0.24 (0.05)	<0.001
Abundance	0.81 (0.17)	<0.001	0.29 (0.08)	<0.001	0.14 (0.09)		-0.14 (0.10)	
%EPT richness	0.32 (0.25)		-0.23 (0.12)	<0.001	-0.26 (0.07)	<0.001	0.42 (0.09)	<0.001
%EPT abundance	1.50 (0.16)	<0.001	-0.73 (0.23)		-0.42 (0.17)		0.18 (0.14)	
ASPT	0.05 (0.03)	<0.001	-0.16 (0.03)	<0.001	-0.03 (0.02)		0.10 (0.02)	<0.001
Shannon diversity	0.70 (0.11)		-0.37 (0.05)	<0.001	-0.06 (0.05)	0.002	0.07 (0.05)	

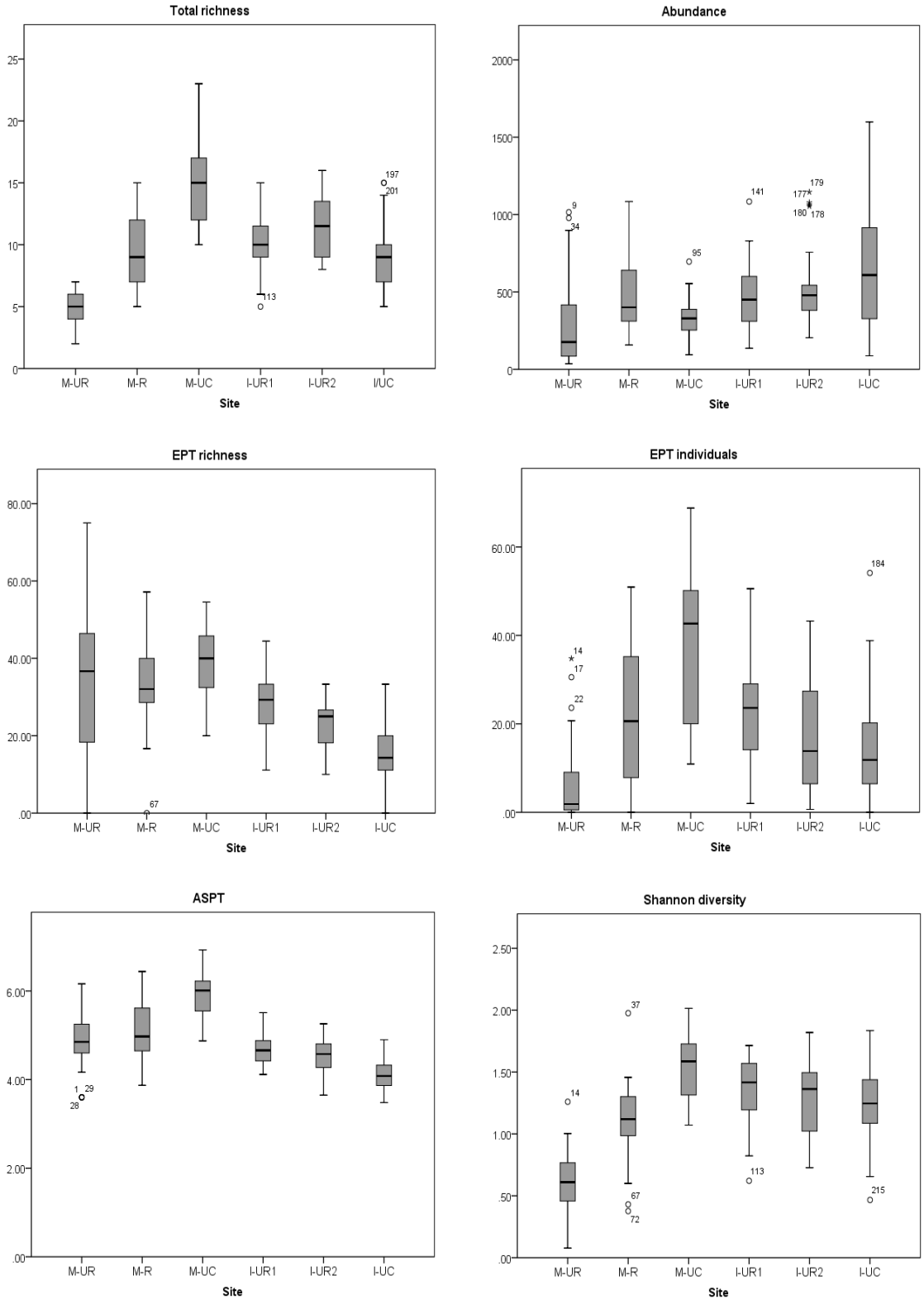

Figure 3 Comparison of macroinvertebrate diversity and pollution tolerance metrics for all sites on the restored and unrestored rivers.

On the unrestored Irk, there was some difference in ecological health between the unrestored upstream (I-UR2) and unrestored downstream (I-UR1) sites. Response ratios differed significantly from zero for richness, EPT richness, and Shannon diversity. These metrics were all higher at the unrestored upstream site (I-UR2), indicating more diversity and pollution tolerant macroinvertebrates but no difference in abundance (Fig. 3; Table 2). In contrast to the Medlock, the unrestored comparison site (I-UR2) was more ecologically healthy than the upstream site (I-UC), as richness, EPT abundance, and ASPT all differed significantly from zero, with all apart from EPT abundance being higher at the unrestored site (I/UR2) (Fig.3; Table 2).

There were significant differences in all metrics for response ratios between the restored (M-R) and upstream (M-UC) sites and comparison sites (I-UR2 and I-UC) on the unrestored river (Table 3; Fig. 4). The difference was larger between these sites for abundance on the Medlock, and on the Irk for all other metrics, indicating that there is a larger difference in diversity and pollution tolerance between the upstream sites (I-UR2 and I-UC) on the Irk than the restored (M-R) and upstream (M-UC) sites on the Medlock (Table 3; Fig. 4).

Table 3 Comparison of response ratios for each metric from the restored and unrestored rivers. P-value calculated using Mann-Whitney U test and displayed when significant.

	M-R:M-UR compared with I-UR2:I-UR1	**M-R:M-UC compared with I-UR2:I-UC**
	p-value	**p-value**
Richness	<0.001	<0.001
Abundance	<0.001	0.004
%EPT richness		<0.001
%EPT abundance	<0.001	0.014
ASPT	0.043	<0.001
Shannon diversity	<0.001	<0.001

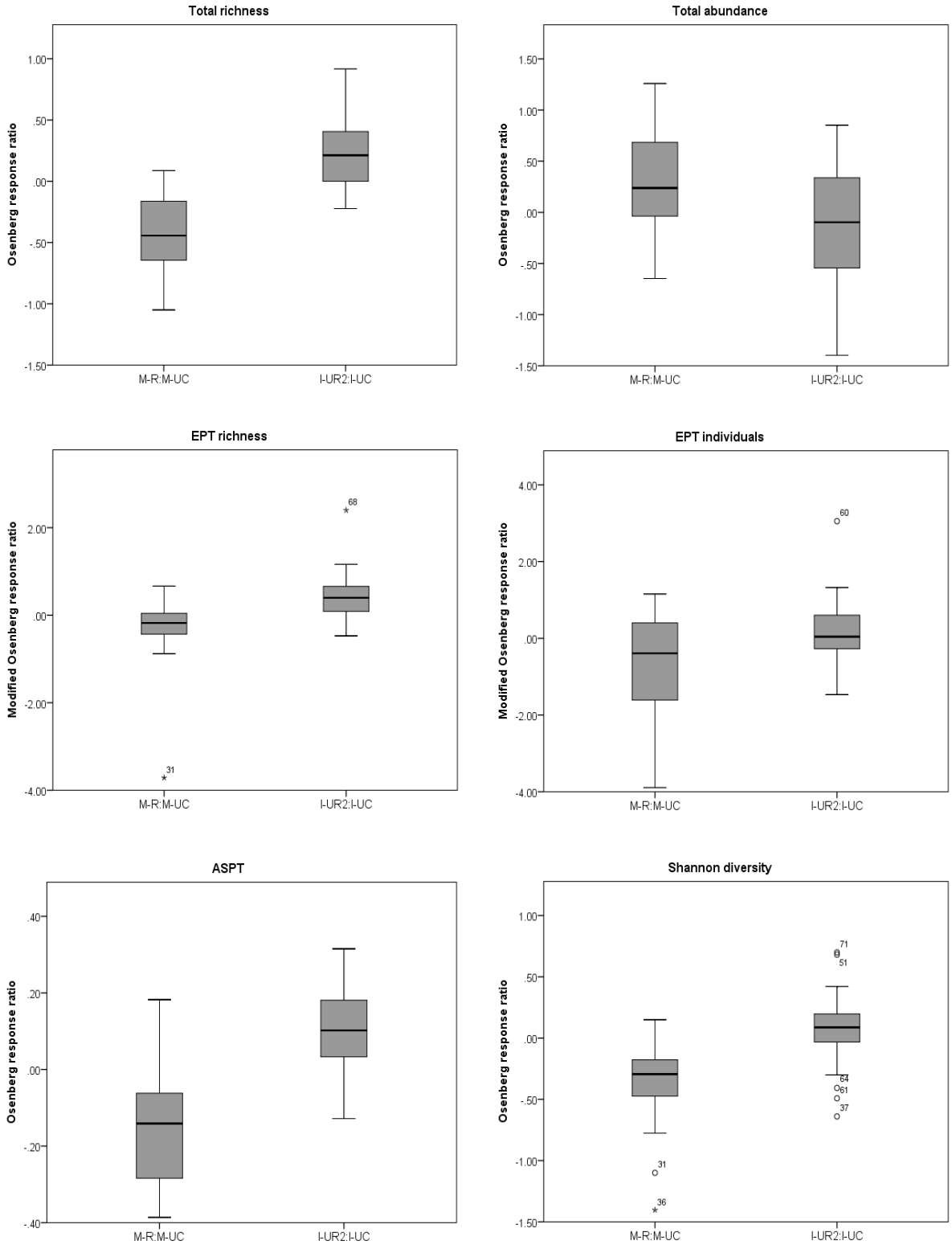

Figure 4 Comparison of response ratios of diversity and pollution tolerance metrics for the restored (M-R) and upstream (M-UC) sites on the Medlock, and unrestored and upstream comparison sites (I-UR2 and I-UC) on the Irk.

A comparison of metrics between the restored site (M-R) and unrestored downstream site (M-UR), and comparison sites (I-UR2 and I-UR1) on the unrestored river showed there were significant differences between response ratios for richness, total abundance, EPT abundance, ASPT, and Shannon richness, although no significant difference was seen for EPT richness. Response ratios were higher on the restored river, indicating a bigger difference in ecological health between the restored (M-R) and unrestored (M-UR) site than the comparison sites (I-UR2 and I-UR1) on the unrestored river (Table 3; Fig. 5).

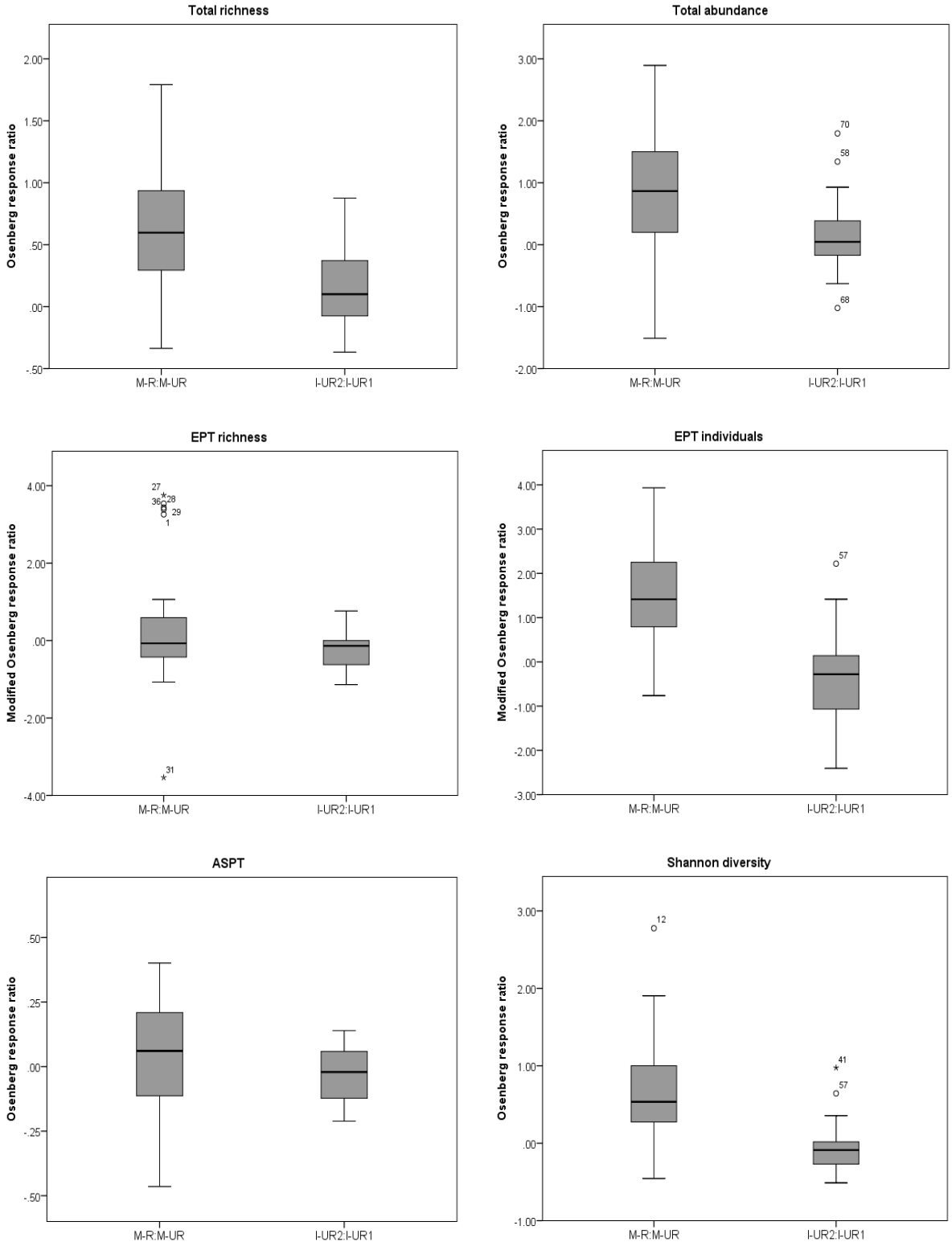

Figure 5 Comparison of response ratios of diversity and pollution tolerance metrics for restored (M-R) and downstream unrestored (M-UR) sites on the Medlock, and unrestored comparison sites (I-UR2 and I-UR1) on the Irk.

Users of the restored and unrestored rivers both felt that the restoration of the Medlock had been successful in improving the ecological health of the river. When comparing the unrestored and restored sites on the Medlock, users of the unrestored river commented *"that's more…contrived again…[unrestored site], that's more natural [restored site]"*, whilst local users noted that the restoration *"just shows how nature quickly takes over"*. Local users of the restored river emphasised that the restoration had improved the variety of wildlife at the site: "*all of a sudden a kingfisher was fishing there, and you could see little shoals of fish…and…these three dragonflies…all dancing over the river"*.

In contrast, comments by users of the unrestored river indicated that they perceived ecological health to be equated with the neatness of the site: *"I do think it [the Irk] could perhaps do with a bit of tidying up…there's a tendency to want to let stuff grow at the sides…[which]…acts as a sort of filter for collecting rubbish"*.

4.3.2 Benefitting and engaging society

Overall, all participants viewed the restoration of the Medlock as a success, with users of the restored river commenting *"that has been the biggest change, the Vale, it is lovely when you're walking along"*. Seeing the changes in the river led users of the unrestored river to reflect on the possible restoration of the Irk: *"they're doing it all up, aren't they, with this…Big Local thing, the walkway…that'll be nice"*.

Positive views of the restoration were related to the benefits participants attributed to urban natural spaces. Users of both rivers felt that spending time in a natural environment improved their mental well-being, with a user of the restored river commenting on Clayton Vale: *"I suffer from depression and I think going out here it lifts you"*, whilst a user observed *"everyone feels better after you've been to the park"* when discussing the natural spaces around the unrestored river. Emphasis was placed on the role of the natural environment as a space to escape the urban environment. Users of the unrestored river felt that the natural spaces around the river were important in *"just getting away from it all...if we go to town, it's all cars and whatnot, so it's nice just to think you've gone away somewhere [to] be out of yourself"*. Another user similarly commented *"you walk [the]…Irk Valley and you're seeing all these cars and all of a sudden…all you can hear is the birds and the stream"*. Users of the restored river expressed similar views: *"if you stand there and listen, you get in the centre of Clayton Vale, you can't hear any traffic, you can hear birds…it's just a little oasis in the centre of Manchester, it's lovely"*.

Water was considered particularly important in natural spaces. Discussing pictures of natural spaces containing water, the relaxing and calming nature of watching water was emphasised by users of the unrestored river *"it'd just be calming I think, you know, you could sit and it'd be*

calming…to sit there and watch that" and by users of the restored river *"very tranquil, just the sound of the water…it's very relaxing"*.

Users' aesthetic preferences for natural environments contributed to their positive view of the restoration. Both groups felt that variety in natural habitats makes them interesting to visit. When looking at pictures of the restored site, participants who were familiar with the restored river commented specifically on how at the restored site *"you've got a variety of colours and that…stands out"* and users of the unrestored river agreed *"it's more varied isn't it, I've got more different habitats there for finding plants*".

The importance of natural elements such as plants and wildlife in the natural spaces around the unrestored river was emphasised by users as important when they felt stress: *"when I'm having a bit of a stressful day, I'll go there and sit on the benches, and just walk around there…listen to the birds and what have you cause I think it's all about nature"*. Users of the restored river also commented on natural features in the green spaces around the restored river *"trees and that are important because if you've got no trees in there what's the point in walking down it, nothing to look at, no point in going is there"*, emphasising their importance as focal points for visits to natural spaces.

In terms of the restoration work, users of the restored river commented that they *"don't remember the work being done"* and felt that *"they [users] were more concerned about the cycle track than they were about that [the Medlock restoration]"*. The ecological restoration was seen as a positive change whereas features such as the new cycle track were perceived as being likely to change the use of the park and lead to an increase in anti-social behaviour.

Contributing to restoration work was also successful in engaging local users; improving ecological health was a motivation for volunteering at both the restored: *"that's one of the reasons why I joined anyway and we're really interested in what's on here…the wildlife and everything…it's terribly important especially the bees"* and the unrestored river: *"I quite like the river…it's one of the reasons we turned up on the clear-up day to try and improve the river"*.

4.3.3 Taking account of the past and future

Discussions among participants indicated that, in their view, the restoration had not been successful in terms of taking the past and future into account, with comments pointing to a conflict for some between ecological restoration and the heritage of the restoration site.

Some users of both rivers felt that improving the ecological health of the space matters more than its history, with comments including *"it's part of our heritage…I'm into heritage and old buildings and things like that but some things you've got to change, especially for the better"*.

Users of the unrestored river were not attached to built features which they considered undesirable despite their historical importance. For example, commenting on the brick channel of the Medlock, one participant said: *"that looks more like a…sewer thing really"*. Some users of the unrestored river placed less value on the areas of the Irk that had poor ecological health as a result of past industry: *"I'm not worried what they're doing with that part really, I don't know what it was before but it looks as though it's been reclaimed"*.

However, not all participants felt this way. The history of their urban natural spaces was important to some local users, on both the restored river *"that red brick is part of our history…it's part of the history of Philips Park, it's part of the history of Clayton"*, and the unrestored river *"the industry is part of its heritage in a modern way"*. These users felt that restoration should respect local history and the heritage of the area. Whilst users of the restored river commented of the unrestored section of the Medlock that *"I really would like to see something done to it as long as…it's done properly"*, they expressed the view that *"that [red brick] is also part of our history and some of it should be left"*. This view was echoed by users of the unrestored river: *"the industry is part of its heritage…and although we moan about it and about the quality of the water for people, I'm not sure it's as much of an issue…not for me I find looking at the water quite pleasant even though I might not want to get in it*".

Users of both rivers felt that familiar manmade features were either unnoticed or acceptable in natural landscapes. On the restored river, one user commented on the brick channel of the Medlock: *"I suppose when you think about it, [it's] not very natural looking, but it was something you'd always seen so you didn't really think about it"*. Users of both rivers also compared the Medlock pre-restoration to other landscapes, e.g. *"when you're up there [the Pennines], with the reservoirs and the water stations and the channels, there's this whole load of manmade stuff up there which I don't find unpleasant"*.

4.3.4 Sustainability

Despite the perceived improvement in ecological health, users of the restored river felt that the long-term sustainability of the project was a concern. Users expressed the view that there is a general problem with the management of natural spaces in urban areas: "*you come into Manchester, they're [green spaces] badly neglected at the moment"*; and commented that continued management of the restoration was needed: *"it was nice when I went through there [Clayton Vale] the first time…but…what it's like now I don't know…it's the follow up…that's the problem"*.

Despite this, restoration was considered essential to ensuring that people continue to use natural spaces in urban areas, thus suggesting that restoration was integral to their sustainability

in the long-term. Both groups felt that restoration was needed to provide access to natural spaces. Users of the restored river commented on the unrestored section of the Medlock *"it'd be nice to have it opened up, I mean at the moment it's all fenced off"*. Similarly, users of the unrestored river said *"it's [unrestored park and river] got to be done up, they're building more [houses] up here now, there's going to be no green space so we'll need it even more"*.

Users of the restored and unrestored rivers agreed that, to ensure long-term sustainability of urban natural spaces, ecological restoration is not sufficient. They emphasised the need for restorations which provide amenities and facilities so that parks appeal to people: *"we need these goalposts putting back in…that will as I say attract a lot more"*. These facilities were also considered essential in allowing a wide range of users to access the parks, including children *"especially when you're taking little ones, I think you'd really need them [toilets]*", and elderly users *"we need the community to go through there [Queen's Park], so we need a couple of benches…the elderly can go maybe walk through with their grandchildren"*.

4.4 Discussion

Macroinvertebrate data indicate that restoration has led to some improvement in the ecological health of the Medlock. Compared to the downstream unrestored site on the same river, there is greater species richness and abundance, and more pollution-intolerant macroinvertebrates in the restored section of the Medlock, indicating that the ecological health of the restored site is better than that of the unrestored site. However, the restored site was less ecologically healthy than the upstream comparison site. Comparison of the ecological health of sites on the Medlock to those on the Irk show that there is a larger difference in richness, abundance, and the presence of less pollution-tolerant macroinvertebrates between sites on the Medlock than the Irk, suggesting that it is the restoration which has led to an improvement in ecological health.

Users of the restored and unrestored rivers viewed the restoration positively, and attributed psychological benefits to visiting the natural spaces around the rivers. They considered nature important, including sensory experiences in these environments and the presence of a variety of habitats and wildlife. However, there were differences of opinion within both groups regarding the importance of restoring ecological health compared to preserving the presence of built features relating to the cultural and industrial heritage of the area. Users of the restored river expressed concerns regarding the long-term sustainability of the project but agreed with users of the unrestored river that restoration was essential to ensure that people use urban natural spaces.

4.4.1 Ecological and social benefits of restoration

Although studies of river restoration have shown that projects have mixed success (Kail et al., 2015), improvements in ecological health have been seen after enhancement of riverbed heterogeneity (Hering et al., 2015; Neale & Moffett, 2016). The ecological improvement resulting from the restoration can likely be attributed to the creation of habitats within the river through the removal of the brick channel and introduction of boulders and gravels. However, differences in ecological health were also seen between sites on the unrestored river, so variation in the ecological health of the Medlock may not be entirely due to restoration. The restoration is relatively recent so the river may need longer to recover from both the canalisation and the disturbance caused by the restoration, through colonisation by taxa from upstream communities. The river is also situated in an urban area which has had a highly industrial past. It is likely that achieving a larger improvement in ecological health would require the adoption of a wider catchment approach to address impacts from the urban environment (Neale & Moffett, 2016).

Local users highlighted the benefits of the restoration for wildlife and commented on seeing birds and insects at the site. There was an increase in the abundance of macroinvertebrates as a result of the restoration which may attract more birds to feed at the site. Whilst users' observations of wildlife may not be accurate, there is evidence that people find spaces they perceive as more biodiverse to be more restorative (Dallimer et al., 2012). Users derived psychological benefits from visiting the restored river and associated natural spaces, and highlighted the sensory and aesthetic appeal of the site. This corresponds with the increasing evidence of the benefits of visiting natural environments for mental health and well-being (Gascon et al., 2015; Hartig et al., 2014). It also suggests that the ecological improvements have been effective in increasing the ability of the restoration site to provide psychological benefits by improving the appearance and enhancing the sensory appeal of the site. For example, the restoration added the distinctive sound of flowing water to the site as it changed the shape of the river bed.

Users of the unrestored river felt their mental well-being was improved by visiting the Irk and associated natural spaces too, demonstrating that natural spaces provide benefits, and highlighting the importance of access to local nature in urban environments. People are more likely to visit spaces which are near to their homes and therefore obtain benefits from them (Schipperijn et al., 2010). However, users of both rivers felt that restoration was needed to ensure that people use natural spaces and that they are sustainable in the long term indicating the quality of the space is also a determinant of use. There is some evidence that it may take time for the social benefits of restoration to become apparent (Åberg & Tapsell, 2013), although

our findings suggest that the social benefits of the restoration of the Medlock are evident even in the short-term. The provision of social benefits as a result of restoration is important as they can help achieve ecological objectives, by leading to support for the project and its long-term sustainability meaning that the ecosystem has time for recovery (Smith et al., 2016).

4.4.2 Concerns regarding restoration

Despite the positive views held of the restoration overall, concerns regarding the project were identified by local users, which link to the four principles proposed by Suding et al. (2015). Negative views of restoration arose as a result of people's sense of place. People place value on features which reflect the history or cultural heritage of their local environment (Pietrzyk-Kaszyńska et al., 2017). Both the Medlock and Irk are situated in areas which were home to heavy industry and people value features which reflect this past. Our findings indicate that, if these features are not detrimental to the environment, it is important to consider the views of local users before removing them. The long-term sustainability of urban restoration projects is dependent on community support and use, and a lack of engagement can lead to low levels of trust which have been identified as critical to restoration success (Metcalf et al., 2015).

Although the restoration led to an improvement in ecological health, users of both rivers felt that the sustainability of restoration projects and the use of natural spaces are dependent on changes beyond the ecological. They wanted to see improvement of facilities as well as what they considered proper management. Studies indicate that people expect urban natural spaces to be more managed than rural environments (Cooper et al., 2017), and that the public often describe more natural-looking environments as untidy and messy (Hands & Brown, 2002; Özgüner & Kendle, 2006). This suggests these concerns may be at least partly attributable to a disconnection and lack of understanding regarding natural environments (Soga & Gaston, 2016). Providing facilities such as paths, benches, and toilets in natural urban spaces is important to ensure they can be accessed by a range of user groups and help to overcome some of these concerns.

4.4.3 Limitations

Our study participants were recruited via local venues; they also included participants who were members of groups linked to local green spaces. While these methods are widely used in community-based studies, we may have recruited those who held strong views on local green spaces and their restoration. Residents making little use of local green spaces were also underrepresented in the study and it would be useful to investigate their views in future studies in order to design restorations to encourage them to visit urban natural spaces (Coldwell et al., 2017).

We were unable to take before and after measurements of either the ecological or social impacts of the restoration, a problem often experienced when researching restoration. However, using a space for time substitution and a qualitative study design has allowed in depth exploration of the benefits of the restoration.

4.4.4 Setting goals and achieving success

This study considered four principles proposed by Suding et al. (2015) to evaluate the ecological and social success of an urban restoration project. The main benefits of the restoration relate to its impact in increasing ecological integrity and benefitting and engaging society. The restoration of the Medlock has led to improvement in the ecological health of the river and, despite some concerns over the project taking insufficient account of the past and future, its sustainability is viewed positively by local users who feel the restoration has improved the aesthetic and sensory appeal of the space. Increases in ecological health resulting from restoration may be small, especially in the short-term, but the process of restoration can yield important social benefits. This is particularly significant in urban environments where improvements to the ability of natural spaces to provide benefits will affect a large human population. In the longer term, societal support and engagement can enhance the sustainability of projects, allowing time for the full ecological benefits to be realised.

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Chapter 5 The role of managed natural spaces in connecting people with urban nature: a comparison of local user, researcher, and provider views

Preface

People are becoming increasingly disconnected from nature which is a problem as it means they do not visit natural spaces and therefore do not receive benefits from them (Soga & Gaston, 2016). In order to encourage use, urban natural spaces need to be managed so that they are attractive to local people. However, this requires providers, who are involved with the management of these spaces, to be aware of user needs and preferences. This chapter includes data from Chapter 4 on the views of local users regarding urban natural spaces, supplemented with data from interviews with researchers, the research community providing evidence on local user preferences, and providers, who are involved in the provision and management of these areas. The views of these groups are compared to explore the importance of the management of urban natural spaces in connecting people with nature.

This chapter is written in the style of, and will be submitted to, *Urban Ecosystems*.

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Soga, M., & Gaston, K. J. (2016) Extinction of experience: The loss of human-nature interactions. *Frontiers in Ecology and the Environment*, 14, 94–101. http://doi.org/10.1002/fee.1225

Abstract

Increasing evidence of the health and well-being benefits of urban natural spaces has resulted in policy goals to increase their use. Making these spaces accessible and attractive to potential users is fundamental to realising their benefits, but there has been limited investigation of whether the ambitions of providers align with local user preferences. We investigated similarities and differences in the views of different stakeholder groups regarding urban natural spaces in the UK. Using a qualitative approach, we combined interviews of providers and researchers with focus groups of local users and analysed the resulting transcripts using framework analysis. Three overarching themes were identified: (i) the role of managed environments in connecting people with nature; (ii) built features as facilitators of connection with nature; and (iii) challenges to connecting with nature arising from built features and the management of natural spaces. Although there were points of agreement between the stakeholder groups, we identified some key differences. Local users expressed a preference for both wilder and more formal urban natural spaces and opposed the removal of built features which were significant to the local history of the area. Providers were not aware of local user preferences for wilder spaces or the extent that local users considered certain built features important. Our findings regarding the importance placed on natural spaces by local users have implications for the design of policies to provide co-benefits for the environment and health.

5.1 Introduction

Over half the world's population lives in urban areas and this proportion will increase with ongoing urbanisation (Lin et al., 2014). 'Natural' spaces in urban areas, which include green and blue space, provide residents with everyday nature experience and the opportunity to connect with nature (Miller, 2005; Palliwoda et al., 2017). The health benefits of these spaces are increasingly recognised, both in high-income countries and emerging economies such as Brazil, China, and India (Soga & Gaston, 2016; Mell, 2017). Whilst few countries have national policies to increase opportunities for people to visit natural spaces, many implement policies at regional, city, or local level (Lin et al., 2014; Mell, 2017). In Europe, networks such as the WHO European Healthy Cities Network encourage investment in biodiversity conservation to promote human health (Ten Brink et al., 2016). However, despite these ambitions, the last 20 years has seen an increasing disconnection of people from nature in many countries (Soga & Gaston, 2016).

5.1.1 Increasing nature experience in the UK

In the UK, the National Planning Policy Framework highlights the importance of green space and places the responsibility for incorporating green infrastructure into built developments with local authorities (Department for Communities and Local Government, 2011). Many local

authorities set minimum targets for quantity of green space in the living environment. For example, Bristol City Council aims to provide accessible green space within 400m of the home (Bristol City Council, n.d.).

Yet almost 10% of the UK population do not visit the natural environment at all and, of those who do use natural spaces, visits by 32% of the population account for 75% of time spent in nature (Cox et al., 2017; Natural England, 2015). There is evidence that people exercise more in parks with greater biodiversity (Lovell et al., 2014), and that visiting spaces that are, or are perceived to be, more biodiverse is beneficial for mental health (Fuller et al., 2007; Luck et al., 2011). Public interaction with urban natural spaces might therefore be encouraged by increasing opportunities to experience and connect with nature through the provision of areas of high quality nature within people's living environments, whether through management for nature or ecological restoration, the improvement of damaged or degraded ecosystems (Dunn et al. 2006; Miller 2005).

Responsibility for the restoration and management of urban natural spaces falls to providers, both strategic providers at policy or planning level who ensure the provision of urban natural spaces, and implementers responsible for the management of individual sites, such as project managers for local authorities or environmental organisations (Smith et al. 2016). Providers need an understanding of user preferences to ensure they are providing spaces which meet people's needs (Riechers et al., 2016), and are attractive, ensuring interaction by local users (Clayton et al., 2016; Colleony et al., 2017). However, there has been little research into how the views and preferences of local users and providers are aligned concerning management and restoration initiatives (Buijs & Elands 2013).

This paper therefore compares the views of local users and providers regarding the restoration and management of urban natural spaces. It also considers the views of researchers, as members of the research community both gather and provide evidence on preferences in natural environments, so influence the management of these spaces. The following section of the paper will discuss research into the preferences of local users regarding urban natural spaces and the limited evidence base comparing the views of local users, providers, and researchers.

5.1.2 Local user preferences

Recent reviews of biodiversity preference and urban park use have found that the aesthetic appearance of urban natural space is more important to the majority of users than high levels of biodiversity (Botzat et al., 2016; McCormack et al., 2010). Within these spaces, people enjoy seeing focal landscape features such as water as well as wildlife and plants, particularly trees and colourful displays of flowers (Botzat et al., 2016; McCormack et al., 2010). Southon et al.

(2017) found that wildflower meadows are preferred to formal border displays although preferences were dependent on level of connection with nature.

Whilst people expect rural nature to be natural, they have different expectations of urban natural spaces (Cooper et al., 2017). Within urban areas, people prefer spaces with amenities such as paths, seating, toilets, and play equipment (McCormack et al., 2010; Wang et al., 2015). They are also more likely to visit relatively open landscapes without dense vegetation, as they feel safer in areas with high visibility (Qiu et al., 2013), and spaces which are well-maintained and litter-free (McCormack et al., 2010). Bertram & Rehdanz (2015) found park visitors considered a park's cleanliness a more important characteristic than the 'naturalness' of its appearance.

5.1.3 Comparisons between views of local users, researchers, and providers

A study of scientists and local users noted similarities regarding their connection with nature, particularly their emotional responses and the association of memories with the natural environment (Prévot et al., 2016). However, assessments of various tools for evaluating neighbourhood quality indicate stakeholders and residents view the quality of green spaces differently (Bonnes et al., 2007; Dunstan et al., 2005). Providers have specific knowledge regarding the management and environmental characteristics of urban natural spaces which can influence their views (Hofmann et al., 2012); preferences regarding the appearance of urban natural spaces have been found to differ even between groups of providers (Özgüner et al., 2007). Studies have found that strategic providers involved in landscape planning prefer 'natural' green spaces whereas local users would rather visit more formal or artificial spaces (Hofmann et al., 2012); and that providers, both strategic providers and implementers, take a more utilitarian view of nature compared to local users who find enjoyment of nature important (Riechers et al., 2016).

Available evidence comparing the views of local users, researchers, and providers indicates differences in their preferences in urban natural spaces. However, the evidence base is limited and derived primarily from quantitative studies. Such study designs provide little insight into meanings attached to the local environment and natural spaces (Gill et al., 2008). These are influenced by a wide range of factors, including the value people place on nature, their experiences in natural spaces, and relational values, such as the contribution of people's relationships with nature to their cultural and individual identity (Chan et al., 2016; Cooper et al., 2017). This study will take a qualitative approach to comparing the views of these stakeholder groups as qualitative studies can shed light on these influences (Gill et al., 2008),

and contribute to a deeper appreciation of the individual and societal benefits of natural spaces (Chan et al., 2016; Swanwick, 2009).

5.1.4 Objectives

This study investigates similarities and differences in the views of four stakeholder groups regarding the restoration and management of urban natural spaces, using the ecological restoration of an urban river as a case study. These groups are (i) local users who access these spaces; (ii) researchers, members of the research community providing evidence on the restoration and management of these spaces; and two groups of providers (iii) strategic providers who are responsible for the provision of urban natural spaces; and (iv) implementers involved with the daily management of urban natural spaces. Specifically, views were sought on the following questions:

- How should urban natural spaces be managed to encourage interaction of local users with nature?
- What is the role of built features in urban natural spaces in encouraging interaction with nature?

5.1.5 Case Study

The study is part of an investigation of the ecological restoration of an urban river in a major UK city. The Medlock is located in Manchester, a city with a population of 2.5 million, in what was once an area of heavy industry. It was culverted in the late 1880s and a section of the river was then restored over a nine-month period from autumn 2013 to spring 2014 with the aim of improving the environmental health of the river and increasing access for local residents. The Medlock flows through two urban green spaces accessible to the public, the restored section is located in Clayton Vale, and an unrestored section of the Medlock flows through Philips Park. The river Irk flows through a similar area of Manchester to the Medlock including two areas of accessible green space, Queen's Park and Blackley Forest, but has not been restored, so serves as a comparison to the Medlock.

5.2 Methods

5.2.1 Study design

We used a mixed methods design, using focus groups for local users of green spaces around the Medlock and Irk and interviews for researchers and providers. Focus groups can facilitate participation by those who may find the interview format off-putting (Kitzinger, 1995), while researchers and providers can be more comfortable in the 1:1 format of an interview (Gill et al., 2008).

5.2.2 Data collection

5.2.2.1 Focus groups with local users

Focus group discussions were conducted with users of the four natural spaces – Clayton Vale, Philips Park, Queen's Park and Blackley Forest - surrounding the restored river and unrestored river. Participants were recruited from local groups: three of the natural spaces around the rivers have regular walking groups which were contacted, as were the community groups associated with these areas including the Friends of Clayton Vale, the Friends of Philips Park, the Friends of Blackley Forest, and the Big Local initiative at Queen's Park. Posters were displayed on the park noticeboards at all of the green spaces and posters and flyers advertising the focus groups were left at local venues including corner shops, libraries, and community centres. Focus groups were conducted until data were collected from users of all four green spaces around the restored and unrestored rivers.

The focus groups began with a discussion of how often participants visited the parks, areas they liked and disliked, and their reasons for visiting. Photo-elicitation techniques were then used to prompt discussion (Harper, 2002). A range of photograph sets were used; these pictures displayed spaces with a dominant natural characteristic such as water, trees, or flowers, in either a more formal or more natural management regime. A set of photos of the river Medlock, before, during and after restoration, along with a picture of an unrestored downstream section of the river Medlock, were also shown. The discussion was centred on the spaces people would prefer to visit if they were visiting a natural environment for either exercise or relaxation and the importance of nature to their visit. The presence of water, its importance, and how it made people feel when visiting a natural space, was also discussed (see Appendix 3 for the focus group protocol).

5.2.2.2 Interviews with stakeholders

Interviews were conducted initially with local providers and researchers, and then extended beyond the area to gain a wider UK perspective. Purposive sampling was used to obtain a range of views. The aim was to recruit a sample containing representatives of the research community (academics and senior members of research organisations), and providers. Providers included those involved in implementation (e.g. city council, Wildlife Trust, and agency project managers), and those with a strategic role (e.g. Directors of Public Health and strategy managers). Additional participants were recruited and interviewed until data saturation was achieved (Heath et al., 2012).

An email invitation was sent to participants; interviews were conducted either face-to-face or over the telephone. The interviews were semi-structured around key topics (Box 1); see

Box 1 Guide to topics covered in the interview

- Appearance and characteristics of an ecologically healthy urban natural space
- Interactions by local people with urban natural spaces
- The impact of ecological health on people's interactions with urban natural spaces
- Perceptions of the benefits of urban natural spaces for human health and well-being
- Discussion of the ecological restoration of the Medlock and its ecological impact (using pictures of the restoration and ecological data)
- Discussion of the ecological restoration of the Medlock and its social impact (using pictures of the restoration and quotes from the focus groups)
- Compatibility of nature conservation in urban natural spaces and their use by local people

Appendix 4 for the full interview protocol. Photographs of the restoration, as shown in the focus groups, were used to facilitate discussion, as were quotes from the focus groups and data regarding the ecological impact of the restoration.

5.2.3 Study participants

The overall sample (n=44), included 12 local users and 32 providers and researchers.

Five focus group discussions, lasting between 20 minutes and one hour 40 minutes, were conducted during October 2015; two with users of the restored river, and three with users of the unrestored river. Of the 12 participants, 10 were female and 2 male, and all were 45 years or older. Half had lived in the area all their lives, four for more than five years, and two between one and five years.

Thirty-two interviews were conducted between July and November 2016; each interview lasted between 20 minutes and one hour. Participants included 8 researchers, 12 implementation providers, and 12 strategic providers.

5.2.4 Analysis

All focus groups and interviews were audio-recorded and fully transcribed. The transcripts were analysed using framework analysis (Ritchie & Spencer, 2002); a two-stage framework analysis

was carried out as in Furber & McGowan (2011). The first stage involved the separate analysis of the focus groups and interviews. After familiarisation with the dataset, an initial thematic framework was constructed for each dataset. An inductive approach was adopted using thematic analysis techniques (Braun & Clarke, 2006; Tonkin-Crine et al., 2011); themes were identified from the data rather than being taken from existing literature. Themes were cross-checked between authors and the two frameworks were then applied to their corresponding data sets. Text was coded in paragraphs to place each quote in context (Finlay et al., 2015). The transcripts were coded in NVivo 11.

Once completed, the common emergent themes between the two data sets were identified and a second framework analysis was undertaken. The management of the natural environment and the role of built features were major topics of discussion in the focus groups and interviews so a thematic framework encompassing these issues was developed and applied to both data sets. This was followed by charting, with data relating to each participant being organised and summarised by theme allowing interpretation of the data (Gale et al., 2013; Ward et al., 2013). Responses were compared within each theme in order to understand similarities and differences in the views of different groups of participants (Metcalf et al., 2015).

5.3 Results

Three overarching themes were identified regarding the role of the built environment and management of urban natural spaces in facilitating connection with nature (summarised in Table 1). The themes were (i) the role of managed environments in connecting people with nature; (ii) built features as facilitators of connection with nature; and (iii) challenges to connecting with nature arising from built features and the management of natural spaces. The views of local users (LU), providers – strategic (PS) and implementers (PI) - and researchers (R) in relation to these three themes are compared and contrasted below. Strategic providers and implementers are referred to as providers apart from where the two groups express different views.

Table 1 Summary of the views of local users, researchers, and providers for each theme

Theme	Local users	Commentators	Implementers	Strategic providers
The role of managed environments in connecting people with nature	People want access to natural space in urban areas.	Access to natural space in urban areas is important for local users.	Access to natural space in urban areas is important for local users.	Access to natural space in urban areas is important for local users.
	Some users prefer, and connect to nature, in more managed environments, some prefer wilder natural spaces. Individuals connect with nature in spaces in which they were comfortable.	Local user preferences' in natural spaces are dependent on the individual. People are more likely to connect with nature in spaces in which they feel comfortable; these may be wild or more managed.	Local users prefer natural spaces with the appearance of management and are more likely to feel comfortable and connect with nature in these spaces.	Local users prefer natural spaces with the appearance of management and are more likely to feel comfortable and connect with nature in these spaces.
		Managing urban natural spaces for nature exposes people to nature and therefore facilitates connection with nature.	Managing urban natural spaces for nature exposes people to nature and therefore facilitates connection with nature.	
	Connecting with nature was a reason for becoming involved with volunteer management.	Volunteering encourages people to connect with nature.	Volunteering encourages people to connect with nature.	Volunteering encourages people to connect with nature.

Built features as facilitators of connection with nature	Built features add value to natural spaces, are important in increasing their accessibility, and allow people to come into contact with nature. Built features are seen as part of the natural environment. Built features contribute to people's sense of place.	Built features add value to natural spaces, are important in increasing their accessibility, and allow people to come into contact with nature. Built features contribute to people's sense of place.	Built features add value to natural spaces, are important in increasing their accessibility, and allow people to come into contact with nature. Built features are seen as part of the natural environment and can enhance experiences of the space. Built features can facilitate connection with nature by making people feel safe in natural spaces.	Built features add value to natural spaces, are important in increasing their accessibility, and allow people to come into contact with nature. Built features are seen as part of the natural environment (negative).
Challenges to connecting with nature arising from built features and management	Removal of built features which are part of cultural heritage disrupts sense of place. Built features and lack of management, particularly resulting in a poor appearance, lead to negative perceptions of the space and mean it is hard to use.	Built features which are part of cultural heritage and contribute to sense of place should be kept in urban areas if possible. Built features and lack of management, particularly resulting in a poor appearance, lead to negative perceptions of the space and mean it is hard to use.	Built features which are part of cultural heritage and contribute to sense of place should be kept in urban areas if possible. Built features and lack of management, particularly resulting in a poor appearance, lead to negative perceptions of the space and mean it is hard to use.	Built features which are part of cultural heritage and contribute to sense of place should be kept in urban areas if possible. Built features and lack of management, particularly resulting in a poor appearance, lead to negative perceptions of the space and mean it is hard to use.

Lack of provision of wilder natural spaces means some local users do not have spaces in which they can connect with nature.	Assumption that users do not want wilder natural spaces means some do not have spaces in which they can connect with nature.	Local users do not recognise more ecologically healthy spaces.	Urban natural spaces are managed for local users not nature. They are of poor quality due to the surrounding urban environment.
Management for nature can mean people do not feel safe using natural spaces.	Management for nature can mean people do not feel safe using natural spaces.	Management for nature can mean people do not feel safe using natural spaces.	Management for nature can mean people do not feel safe using natural spaces.

Theme 1: The role of managed environments in connecting people with nature

Local users commented that nature in urban areas should be accessible and expressed displeasure that nature they want to access "*is all fenced off" (LU1)* and *that "they're building more up here now so there's going to be no green space" (LU4)*.

Providers highlighted the importance of providing access to natural spaces in urban areas to give people a place to interact with nature. Similarly, researchers emphasised that people need access to natural spaces in urban areas so they see nature as part of their everyday lives: *"you don't want people to think that they have to leave the city to experience nature" (R1)*. For implementers, the provision of this space mattered more than its quality*: "some of that space where that interaction might happen might not be the most natural bit of river but you've made sure it's safe enough for people to sort of go and [play]" (PI3)*.

Providers and researchers considered that people prefer spaces with the appearance of management and do not perceive ecological health, but that they appreciate managed space as it shows the space is valued: *"I don't think the average person thinks anything about it beyond it looking well maintained and looked after" (R1)*. Implementers agreed that *"if you see something that has been restored or cared for, you can interpret it as a valuable space" (PI8)* as did strategic providers: *"there's something about it being looked after and cared for which I think goes back to that bit about connection really around place, looking after your place" (PS6)*.

Providers felt that, as people value more managed spaces, they are more likely to feel comfortable and connect to nature in these areas: *"you could probably tidy a river up and mow the banks and have it nice and neat and straight, and still do a project that delivered lots of health and well-being benefits in terms of putting in a path and getting people running in the outdoors and seeing flowers" (PI3)*. In contrast, whilst researchers agreed that people connect with nature in spaces in which they feel comfortable, this did not require managed space as it would be different for different people: *"quality and aesthetics are quite sort of personal and they depend on what you're used to and what your history is" (R7)*.

Connecting with nature in spaces in which they felt comfortable was discussed by local users in the context of the different preferences people have for formality or naturalness in urban natural spaces. Views were varied. Some preferred formal parks, as they felt that the definition of a park implies management: *"where the park I think they just like to be a little bit more…regimented" (LU1)*, whereas others preferred wild spaces: *"I don't like it too landscaped, I don't like it too pretty and perfect, and I like nature to be nature" (LU2)*.

Local users, implementers, and researchers felt that managing urban natural spaces to enhance nature could facilitate connection with nature. Local users who preferred natural areas said they were more likely to visit these spaces *"it looks like a more interesting landscape, it looks a bit wilder, if I was going to visit somewhere that might be a nicer place to walk round" (LU12)*. Similarly implementers emphasised the importance of nature in enhancing people's experience of the space: *"the more naturalised it is, the better…to give you a kind of feeling of being removed from your normal surroundings, I think is really beneficial" (PI11)*. Implementers and researchers agreed that managing spaces for nature was an opportunity to expose a wide range of people to nature: *"those areas of grass offer blank canvases for us to be able to do some very innovative conservation work…adding an educational aspect, an engagement aspect [for] people who might not necessarily escape the boundary of their city" (R3)*.

Although not discussed by local users, providers and researchers also mentioned opportunities to manage the wider urban environment to lead to incidental connection with nature*: "one of the things the city owns and manages is a massive acreage of highway verge…they're all just manicured…if we could make [these] changes…everybody driving into [the city] would suddenly be welcomed by seasonal wildflower displays, which again would reconnect people to that whole thing of, actually, it is April, or it is July"(PS5)*.

All groups noted that participation in the management of urban natural spaces can help connect local users with nature. Nature was a motivating factor for volunteering: *"that's one of the reasons why I joined [the Friends of group] anyway…to encourage…the wildlife" (LU9)*. Local users also emphasised the importance of volunteering as *"it makes you feel as though you're part of something and you're giving something back" (LU8)*.

This feeling of 'giving something back' was discussed by researchers; *"older people sometimes…when they've retired…feel like they have time to give something back" (R5)*. Similarly, strategic providers commented that, by being involved in the management of the space, local users *"begin to understand the issues involved, they have some sort of local ownership" (PS7)* and that participation in management can facilitate user engagement with nature: *"the local community have built [a sustainable urban drainage system]…and they're engaging with it, and…there is that health and well-being aspect to it, and understanding and engaging in nature and valuing nature" (PS7)*.

Theme 2: Built features as facilitators of connection with nature

All groups discussed manmade structures in urban natural spaces. The most commonly-mentioned features were park amenities such as paths, benches, and playgrounds. Others built features included artificial river channels, dams, or weirs.

All groups considered that built features aided appreciation and enjoyment of natural spaces. Local users spoke about features which enhanced their experiences, such as playground equipment as *"I take the grandkids so that they can play in the park" (LU1)*. Similarly, researchers mentioned how built features added value to sites, for example *"some industrial mining sites…they have kind of tried to, you know, create interpretation sculpture that kind of links to that industrial heritage" (R5)*. Providers and researchers both noted that built features can aid connection with nature through nature education: *"interpretation [boards] for the general public so they can see what's going on and understand it" (PI10)*, but local users did not discuss interpretation boards.

All groups commented that built features facilitated connection with nature by making natural spaces accessible. Local users emphasised the importance of paths so that *"it's no restriction to…anybody in a wheelchair" (LU2)*. Paths were seen by providers and researchers to encourage people, especially more casual users, to visit natural spaces: *"[who] we want to encourage to use these facilities, it is the more casual user, who you know isn't going to get dressed up in their hiking boots to go out for half an hour" (PS4)*. They enabled users to know where they can go, and therefore made them more comfortable using the space. Other built features highlighted by local users as facilitating access included: *"benches…[so] the elderly can go maybe walk through with their grandchildren"(LU5)* and *"some form of shelter…not a proper structure but…with our weather….half the time it's just a quick shower and you could stay there"(LU4)*.

Local users also considered built features important in creating contact with nature: *"when I'm having a bit of a stressful day, I'll go there and sit on the benches and just…listen to the birds" (LU7)*. Similarly, implementers commented *"you've been increasing human contact with nature there with the creation of a footpath along here" (PI4)* and researchers suggested that *"people will like walking along that kind of place [path], and you know, people who are interested in species, it gives them an opportunity to go and observe things" (R1)*.

Built features that related to past industry were seen by many local users as part of the history of the area: *"that red brick is part of our history" (LU2)*; and were important to local users in contributing to their sense of place. Researchers remarked on the importance of these features for people's sense of place, for example *"in Sheffield…there's old mill workings and stuff which*

once they've grown over with habitat are actually very attractive and I think that's of importance to maintain that for people's sense of place" (R6). Implementers noted that, because they made people feel comfortable within a natural space, they could help people connect with nature *"I think for some people that historical aspect is important….maybe in an urban setting if you want to introduce people in a safe way to nature…then that's appropriate" (PI4)*.

Local users and providers both felt that built features are seen as part of the natural environment in natural spaces. Local users commenting on the unrestored Philips Park said *"when you think about it, [it's] not very natural looking but it was something you'd always seen so you didn't really think about it" (LU9)*. Providers felt that this could contribute to people's experience, for *example "even though that's a completely manmade noise, they [local users] still really like that louder sort of gushing noise of the water going over the weir" (PI2)*. However, this was sometimes seen as negative by strategic providers: *"let's be uncharitable and say that's a 50% entirely artificial environment, that would probably meet a lot of people's aspirations as much as the nicest piece of semi-natural woodland or old meadow or rich pond or something decent" (PS3)*.

Theme 3: Challenges to connecting with nature arising from the built environment and management

All groups highlighted potential challenges to connecting with nature arising from the management of natural spaces. Challenges included the removal of built features relating to cultural heritage, and various issues surrounding management such as lack of management and management with the assumption that local users did not want natural spaces.

Local users felt the removal of built features in order to restore nature was a challenge to connecting with nature as it disrupted their sense of place: *"and we don't want it ripping out, we said, alright maybe…bring it back…but you must keep some of [it] because it's part of the history of Philips Park, it's part of the history of Clayton" (LU1)*. In some cases local users felt the cultural heritage should be kept despite the impact on environmental health *"the industry is part of its heritage…although we moan about it and about the quality of the water…I'm not sure it's as much of an issue… I find looking at the water quite pleasant even though I might not want to get in it" (LU12)*. In contrast, providers felt these features should be removed if they were having a negative environmental impact, especially if this might be harmful to human health: *"if it's contaminated in some sort of way then just because it's our history…"* (PS6). However, providers and researchers agreed that, in urban areas especially, if these features were important for people's sense of place they should be integrated into the design of urban natural space where possible.

In some cases, built features prevented people connecting with nature by creating negative views of the natural environment. Some built features had negative associations for local users: *"that [brick-lined river channel] looks more like…a sewer" (LU4)*. Similarly, providers commented that: *"they [canalised rivers] might be functional, but they look horrible, and people don't engage with them" (PS7)*. Researchers felt that aesthetically unpleasant places are used less: *"if the local bit of river near your house is slightly intimidating and it's got concrete sides and smells a bit wrong, you're less inclined to want to go and run alongside it or take your kids down there or sit and enjoy the scenery" (R8).*

Poor management was another issue seen to lead to negative views of the natural environment. This is because it makes the space unappealing to visit, for example, if *"the pond is full of trolleys or bike pieces" (LU2)*, and difficult to use: *"you wouldn't go down [there] because it's that thick and y'know, the leaves and everything, you'd end up slipping in it"* (LU1). Providers and researchers agreed that people did not interact with spaces which had poor appearance: *"people would probably actively avoid areas that they felt were depleted or stagnant" (PI3)*. They also felt that people did not value these spaces: *"if you've got sort of bubbling greywater, to give an extreme example, full of litter, people really won't want to engage with it and won't value it" (PS7)*.

However, some providers thought that over-management of urban natural spaces was challenge to connecting with nature: *"they [urban parks] are very poor environmental quality, so you don't get people interacting with them in the same way, viewing them in the same way, or even, even seeing them as nature, because they're so urbanised, they're just a reflection of the urban environment" (PS5).* Others considered that there was no other way of managing urban space in ways that met the needs of local people *"if you are short generally of any green space…it becomes a problem, if you for example would have to choose that little square…can be used for pushing a ball around and pushing a buggy around or whether you say "oh no it needs to all be wild and nobody can access it because we disturb the nature"" (PS1)*.

Local users differed on whether under- or over-management was a challenge in connecting to nature. Commenting on more formal environments, some felt *"[I] wouldn't know what to do with it" (LU9)* but others considered more natural spaces did not belong in urban setting: *"that one would be nice but not in a park" (LU1)*. Providers felt that people did not recognise the difference between ecologically healthy and unhealthy spaces: *"I'm not sure if the general public would see beyond it being a field. I'm not sure if the dog walkers at [an urban nature reserve] necessarily recognise the natural, you know, the ecological value of it, or whether they just see it as a bit of green space" (PI11)*, which is why spaces are often managed on the assumption that

people do not value nature. Researchers noted that it was assumed that people did not want natural spaces: *"what the council think people want is large expanses of short mown grass, a scattering of trees, and a canalised river running through it" (R3)*.

Some local users noted that concerns about personal safety in wilder natural spaces created a challenge to connecting with nature: *"they had big leaves y'know that shaded…these big leaves…anybody could have been [behind]" (LU1)*. This need for safety was recognised by providers and researchers: *"I think probably there's a balance somewhere – you know, ecologically healthy, but probably not with a great diversity of species, partly because…a more sort of natural wild space, you know, the edges of the river might not be quite so clear, they might be perceived to be a bit dangerous to some user groups" (R1)*.

5.4 Discussion

Local users, researchers, and providers agreed that managed natural spaces and built features could be valuable in aiding connection with nature in urban areas (Table 1). However, their views differed concerning certain key issues (Table 1). The discussion highlights three issues regarding these findings.

5.4.1 Increasing opportunities for nature experience

The importance of the provision of urban natural space was emphasised by all stakeholder groups. Current UK policy aims to improve green infrastructure in urban areas (Department for Communities and Local Government, 2011) and providers, particularly those involved at a strategic level, were aware of the needs of local users regarding green space provision.

Involvement in management can facilitate connection with nature: local users felt that volunteering was important and providers and researchers agreed that it could increase interaction with nature. Studies have noted the role of volunteer work in obtaining benefits from nature (Husk et al., 2013), as well as the educational potential of natural spaces (Shanahan et al., 2015). Whilst researchers and providers emphasised the importance of built features such as information boards in educating and engaging people with nature, local users did not discuss education in urban natural spaces. This suggests that providing opportunities for active engagement with natural spaces is more important to local users than passive methods such as providing information.

5.4.2 The management of urban natural spaces

The largest difference between stakeholder groups was regarding the degree of naturalness or formality in urban natural spaces. People's connection with nature, and preferences in natural

spaces, are subjective and dependent on the individual (Fish et al., 2016), and accordingly we found local users had preferences for both formal and wilder urban natural spaces. However, whilst researchers acknowledged these different preferences, providers felt that local users wanted formal managed spaces. Research has indicated that the public place more importance on the visual and scenic aspects of natural spaces (Prévot et al., 2016), whilst finding that providers tend to prefer spaces which are wilder and more biodiverse (Hofmann et al., 2012). Our findings suggest that providers are aware that their preferences do not match with those of local users but that they do not appreciate the range of preferences held by the public.

That providers favour formal natural spaces is an issue because, for many people in urban environments, these spaces are their only means of experiencing nature (Dunn et al., 2006). Studies suggest that visiting rural natural spaces leads to biodiversity exposure and increases support for conservation but this does not happen after visiting less biodiverse urban spaces (Coldwell et al., 2017; Southon et al., 2017). Whilst the loss of biodiversity and human pressures in urban environments means that these areas will never be in pristine ecological health, it is possible to increase their biodiversity (Dennis & James, 2016). Our study indicates a clear need for the provision of spaces which are managed for nature, for users wishing to enjoy more natural environments, and to ensure that urban residents are exposed to areas of high biodiversity.

Whilst researchers, implementers, and local users agreed that management for nature in urban natural spaces can facilitate connection with nature, they felt that management for nature is not always compatible with factors such as the need for safety in urban environments. Users generally accept wilder spaces as long as there is the minimum of access and some elements that suggest human influence as this gives a 'cue to care' (Hofmann et al., 2012). This suggests that parks could be managed to encourage human-biodiversity interaction, for example through planting species-rich meadows and edible plants (Palliwoda et al., 2017), as long as features such as paths are present.

5.4.3 The role of built features in natural spaces

Providers appear to be aware of local user needs regarding built features in urban natural spaces. All groups emphasised the importance of built features in facilitating interaction with nature, highlighting the role of paths and benches in allowing sensory experiences of nature. Built features in urban natural spaces were also considered important by all groups as they increase the value and accessibility of these spaces. Unlike rural nature, people expect urban environments to have amenities (Cooper et al., 2017), perhaps because they are places for everyday use. Studies show that paths and other facilities allow a range of user groups to visit

natural spaces, particularly older people, those with mobility issues, and those with small children (Finlay et al., 2015; Schipperijn et al., 2010).

Built features which relate to cultural and historical heritage are considered important in urban natural spaces because they contribute to people's sense of place (Pietrzyk-Kaszyńska et al., 2017) and we found that researchers and providers were aware of the importance of these features to local users. However, whilst local users were opposed to changes in their local environment, providers and researchers felt these features should be removed if they were environmentally damaging. This difference in views may be explained by the concept of relational values, which concern people's relationships with or involving nature (Chan et al., 2016). Implementers do not have the same relationship with these built features as local users and therefore may not value them in the same way. Whilst not every urban natural space will have a cultural heritage, there may be specific features which are important to people, indicating a potential for conflict. This underlines the importance of site-specific management and the involvement of communities in the decisions regarding natural spaces (Åberg & Tapsell, 2013).

5.4.4 Strengths and limitations

Our sample of researchers and providers were recruited from a range of backgrounds and organisations across the UK so give a national perspective on managed urban spaces but the local users were not representative of the population of local area. The recruitment method meant that the study is likely to have captured the views of engaged users, a group who may differ from the wider community. However, our aim was to capture the views of users of urban natural space and, as half of our users had lived in their area for their entire lives and the majority for a number of years, we feel their views are valuable in understanding use of local natural spaces. To reverse declining nature experience in urban areas will require further research on motivations for visiting and the management of urban spaces to facilitate everyday nature encounters (Cox et al., 2017). In particular, studies should include people who do not use these areas in order to design spaces and interventions to encourage them to visit (Coldwell et al., 2017).

5.5 Conclusions

In this study, local users, providers, and researchers considered that managed natural spaces were important places for interaction with nature and all groups emphasised the need for access to these spaces. However, there were key differences regarding their management. Whilst local users preferred a wide range of spaces, both natural and formal, providers held

the view that that local users preferred formal spaces. This mismatch may lead to providers designing spaces which negatively affect the experiences of local users.

All groups agreed that built features played an important role in allowing a wide range of user groups to visit natural spaces and facilitating interaction with nature, pointing to an appreciation among providers and researchers of the needs of local users for accessible spaces. Our study pointed to the potential for conflict around built heritage in natural environments, with local users considering these features more important than providers and researchers.

It is important that urban natural spaces are designed to meet the needs of local users if they are to access the wide range of benefits that people can obtain from visiting nature. Our findings regarding preferences among local users for spaces that include more natural environments point to the opportunity for policies which provide co-benefits for nature and health.

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Chapter 6 Discussion

6.1 Summary of thesis aims and results

This thesis aimed to explore the role of the environment in providing health benefits, by examining freshwater blue space, ecological health, and management. Chapter 1 put this aim in context, drawing together the current literature regarding the relationship between the natural environment and health, placing it in the broader context of ecosystems and health, and identifying areas which need further research.

Chapter 2 used a scoping review to investigate whether studies of the green space-health relationship take account of socioeconomic position as a potential confounding factor, given that socioeconomic position is both a determinant of living near green space and of health (Mitchell & Popham, 2008). The review also considered the integration of health and environmental sciences in this area by examining how green space and health were measured in existing studies. Overall, 171 studies were identified. Health was measured in a variety of different ways, using objective and validated scales as well as self-reported measures. Most (80) studies measured both physical and mental health. However, a limited number of green space measures were used, with studies generally focusing on the quantity of green space. The majority of studies (118) considered socioeconomic confounding in their analyses. Of these 80 found a positive relationship between green space and health, indicating that this association is not explained by socioeconomic status.

Chapter 3 concentrated on a single environment type which has received little research attention - freshwater blue space – and the benefits people derived from visiting blue spaces at the population level. Original data from a national survey were used to investigate the sociodemographic and health factors which determined the frequency and location of a person's last visit to blue space, the single most important benefit of their visit, and the importance of nature during the visit. Fifty per cent of people surveyed visited a blue space frequently, and these visits were split almost evenly between urban and rural blue spaces. The majority of respondents identified social interaction (33%) and psychological benefits (40%) as the single most important benefit of the visit. Socioeconomic status, as measured by highest educational qualification, was associated with both visit frequency and location, and choosing social interaction as a benefit. Nature was very important to the majority (57%) of visitors; those who received psychological benefits from their visit were more likely to find nature important. These findings indicate that freshwater blue space, like green space, is important in providing benefits to people.

Chapter 4 focused on the local level, evaluating the success of an ecological restoration project in a large ex-industrial city from an ecological and social perspective. The study drew on Suding et al. (2015) which outlines four principles for ecological restoration: increasing ecological integrity, benefitting and engaging society; taking account of the past and future; and sustainability. The project chosen was an urban river restoration which was compared to an unrestored river in the same area. Macroinvertebrate data were used to investigate the impact of the restoration on the ecological health of the river, whilst focus groups were used to capture the views of local users regarding the restoration. The views of local users of the restored and unrestored river were compared using framework analysis, a widely-used method of qualitative data analysis. The restoration was successful in improving ecological health, leading to an increase in species diversity at the restored site. Local users believed it had led to an improvement in ecological health and saw the space as delivering important psychological benefits. However, they expressed concerns regarding the erasure of the cultural heritage of the site. Evaluating both the ecological and social success of the project demonstrated how ecological restoration can provide opportunities to deliver co-benefits for the environment and health.

Chapter 5 also analysed data from the focus groups with local users. These data were supplemented by additional one-to-one interviews with commentators, members of the research community providing evidence on preferences in natural spaces, and providers, both those involved with the strategic planning of these spaces and implementers who are responsible for their management. Framework analysis was used to compare and contrast the views of local users with those of providers and commentators from across the UK, to gain an insight into the importance of management and built features in urban natural spaces in connecting people with nature. Three main themes were identified: (i) the role of managed environments in connecting people with nature (ii) built features as facilitators of connection with nature, and (iii) challenges to connecting with nature arising from built features and the management of natural spaces. Although providers and commentators were aware of local users' needs and preferences regarding most aspects of management and built features in natural spaces, there were several important points of disagreement. Providers thought local users only wanted more managed formal spaces but local users expressed a desire for both formal and wilder urban natural environments. This misperception points to a potential disjunction between local users and providers with implications for the management of natural spaces to provide co-benefits for the environment and health.

6.2 The role of the natural environment in the provision of benefits

This thesis has examined the role of the environment in providing benefits for people by investigating characteristics of the natural environments at different spatial scales. The analysis has identified a number of subjects or themes which have arisen consistently across these different scales.

6.2.1 The importance of nature

Nature is highly valued. In the large national survey, the majority of people found nature very important when visiting a blue space; in the qualitative case study, local users discussed how their visits were enhanced by nature, expressing preferences for wilder spaces when discussing the management of urban natural spaces.

There is increasing evidence of the links between biodiversity, actual or perceived, the restorative potential of the environment, and its benefits for mental well-being (Cox et al., 2017; Dallimer et al., 2012; Fuller et al., 2007). Results from Chapters 3 and 4 support the evidence from these studies. At a population level, those who perceived psychological benefits as being the single most important benefit of their visit were more likely to find nature very important, and at a local level, improvement seen as a result of the ecological restoration was felt to add to the psychological benefits of the restored site. These results also support the suggestion by Pett et al. (2016) that interventions, such as increasing access to ecologically healthy green space, may have small impacts at an individual level but these could translate to larger benefits for the population.

In a systematic review, Lovell et al. (2014) found there is evidence of a relationship between biodiversity and health, but that this relationship is complex. Studies have suggested that more biodiverse spaces are more restorative (Carrus et al., 2015), as are spaces with more natural rather than formal planting arrangements (Hoyle et al., 2017) and that sounds of nature, such as birdsong, are important in stress recovery (Annerstedt et al., 2013). Whilst the definition of nature was left to the interpretation of the study participants in Chapter 3, to local users, nature encompassed flora and fauna, the presence of natural features such as water, and the variety or diversity of habitats seen in a space. Multiple sensory experiences of these different aspects of nature, hearing and smelling as well as seeing, were considered to deliver benefits. Restorative potential has been shown to differ depending on personal factors including connection with nature (Southon et al., 2017), and differences were seen between individuals in their preferences. The range of natural attributes discussed by local users and differences in

individual experiences demonstrate the complexity of the relationship between people and the natural world.

We live in an increasingly urbanised world, and there have been debates in urban planning about whether a land sparing or land sharing approach should be taken to urban development (Kabisch et al., 2015; Soga et al., 2015). Whilst intensive development leads to less urban sprawl so saves land outside towns and cities for conservation, by decreasing areas of natural environment within cities, it reduces the chance to experience nature. The studies undertaken here highlight the importance of the provision of natural spaces in the urban environment. Results at both the national and local level indicate that people gain benefits from visiting natural spaces and, despite worries that we are becoming disconnected from nature (Soga & Gaston, 2016), that they value nature and want to experience it. These findings suggest a need for less intensive urban development, giving people nearby natural spaces to use, and easier access to the countryside, to allow people to visit wilder natural spaces which may not be present in urban environments (Coldwell et al., 2017).

6.2.2 Ability to use the space

The accessibility and amenities of green spaces need to be considered. Chapter 2, a scoping review of green space-health studies, shows that studies concentrate on the quantity of green space available for local users. Measures of quantity include area and the distance from a person's house to the nearest green space. However, size and linear distance do not necessarily translate into accessibility. At the population level, my results suggest that access to certain types of natural environment may be restricted by the location of these environments, as people in rural areas were more likely to visit freshwater blue spaces than those in urban areas. Respondents who did not own a car were less likely to visit rural blue spaces, indicating constraints to access are not just environmental but also relate to the individual's ability to access the space (Lachowycz & Jones, 2013). Spaces may be difficult to access because of fencing, or barriers such as major roads preventing pedestrian access, and also because they may be used and therefore perceived differently by different subgroups of the population (Gren, 2017; Lee & Maheswaran, 2011). Local users discussed how certain user groups, such as dog walkers, reduced their enjoyment of urban natural spaces and led to fears for personal safety. They also emphasised the need for restoration of urban natural spaces to allow them to use these areas, particularly environment types such as freshwater blue space which may be culverted or otherwise unavailable to the public, highlighting the importance of accessibility.

There is increasing recognition that the presence of natural spaces alone does not mean that people use these areas and that there are many factors which influence whether an individual

visits a particular space (Lachowycz & Jones, 2013). Study at the population level showed that around half of visits to freshwater blue spaces were to urban areas, whilst half were to rural environments. Discussion with local users indicated that they had different expectations regarding urban and rural blue spaces. Some studies suggest that people have different expectations of natural spaces depending on the location of the space, with rural spaces being valued for their wildness but urban spaces expected to have facilities (Cooper et al., 2017). In line with these findings, in my study local users contrasted urban natural spaces to rural environments; they expected urban natural spaces to contain a wider range of facilities.

Chapter 2 indicated that there has been little focus on the quality of the natural environment, whether the presence of facilities or its ecological health, in providing benefits. The focus on visits to natural spaces in Chapters 4 and 5 showed that, although nature was valued by users, the quality of the natural environment beyond the ecological was important. Local users felt the provision of facilities added value to natural spaces because they enabled different groups, including children and the elderly, to use these spaces. A review found that elements such as paths, benches, and other built features make spaces valuable (Taylor & Hochuli, 2014), and that they allow and encourage park use (Finlay et al., 2015; McCormack et al., 2010). It is important that a wide range of people are able to use natural spaces so that they can gain benefits from them: analysis of a national dataset found that it was users who might have problems with accessibility, such as elderly users or those with limiting long-term illnesses, who were most likely to gain psychological benefits from using the space.

Interviews with providers in Chapter 5 suggested that, whilst implementers and strategic providers are generally aware of the preferences of local users, there were some situations in which they were not. Spaces need to be designed to ensure use so that people can access benefits from them. This is important, for example, in addressing socioeconomic inequalities. Chapter 2 indicated that the majority of studies consider socioeconomic confounding when investigating the health benefits of natural environments and still find a positive relationship between green space and health, and some studies additionally suggest that access to green space may reduce health inequalities (Mitchell & Popham, 2008; Mitchell et al., 2015). However, access to green space is often unequal (Jones et al., 2009), and the provision of natural spaces does not necessarily mean that people will use these spaces; they need to be places that people want and are able to use to ensure equitable health benefits (Lachowycz & Jones, 2013).

6.2.3 Human relationships to natural spaces

Despite the benefits that people can derive from visiting these spaces, natural environments are not always viewed positively. Different people may view the same space with different emotions

or respond differently to the same experience of the same place. There is a literature surrounding the concept of relational encounters and contested healthy spaces, stating that people's encounters with natural environments happen in a wider socio-environmental context and this determines what they gain from the experience (Conradson, 2005; Plane & Klodawsky, 2013). Factors such as age, gender, illness, and socioeconomic deprivation all affect encounters with the natural environment, as well as aspects of the environment itself (Conradson, 2005; Finlay et al., 2015; Plane & Klodawsky, 2013).

It is evident that a range of personal and social factors affected how local users experienced the natural spaces around the restored and unrestored rivers as individuals held different views regarding both the restoration and the management of the same spaces. Connection with nature was an important determinant of an individual's relationship with the space. Those who were more supportive of nature conservation viewed more natural aspects of the park as positive features and felt they added to the benefits provided by the space. However, local users who preferred more formal natural spaces found these features, for example overgrown vegetation, either as unsightly or as a cause for concern with respect to their personal safety. Differing opinions have been found by other river restoration projects, for example some users of the river Skerne preferred the restored section which had new footpaths, whereas others favoured the unrestored section and the solitude afforded by the more difficult access (Åberg & Tapsell, 2013).

The importance of sense of place should also be noted. Sense of place refers to the connection an individual has to a place and their emotional attachment whether due to history, memories, or other reasons (Soini et al., 2012). An individual's sense of place contributes to the health benefits they derive from specific spaces (Lengen & Kistemann, 2012). However, due to the specificity of sense of place to both the individual and the location, its impact on perceptions of restoration differs between restoration schemes (Westling et al., 2014). Regarding the restoration of the river Medlock, users expressed negative views of restoration that removed elements of natural spaces related to the cultural and industrial heritage of the area. Changes which disrupt place attachment could lead to a space becoming a contested healthy space, a place with the capacity to provide benefits but which does not deliver these benefits (Conradson, 2005; Dinnie et al., 2013). For example, green spaces may be contested spaces for people who are overweight as they feel judged by others for using the space and the negative effects of this judgement on their psychological well-being outweigh the benefits of exposure to the natural environment (Thomas, 2015). In this case, by disrupting sense of place, restoration changes the individual's relationship with the space and therefore the benefits they derive from their visit.

6.2.4 Co-benefits for the environment and health

In rural landscapes, a strong sense of place has been linked to willingness to engage in and support conservation (Soini et al., 2012). Sense of place indicates care for an environment as well as an attachment to its current state; in my study, local users supported restoration as long as this was respectful of local history and created a space they wanted to use. Overall, the evaluation in Chapter 4, where the ecological benefits of restoration were considered alongside the social benefits, found that the restoration of the Medlock was successful from both perspectives, demonstrating that ecological restoration can be an effective way of providing co-benefits for the environment and health. In urban areas, where urbanisation is placing both the social and ecological functions of natural spaces under pressure (Taylor & Hochuli, 2014), restoration could improve biodiversity and ecosystem health whilst benefiting a large human population.

The importance of nature to people was considered in Chapters 3 and 5. The chapters further emphasise the potential to derive co-benefits as a result of the relationship between the natural environment and health. Local users expressed a preference for a greater number of wild natural spaces in urban environments, indicating that urban natural spaces could be managed to provide benefits for nature as well as use by people. However, there was an assumption among providers of urban natural spaces that users preferred more managed areas. There has been increasing recognition of the importance of community engagement in the restoration process (Herringshaw et al., 2010; Westling et al., 2014), particularly at the beginning of the project, and that collaboration is often most effective on small scale projects (Metcalf et al., 2015). These findings highlight the need to involve local people in the design and implementation of projects but also in the management of natural environments, to ensure that people have access to spaces that meet their needs and to provide benefits for the environment.

6.3 Further research

Although the local-level study did not try to recruit people who do not visit natural environments, the national-level survey found that one in six people do not visit freshwater blue space. When considering the natural environment more generally, results from the Monitor of Engagement with the Natural Environment (MENE) survey indicate that around 10% of people in the UK do not visit natural spaces (Natural England, 2015). Chapter 3 found that people who did not visit were significantly different socio-demographically to people who did visit, and were more likely to be elderly, of low socioeconomic status, and in poor health. There is a need to consider people from a range of socioeconomic, cultural, and demographic backgrounds when researching the relationship between natural space and health (Botzat et al., 2016). Barriers

preventing some groups of people visiting natural spaces should be a priority for further research; if these groups are not accessing these spaces, they are unable to obtain benefits from them.

Further use of qualitative research, particularly when researching groups such as non-users, should also be considered. The study of the relationship between the natural environment and health is inherently interdisciplinary and this thesis used a range of quantitative and qualitative methods from ecology and the social sciences to give perspectives that would not have been possible using methods from only one discipline. However, there has been a reliance on quantitative methods and cross-sectional study designs when investigating the nature-health relationship (Lachowycz & Jones, 2013). Qualitative methods should be used more (Maxwell & Lovell, 2017); they allow in-depth exploration of complex issues (Gill et al., 2008), and can be particularly valuable for under-researched groups, for example non-users where little is known regarding the reasons why people do not visit natural spaces.

Research into the natural environment and health also needs to consider study design in order to build a robust evidence base. Study of the nature-health relationship provides opportunities for applied research (Richardson et al., 2016). As ecological restorations and other interventions form natural experiments (Lovell et al., 2014), their benefits should be investigated using appropriate study designs such as controlled before-and-after designs (Husk et al., 2013). Studies of interventions should examine longer time scales whilst more longitudinal studies are also needed at the population level to assess the long-term benefits of living in areas with more natural space (Gascon et al., 2015; Husk et al., 2013). Where possible measures of health and well-being should be objective or use validated scales and studies should control for potential confounding factors, including factors such as nature connection as well as sociodemographic variables (Husk et al., 2013; Richardson et al., 2016; Shanahan et al., 2015).

The findings in this thesis highlight the benefits of the natural environment beyond green space. More research is needed into different types of environment and their benefits for health and well-being. At a population scale, this might concentrate on the complexities of biodiversity-health relationship (Pett et al., 2016), examining issues such as whether biodiversity scale, from community to genetic, affects health (Botzat et al., 2016). At the local level, environmental interventions are an effective way of investigating this relationship. If before and after measurements are taken, ecological restorations could be used to investigate causal relationships between biodiversity and health (Maxwell & Lovell, 2017). In my local study, which used a space-time substitution, the results (presented in chapters 4 and 5) indicate that that the management of urban natural spaces affects the benefits they provide. Interventions as simple

as changing mowing regimes or the planting of flower beds can be used to study the importance of different components of biodiversity in conferring benefits to people (Hoyle et al., 2017; Southon et al., 2017).

Understanding better how natural environments deliver benefits to people could also aid use of the nature as a treatment or therapy. A range of organisations such as Natural England, the National Parks, and wildlife trusts are already offering ecotherapy opportunities, for example horticulture or animal-assisted activities (Maxwell & Lovell, 2017). Some of these schemes are the result of collaboration with Clinical Commissioning Groups or other health sector organisations and have been referred to as 'green prescriptions' (Jepson et al., 2010). Green space has been shown to provide psychological benefits for people with health conditions such as depression or dementia (Policy Exchange, 2014). Research regarding how the environment benefits these different groups of people could allow treatments using the natural environment to become more targeted and effective.

The evaluation of ecological restoration in Chapter 4 demonstrated the importance of considering the ecological and social when judging the success of ecological restoration projects. There is great potential to deliver co-benefits for the environment and health from these projects, particularly in urban areas. However, further research using a range of approaches is needed to investigate these co-benefits and build a robust evidence base to inform planning and policy.

6.5 Recommendations for policy

With ongoing urbanisation and the problem of extinction of experience, as discussed in the introduction to this thesis, the provision of green space and other natural environments in urban areas is an issue of importance for policies regarding the natural environment and public health. As a result of the findings in this thesis, I have three recommendations for policy.

Currently, the UK National Planning Policy Framework defines green infrastructure as "a network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities" (Department for Communities and Local Government, 2011), but places responsibility for the provision of green space with individual local councils. Generally, local councils aim to provide green space within a certain distance of an individual's home. Whilst my findings add to the evidence regarding the benefits of natural spaces, so support setting targets regarding the quantity of green space in urban areas, they indicate the importance of environments beyond green space. As a result, I would recommend policy regarding the supply of natural environments in urban areas gives

targets not just for quantity but the type and biodiversity of accessible spaces, ensuring more varied and natural spaces alongside more formal parks. Developing a green infrastructure strategy detailing this at a national level would provide clarity for urban planners and other stakeholders and could lead to a more equitable provision of natural spaces in urban areas.

Many natural spaces in urban environments are degraded or damaged (Gobster, 2010). Consequently, my second recommendation for policy is for the restoration and conservation of urban natural spaces, to provide co-benefits both for nature and people. This could be through management for nature, with changes as small as planting wildflower meadows and reducing mowing regimes, to large-scale restoration projects. Although these changes may not result in pristine environments, by providing more ecologically healthy spaces they will offer opportunities for people to reconnect with nature in urban environments, helping alleviate the problem of extinction of experience. Accessing these spaces will benefit individuals in terms of their health and well-being, whilst reconnecting people with nature could have a wider societal benefit by increasing support for environmental causes (Soga & Gaston, 2016).

Finally, my findings have shown that different people use urban natural spaces in different ways and have a range of expectations regarding their appearance and facilities. The importance of these spaces to people's sense of place, and evidence of some mismatch in views with the providers of these spaces, means that my third recommendation is for policy to involve local users in the management of their natural spaces. The Localism Act (2011) and its introduction of community involvement in neighbourhood planning has given local people some ability to influence the provision of natural spaces in their neighbourhoods. However, they should also be involved in shaping individual spaces to ensure these meet their needs, whether this is through consultation on management plans or opportunities for direct involvement in management. Where there are major plans for change, such as ecological restoration, local users should be involved in the initial stages of planning so their views can be incorporated into the project design (Landscape Research, 2013; Smith et al., 2016).

6.5 Conclusions

Research into the natural environment and health has focused on green space, which has been found to be beneficial to both physical and mental health, a relationship not explained by confounding factors such as socioeconomic status. However, there is increasing recognition that a range of environment types beyond green space can provide benefits to human health and well-being, and that the quality of this space is important. This thesis found that freshwater blue spaces provide valuable benefits for human populations. People use them for physical activity and social interactions but the most important benefits obtained from visiting freshwater blue

space are psychological. Within these spaces, nature is important, particularly to users who derive psychological benefits from their visits. Local users identify elements of nature such as wildlife, trees, and sounds including running water and birdsong, as reducing stress and improving their experience of the natural environment.

Exploration of different spatial scales has shown that, at a national level, a range of sociodemographic and health factors affect the benefits people receive from blue spaces and the characteristics of their visits to these areas. Visitors interact with natural spaces within a wider socio-environmental setting and discussion with local users revealed how these sociodemographic and health factors, along with management of the space, can enable or prevent people visiting natural areas. This investigation of the individual level showed the complexity of people's relationships with freshwater blue space and nature more generally. Sense of place was found to be important to local users and its disruption negatively affected experiences in these spaces. Despite these complex relationships, local users still supported both the ecological restoration of natural spaces and management regimes which favoured nature and biodiversity.

In summary, freshwater blue space is a valuable source of benefits for human populations at both the national and local level. Nature within these spaces, and more generally in natural spaces, is important to users and contributes to the benefits they receive from the space. These findings show that, whether through ecological restoration or daily management, the relationship between the natural environment and health offers the potential to provide co-benefits for the environment and health.

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Appendix 1 Details of studies included in Chapter 1

Table 1 Details of the studies identified by the review (abbreviations can be found at the end of table).

Author	Year	Research question	Country	Location: urban, rural, both, other	Population (community sample of adults unless otherwise indicated)	Green Space Measure	Health Measure (measures in bold were assessed by the researcher, otherwise self-assessed)	SEP Measure: individual, area, both, none	Adjusted	Association	Number of Measures	Type of measure
LONGITUNDINAL												
Alcock *et al*.	2014	effect of moving to a more/less green urban area on mental health	England	urban		quantity (GLUD)	GHQ-12	both	Y	positive	1	mental
Alcock *et al.*	2015	association between mental health and land cover type	England	rural		quantity, type (LCM)	GHQ12	both	Y	inconclusive	1	mental
Annerstedt *et al.*	2012	association between qualities of neighbourhood green space, mental health, and physical activity	Sweden	both		quality (GIS, SGS, CORINE)	GHQ-12; physical activity	individual	Y	inconclusive	2	both
Astell-Burt *et al*.	2014a	association between neighbourhood green space and mental health	UK	urban		quantity	GHQ-12	individual	Y	positive	1	mental
Dalton *et al.*	2016	association between green space and diabetes diagnoses	UK	both	GP patients	quantity (LCM)	**Type 2 diabetes diagnosis**	both	Y	positive	1	physical
James *et al.*	2016	association between exposure to green space and mortality in women	USA	both	nurses	quantity (NDVI)	**all non-accidental causes mortality**	both	Y	positive	1	physical
Sugiyama *et al.*	2013	association between green space and walking	Australia	urban		quantity (GIS)	physical activity (walking frequency), BMI	individual	Y	inconclusive	2	physical
Takano *et al.*	2002	relationship between walkable green space and longevity of senior citizens	Japan	urban	community sample; older adults	quantity	5-year survival	individual	Y	positive	1	physical
Tamosiunas *et al.*	2014	association between accessibility and use of green space and cardiovascular disease	Lithuania	urban	community sample; age 45-72 yrs	distance ((GIS)	**blood pressure, BMI, cognitive functioning, cholesterol level, blood glucose, CES-D, cardiovascular disease diagnosis, Type 2 diabetes**	individual	Y	inconclusive	10	both

							diagnosis, stroke diagnosis, cardiovascular disease mortality					
van den Bosch *et al.*	2015	effect of green space qualities on mental health	Sweden	both		quality (GIS, SGS)	GHQ-12	individual	Y	no relationship	1	mental
Villeneuve *et al.*	2012	association between green space access and mortality	Canada	urban	community sample; age ≥35 yrs	quantity (NVDI)	**all-cause mortality**	individual	Y	positive	1	physical
Weimann *et al.*	2015	effect of green space on general and mental health over time	Sweden	both		quality (SGS)	general, GHQ-12	individual	Y	inconclusive	2	both
Wilker *et al.*	2014	association between green space and post-stroke survival	USA	urban	acute ischemic stroke hospital in-patients; age ≥21 yrs	quantity (NDVI)	**all-cause mortality**	area	Y	positive	1	physical
Wolfe *et al.*	2014	association between green space and changes in self-rated health in people with chronic conditions	Netherlands	both	National Panel of people with Chronic illness or Disability (NPCD) survey; age ≥15 yrs	quantity (LNG)	general	individual	Y	no relationship	1	both
CROSS-SECTIONAL												
Akpinar *et al.*	2016	association between green space area and type and general and mental health	USA	both		quantity, type (NLCD)	general; psychological (mental health complaints in last 30 days, anxiety/depression complaints in last 14 days)	both	Y	positive	3	mental
Ambrey	2016a	investigation of synergy between green space and physical activity, its impact on well-being, and the moderating role of neighbourhood perception	Australia	urban		quantity (GIS)	SF-36, K10, physical activity	both	Y	positive	3	both
Ambrey	2016b	investigation of synergy between green space and physical activity and its impact on well-being	Australia	urban		quantity (GIS)	SF-36, physical activity	both	Y	positive	2	both
Ambrey	2016c	the effect of population size on the synergy between green space and physical activity and well-being	Australia	urban		quantity (GIS)	SF-36, K10, physical activity	both	Y	inconclusive	3	both
Astell-Burt e*t al.*	2013a	mental health benefits of green exercise for middle and older age adults	Australia	both	community sample; age ≥45 yrs	quantity (GIS)	K10, physical activity	both	Y	positive	2	both

Astell-Burt *et al.*	2013b	association between green space and sleep duration	Australia	both	community sample; age ≥45 yrs	quantity (GIS)	sleep duration, K10, physical activity	both	Y	positive	3	both
Astell-Burt *et al.*	2014b	association between green space and weight	Australia	both	community sample; age ≥45 yrs	quantity (GIS)	BMI	both	Y	inconclusive	1	physical
Astell-Burt *et al.*	2014c	association between green space and skin cancer	Australia	both	community sample; age ≥45 yrs	quantity (GIS)	**skin cancer diagnosis**	both	Y	negative	1	physical
Astell-Burt *et al.*	2014d	association between green space, walking, and moderate-to-vigorous physical activity	Australia	both	community sample; age ≥45 yrs	quantity (GIS)	physical activity (walking, moderate-to-vigorous)	both	Y	positive	2	physical
Astell-Burt *et al.*	2014e	association between green space and risk of Type 2 diabetes	Australia	both	community sample; age ≥45 yrs	quantity (GIS)	**Type 2 diabetes diagnosis**	both	Y	positive	1	physical
Besenyi *et al.*	2014	association between green space and chronic health conditions	USA	urban		quantity (GIS)	number of chronic conditions	individual	Y	inconclusive	1	both
Beyer *et al.*	2014	association between neighbourhood green space and mental health	USA	both		quantity, urbanity (NVDI)	DASS	individual	Y	positive	1	mental
Bixby *et al.*	2015	association between green space and mortality at the city level	UK	urban	mortality records	quantity (LCM)	**all-cause mortality; cause-specific mortality (cardiovascular disease, lung cancer and suicide)**	area	N	no relationship	4	physical
Bjork *et al.*	2008	association between green space quality and neighbourhood satisfaction, physical activity, obesity and well-being	Sweden	both		quality (GIS, CORINE, SGS)	physical activity, BMI, general, SF-36	individual	Y	inconclusive	4	both
Bodicoat *et al.*	2014	association between green space and Type 2 diabetes	UK	both	GP patients; age 40-75yrs (white Europeans), 25-75 yrs (other ethnicities)	quantity (LCM)	**Type 2 diabetes diagnosis**	area	Y	positive	1	physical
Bos *et al.*	2016	moderation of the association between green space and mental health by age and gender	Netherlands	both		quantity (GIS)	DASS	individual	Y	inconclusive	1	mental
Brown *et al.*	2016	association between green space and chronic health conditions for people with low socioeconomic status	USA	both	Medicare beneficiaries; age ≥65 yrs	quantity (NDVI)	number of chronic conditions, number of obesity-related chronic conditions, diabetes, hypertension, hyperlipidemia	area	Y	positive	5	both

Carrus *et al.*	2015	association between biodiversity and benefits of visiting green space	Italy	urban	green space users; adult	quality	Italian PRS, psychological benefits, physical benefits	none	N	positive	2	both
Chong *et al.*	2013	the effects of neighbourhood safety and area deprivation on the association between parkland and psychological distress	Australia	urban		quantity	K10	both	Y	negative	1	mental
Cohen-Cline *et al.*	2015	association between green space, physical activity, and mental health among twins	USA	both	adult identical twins	quantity (NDVI)	PHQ-2, PSS, BSI	both	Y	positive	3	mental
Coombes *et al.*	2010	association between access and use of green space, physical activity and likelihood of being overweight or obese	UK	urban		distance, type (GIS)	physical activity, BMI, general	both	Y	inconclusive	3	both
Coutts *et al.*	2010	association between green space access and mortality	USA	both		quantity, distance (GIS)	**all-cause mortality, cardiovascular disease mortality**	area	Y	inconclusive	2	physical
Coutts *et al.*	2013	association between green space and physical activity	USA	both		quantity (GIS)	physical activity	individual	Y	positive	1	physical
Cummins & Fagg	2012	association between green space and obesity and contribution of physical activity	UK	both		quantity (GLUD)	BMI, physical activity	both	Y	inconclusive	2	physical
Dadvand *et al.*	2016	association between green space and general health and mediators of this relationship	Spain	urban		quantity (NVDI)	general, GHQ-12, physical activity	both	Y	positive	3	both
Dallimer *et al*.	2012	association between urban biodiversity and human health	UK	urban	green space users; adult	quantity, quality	psychological (questionnaire based on mental restoration and sense-of-place frameworks)	individual	N	inconclusive	1	mental
Dallimer *et al.*	2014	factors that influence frequency of green space use	UK	urban	green space users; adult	quality (GIS)	psychological (questionnaire based on mental restoration and sense-of-place frameworks)	individual	Y	positive	1	mental
de Jong et al.	2012	association between perceived qualities of green space and neighbourhood satisfaction, physical activity, and health	Sweden	both		quality (SGS)	general, physical activity	individual	Y	positive	2	both

de Vries *et al*.	2003	association between neighbourhood green space and health	Netherlands	both		quantity, type, urbanity (LNG)	Dutch GHQ-12, general, NS-14	individual	Y	positive	3	both
de Vries et al.	2013	possible mechanisms mediating the relationship between streetscape greenery and health	Netherlands	urban		quantity, quality	MHI-5, PSS, general, NS-14	individual	Y	positive	4	both
de Vries et al.	2016	association between green and blue space, anxiety and mood disorders, and health	Netherlands	both		quantity (LGN)	psychological (mood, anxiety, substance use disorders, or any one of these, in last 12 months), SF-36, MHI-5	both	Y	positive	6	both
Dennis & James	2017	population level association between green space and health depending on type and urbanity	UK	both	health domain of 2010 IMD	quantity, type, urbanity (GLUD)	health deprivation (years of potential life lost, comparative illness and disability ratio, acute morbidity and mood and anxiety disorders)	area	Y	positive	1	both
Elliot *et al.*	2015	characteristics of physical activity in green space	England	both		type	physical activity (intensity, duration, energy expenditure)	individual	Y	positive	3	physical
Fan et al.	2011	effect of green space on stress and mediators of the relationship	USA	urban		quantity, distance (NVDI)	PSS, physical activity, social cohesion	individual	Y	positive	3	both
Flowers *et al.*	2016	investigation of whether nature relatedness and green space perceptions are better predictors of visit frequency than availability	UK	both	employed adults; age 22-65 yrs	quantity, quality	physical activity	none	N	no relationship	1	physical
Francis *et al*.	2012	association between quantity and quality of neighbourhood green space and mental health	Australia	urban		quantity, quality (GIS, POST)	K6	both	Y	positive	1	mental
Fuller *et al.*	2007	association between green space biodiversity and mental well-being	England	urban	green space users; adult	quality	psychological (questionnaire based on mental restoration and sense-of-place frameworks	none	N	inconclusive	1	mental

Grahn & Stigsdotter	2010	association between perceived sensory dimensions of the environment and stress restoration	Sweden	urban		quality	LS, psychological (stress-related complaints suffered in last year)	individual	N	positive	2	both
Ghimire *et al.*	2017	association between green space type and obesity	USA	both		quantity, type	BMI	area	Y	positive	1	physical
Gidlow *et al.*	2015	association between hair cortisol and natural environment near the home	UK	both	public sector employees	quantity (GLUD)	**hair cortisol,** physical activity, PSS, psychological (stressful life events in last 3 months)	area	Y	no relationship	4	both
Gidlow *et al.*	2016	association between natural environment and prescriptions for cardiovascular disease and depression	UK	both	GP prescriptions; mortality records	quantity (GLUD)	**number and cost of (i) cardiovascular medications (ii) antidepressants; all-cause mortality**	area	Y	inconclusive	5	both
Gong *et al.*	2014	association between green space and physical activity among elderly men	UK	both	men, age ≥45 yrs	quantity (NVDI)	physical activity (frequency)	both	Y	positive	1	physical
Grigsby *et al.*	2015	association between exposure to green space and sleep	USA	both		quantity, quality (NVDI)	days of insufficient sleep	individual	Y	positive	1	physical
Hillsdon *et al.*	2006	association between access to quality urban green space and physical activity	UK	urban	GP patients; age 45–74 yrs	quantity, distance, quality (GIS)	physical activity	both	Y	no relationship	1	physical
Houlden *et al.*	2017	association between green space and mental well-being	England	both		quantity (GLUD)	shortened WEMWBS	both	Y	no relationship	1	mental
Hu *et al.*	2008	association between stroke, income, green space and air pollution	USA	both	mortality records	quantity (GIS)	**stroke mortality**	individual	Y	positive	1	physical
Jansen *et al.*	2017	association between natural environment type and physical activity behaviour	Netherlands	urban	adults; age 45-65 yrs	quantity, type	physical activity (intensity, type)	individual	Y	positive	2	physical
Jiang *et al.*	2016	association between natural spaces and physical inactivity	USA	both		quantity (GIS)	physical inactivity	area	Y	positive	1	physical
Jones *et al.*	2009	association between green space, area deprivation, and physical activity	UK	urban		distance, type (GIS)	general, physical activity	area	Y	negative	2	both
Jonker *et al.*	2014	association between green space and life expectancy	Netherlands	urban	life table data	quantity, distance,	life expectancy, healthy life expectancy	area	Y	positive	2	physical

						quality (GIS)						
Kardan *et al.*	2015	association between green space and health	Canada	urban		quantity (GIS)	general, cardio-metabolic conditions, mental disorders, other disorders	both	Y	positive	4	both
Lachowycz & Jones	2014	relationship between access to green space, walking, and mortality	England	both		quantity (GLUD)	**circulatory disease mortality**, physical activity	area	Y	inconclusive	2	physical
Larson *et al.*	2016	association between urban park quantity, quality, and accessibility and well-being	USA	urban	range of secondary data sources eg. US Census	quantity, quality, distance	WBI	area	Y	positive	1	mental
Lee & Lee	2015	comparison of users perceptions regarding urban and mountainous forests	Switzerland, Austria, Germany	both	forest users	setting	psychological (perceptions of effect of environment on psychological & physical health)	none	N	no relationship	2	both
Luck *et al.*	2011	association between urban biodiversity and human well-being	Australia	urban		quantity, quality, urbanity	individual well-being, neighbourhood well-being, connection to nature	individual	Y	positive	3	mental
Maas *et al.*	2006	association between green space and health	Netherlands	both	GP practice patients; adult	quantity, urbanity (LNG)	general	individual	Y	positive	1	both
Maas *et al.*	2008	investigation of whether physical activity is a mechanism behind the relationship between green space and health	Netherlands	both	GP practice patients; adult	quantity, type (LNG)	physical activity, general	individual	Y	inconclusive	2	both
Maas et al.	2009a	investigation of social contact as a mediator of the association between green space and health	Netherlands	both	GP practice patients; age ≥12	quantity, urbanity (LNG)	general, NS-14, GHQ-12, psychological (loneliness), social cohesion	individual	Y	positive	5	both
Maas et al.	2009b	association between access to green space and morbidity	Netherlands	both	GP practice patients; age ≥12	quantity (LNG)	**morbidity (physical and mental illnesses coded using ICPC)**	individual	Y	positive	1	both
MacKerron & Mourato	2013	association between well-being and the individual's immediate environment	UK	both	Mappiness app users	type (LCM)	psychological (happiness)	individual	Y	positive	1	mental
McEachan *et al.*	2015	association between green space and depression in pregnant women	UK	urban	pregnant women	quantity, distance (NVDI)	GHQ-28	both	Y	positive	1	mental

Miles *et al*.	2011	association between urban neighbourhood form and depression	USA	urban		quantity, type	CES-D	area	Y	inconclusive	1	mental
Mitchell *et al.*	2011	investigation of whether the association between green space and health varies depending on the green space indicator used	UK	urban	census data; mortality records	quantity (GIS, CORINE)	**morbidity, all-cause mortality**	area	Y	positive	2	both
Mitchell	2013	benefits of green exercise for mental health compared to other physical activity	Scotland	both		type	GHQ12, WEEMWBS, physical activity	individual	Y	positive	3	both
Mitchell & Popham	2007	investigation of the effects of urbanity and socioeconomic deprivation on association between green space and health	England	both	census data	quantity, urbanity (GLUD)	general	area	Y	inconclusive	1	both
Mitchell & Popham	2008	effect of exposure to green space on health inequalities	England	both	mortality records	quantity (GLUD)	**all-cause mortality, cause-specific mortality (circulatory disease, lung cancer, and intentional self-harm)**	area	Y	positive	2	physical
Mytton *et al.*	2012	association between green space and physical activity	England	both		quantity (GLUD)	physical activity (overall, type of physical activity)	both	Y	positive	2	physical
Ngom *et al.*	2016	association between green space type, cardiovascular disease, and diabetes	Canada	urban		distance, quality, type (GIS)	**cardiovascular disease morbidity, diabetes diagnosis**	area	Y	no relationship	2	physical
Nielsen & Hanson	2007	impact of green space use and access on stress and obesity	Denmark	urban		distance	psychological (feelings of stress measured using questionnaire based on existing Swedish stress surveys), BMI	individual	Y	positive	2	both
Nutsford et al.	2013	association between green space access and mental health	New Zealand	urban		quantity, distance (GIS)	prevalence of anxiety/mood disorders	area	Y	positive	1	mental
Nutsford et al.	2016	association between visible nature and psychological distress	New Zealand	urban		quantity, distance (GIS)	K10	both	Y	inconclusive	1	mental
Ode Sang *et al.*	2016	effects of naturalness, gender, and age on activities, aesthetics, and well-being associated with urban green spaces	Sweden	urban		setting	well-being (based on responses to their feelings when in green space)	none	N	positive	1	mental
Orban *et al.*	2017	association between green space and health	Germany	urban	community sample; age 45-75 yrs	quantity (NVDI)	general	both	Y	positive	1	both

Paquet *et al.*	2013	association between public open space use, its characteristics, and cardiometabolic diseases; the effect of physical activity and psychological well-being as mediators	Australia	urban		quantity, distance, type, quality (NVDI)	**cardiometabolic disease risk,** physical activity, SF-36	both	Y	inconclusive	3	both
Pereira *et al.*	2012	association between green space and coronary heart disease risk	Australia	urban		quantity (NVDI)	**coronary heart disease and stroke diagnosis**	individual	Y	positive	1	physical
Pietilä *et al.*	2015	association between presence of and access to green space, physical activity, and health	Finland	urban		quantity (GIS)	physical activity, general	individual	Y	positive	2	both
Peschardt & Stigsdotter	2013	association between characteristics and perceived restorativeness of urban green spaces	Denmark	urban	green space users; adult	quality	psychological (feelings of being away and fascination), PRS	individual	Y	positive	3	mental
Ord *et al*.	2013	association between green exercise and green space in neighbourhood	Scotland	urban		quantity	physical activity	individual	Y	no relationship	1	physical
Raftopoulou	2017	environmental determinants of individual body weight and obesity risk	Spain	both		quantity, urbanity	BMI, obesity	both	Y	positive	2	physical
Reklaitiene *et al.*	2014	association between proximity and use of green space and depressive symptoms and general health	Lithuania	urban	community sample; age 45–72 yrs	distance (GIS)	CES-D, general	individual	Y	inconclusive	2	both
Richardson & Mitchell	2010	investigation of gender differences in the association between neighbourhood green space and health	UK	urban	mortality records	Quantity (GLUD, CORINE)	**cause-specific mortality (cardiovascular disease, respiratory disease, and lung cancer), limiting long-term illness**	area	Y	inconclusive	2	physical
Richardson et al.	2010	association between green space and cause-specific mortality	New Zealand	urban	mortality records	quantity (GIS)	**cause-specific mortality (cardiovascular and lung disease)**	area	Y	no relationship	1	physical
Richardson *et al.*	2012	relationship between green space and mortality at the city level	USA	urban	mortality records	quantity (NLCD)	**heart disease, diabetes, lung cancer, and motor vehicle fatalities; all-cause mortality**	area	Y	negative	5	physical

Richardson et al.	2013	association between green space, health and physical activity as a mediating factor	New Zealand	urban		quantity	cardiovascular disease, BMI, SF-36	individual	Y	positive	3	both
Roe *et al.*	2013	association between green space and stress in socioeconomically deprived areas	UK	urban	residents of socio economically deprived areas	quantity	PSS, shortened WEMWBS, **salivary cortisol**	area	Y	positive	3	both
Sarkar	2017	association between residential green space and adiposity	UK	urban	community sample; age 37–73 yrs	quantity (NVDI)	BMI, waist circumference, whole body fat, obesity	both	Y	positive	4	physical
Saw *et al.*	2015	association between access or use of different environment types and well-being	Singapore	urban	university students	quantity, distance (GIS)	well-being, PSS	individual	Y	no relationship	2	mental
Schipperijn *et al.*	2013	association between green space characteristics and physical activity	Denmark	urban		quantity, distance, quality (GIS)	physical activity, general	individual	Y	inconclusive	2	both
Shanahan *et al.*	2016	investigation of a dose-response relationship between nature and health	Australia	urban		quality	DASS, high blood pressure, social cohesion, physical activity	both	Y	positive	4	both
Shen & Lung	2016	association between green structure and cardiovascular disease mortality	Taiwan	urban	mortality records	quantity, quality	**cardiovascular disease mortality**	none	N	positive	1	physical
Stigsdotter & Grahn	2011	green space activities and characteristics preferred by stressed individuals	Sweden	urban		quality	LS, physical activity	individual	Y	positive	2	both
Stigsdotter et al.	2010	association between green space and health, quality of life, and stress	Denmark	both		distance	SF-36, PSS	individual	Y	positive	2	mental
Storgaard *et al.*	2013	association between green space and sedentary leisure time	Denmark	both		quantity (GIS)	physical inactivity (sedentary leisure time)	individual	Y	positive	1	physical
Sturm *& Cohen*	2014	association between park proximity and psychological distress	USA	urban		distance	MHI-5	none	N	positive	1	mental
Sugiyama *et al.*	2008	association between perceived neighbourhood greenness and health; effect of physical activity and social factors as mediators	Australia	both		quantity	SF-12, physical activity, social cohesion	individual	Y	positive	3	both

Sugiyama *et al.*	2016	area and attractiveness of green space as mediators of the relationship between psychological distress and socioeconomic status	Australia	urban		quantity, quality (GIS)	K10	area	Y	inconclusive	1	mental
Taylor *et al.*	2015	association between density of street trees and antidepressant prescribing	UK	urban	prescription rates	quantity	**number of antidepressant prescriptions**	area	Y	positive	1	mental
Triguero-Mas *et al.*	2015	association between natural environment, health, and possible mediators and moderators	Spain	both		quantity, distance (NDVI)	SF-36, GHQ-12, psychological (perceived depression or anxiety, visits to mental health specialist, use of medication), physical activity, social support	both	Y	positive	7	both
Tsai *et al.*	2016	association between vegetative cover fragmentation, physical activity, and BMI	USA	urban		quantity (NLCD)	physical activity, BMI	area	Y	positive	2	physical
Ulmer *et al.*	2016	association between tree cover near home and health	USA	urban	community sample; age ≤65 yrs	quantity	general, physical activity, obesity, Type 2 diabetes, high blood pressure, asthma, K6, neighbourhood social cohesion	individual	Y	positive	6	both
Ulrich	1984	effect of a natural window view on recovery rate of hospital patients	USA	other	cholecystectomy patients	setting	**recovery time, medication, minor complications, nurses' notes**	none	N	positive	4	physical
Vaz *et al.*	2015	association between land use and health	Canada	urban		type	general	none	N	positive	1	both
van den Berg et al.	2010	effect of exposure to green space on recovery from stressful life events	Netherlands	both	GP practice patients; adult	Quantity (LNG)	general, NS-14, GHQ-12	individual	Y	positive	3	both
van Dillen *et al.*	2012	association between quantity and quality of green space and streetscape greenery and health	Netherlands	urban		quantity, quality (GIS)	general, NS-14, MHI-5	individual	Y	positive	3	both
Veitch *et al.*	2016	association between green space, physical activity, and TV viewing time in overweight and obese women	Australia, USA	urban		quantity, distance (GIS)	physical activity, BMI	individual	N	inconclusive	2	physical

Votsi *et al.*	2014	association between disease distribution and environment type	Greece	both	hospital records	quantity, type, quality (CORINE)	**disease type (mental, nervous system, circulatory, respiratory, musculoskeletal)**	none	N	inconclusive	5	both
Ward-Thompson et al.	2012	relationship between salivary cortisol and quantity of green space in deprived communities	Scotland	urban	economically inactive, recruited via local community/ job centres	quantity	PSS, **salivary cortisol**	both	Y	positive	2	both
Ward-Thompson *et al.*	2013	impact of environmental improvement on people's activities and quality of life	Scotland	urban	residents of socio economically deprived areas	setting, quality	physical activity	individual	N	positive	1	physical
Ward-Thompson *et al.*	2016	investigation of green space access required to create health benefits	Scotland	urban	residents of socio economically deprived areas	quantity	general, PSS	both	Y	positive	2	both
Wheeler *et al.*	2015	effect of environment type and quality on health	UK	both	census data	type, quality (LCM)	general	area	Y	positve	1	both
White *et al*.	2013a	effect of visiting nature on feelings of mental well-being	UK	both	Monitoring Engagement with the Natural Environment survey (visit to nature in last 7 days); age 16-65+	type	psychological (feelings of mental restoration)	individual	Y	positive	1	mental
White et al.	2013b	association between green space and well-being and mental distress over time	England	urban		quantity (GLUD)	GHQ-12, life satisfaction	both	Y	positive	2	mental
Wu *et al.*	2015	exposure to local natural spaces is associated with lower risk of poor mental health in older people	UK	both	GP patients; age ≥65 yrs	quantity (GLUD)	psychological (depression, anxiety, co-occurrence of both)	both	Y	positive	3	mental
Zhang *et al.*	2015	association between health, attachment to green space, and availability of green spaces	Netherlands	urban		quantity, distance (GIS)	general, physical, MHI-5	both	N	positive	3	general
Zijlema *et al.*	2017	association between exposure to natural spaces and cognitive function, and potential mediators	Spain, Netherlands, UK	urban		quantity, distance (NVDI)	cognitive function	both	Y	positive	1	mental

EXPERIMENTAL

Akers *et al.*	2012	investigation of the role of the colour green in providing green exercise benefits	UK	other	adult men	setting	**heart rate, respiration,** POMS	none	N	inconclusive	3	both
Annerstedt et al.	2013	effect of sounds of nature on stress recovery	Sweden	other	university students & employees	setting	BMI, general, STAI, **heart rate, respiration, heart rate variability, salivary cortisol**	none	N	positive	7	both
Barton et al.	2009	health effects of walking in sites of natural value	UK	rural	site visitors; adult	setting	shortened POMS, RSES	individual	N	positive	2	mental
Beil & Hanes	2013	physiological and psychological effects of visiting four urban environments	USA	urban		setting	**salivary cortisol and sugar,** stress, PSS, PRS	individual	N	positive	5	both
Bodin & Hartig	2003	effect of outdoor environment on psychological restoration during a run	USA	urban	regular runners	setting	psychological (emotion, attention, need for restoration) PRS	none	N	inconclusive	4	mental
Branas et al.	2011	effect of greening urban land on health	USA	urban		setting	general, stress, blood pressure, cholesterol, physical activity	area	Y	positive	5	both
Brown *et al.*	2014	effect of a workplace green exercise intervention on autonomic function		both	office-based employees	setting	**heart rate, heart rate variability, blood pressure, cardiovascular disease risk, BMI, physical activity (number of steps), aerobic fitness,** SF-8	none	N	inconclusive	8	both
Calogiuri *et al.*	2016	effect of a workplace green exercise intervention in reducing stress	Norway	urban	office-based employees	setting	**blood pressure, salivary cortisol levels, serum cortisol levels**, PAAS, PRS	individual	N	positive	5	both
Chang *et al.*	2016	effects of biodiversity on well-being	Taiwan	both		quality	**muscle tension, heart rate, blood pressure**	none	N	no relationship	3	physical
Droomers *et al.*	2015	impact of green space interventions in severely deprived neighbourhoods on health	Netherlands	urban		quantity, quality	physical activity, general	individual	Y	no relationship	2	both
Hartig et al.	1991	effect of visiting nature on mental well-being	USA	other	members of local backpacking/ hiking groups	setting	ZIPERS, OHS, psychological (mental restoration)	individual	Y	positive	3	mental
Hartig *et al.*	1991	effect of visiting nature on mental well-being	USA	other	university students	setting	ZIPERS, OHS, psychological (mental restoration), **blood**	none	N	positive	6	both

							pressure, heart rate, skin conductance					
Hartig *et al*.	2003	association between exposure to natural/urban environments and mental restoration	USA	both	university students	setting	ZIPERS, OHS, psychological (attention), blood pressure	none	N	positive	4	both
Gatersleben *et al.*	2013	assessment of the restorative potential of different green spaces	England	both	university students & alumni	setting	psychological (perceived restoration)	none	N	inconclusive	1	mental
Gatersleben *et al.*	2013	assessment of the potential of different green spaces to enhance recovery from stress and fatigue	England	both	university students & alumni	setting	ZIPERS, psychological (attention), **heart rate**	none	N	inconclusive	3	both
Gladwell *et al.*	2012	the effects of viewing nature on autonomic control	UK	other	university students & employees	setting	**heart rate, heart rate variability, blood pressure, respiration**	none	N	positive	3	physical
Gladwell *et al.*	2016	effect of a lunchtime walk in nature on heart rate variability	UK	other	university employees & general public	setting	physical activity, **blood pressure, heart rate, heart rate variability**	none	N	positive	4	physical
Grazuleviciene *et al.*	2016	effects of walking in natural and urban environment on the cardiovascular system of coronary artery disease patients	Lithuania	urban	coronary artery disease patients; aged 45-75 yrs	setting	**heart rate, blood pressure, salivary cortisol,** psychological (mood)	none	N	positive	4	both
Jiang *et al.*	2014a	investigation of effect of urban street tree density on stress recovery	USA	urban		quality	psychological (stress recovery)	none	N	positive	1	mental
Jiang *et al.*	2014b	investigation of gender differences in relationship between urban street tree density and stress recovery	USA	other	adults; age 18-32 yrs	quality	**salivary cortisol, skin conductance**	none	N	inconclusive	2	physical
Lee et al.	2011	effect of forest bathing on health	Japan	both	university students	setting	shortened POMS, **blood pressure, heart rate, salivary cortisol, HRV (human autonomic activity)**	none	N	positive	5	both
Lee *et al.*	2014a	comparison of the effects of urban and nature walks on arterial stiffness and pulmonary function	South Korea	both	women; age 60-80 yrs	setting	**blood pressure, arterial stiffness, pulmonary function**	none	N	positive	3	physical

Lee *et al.*	2014b	effect of forest walks on cardiovascular reactivity in young adults	Japan	both	young men; mean age 21	setting	**heart rate, heart rate variability, blood pressure,** shortened Japanese POMS, psychological (anxiety, psychological response, feeling refreshed)	none	N	positive	7	both
Lindal *et al.*	2015	effects of trees, grass, and flower beds on restorative potential of natural environment	Iceland	other		quality	psychological (being away, fascination, restoration likelihood)	none	N	positive	3	mental
Martens et al.	2011	impact of walking in forests on psychological health	Switzerland	both	university students & general public	setting	psychological (short-term changes in mood)	individual	Y	positive	1	mental
Pretty *et al*.	2005	benefits of green exercise for mental health	UK	other	university students & employees & general public	setting	POMS, self-esteem, BMI, **heart rate, blood pressure**	none	N	positive	5	both
Rogerson *et al.*	2016	psychological benefits of exercising in an outdoor compared to indoor environment	UK	other	university students & employees	setting	psychological (attention), POMS, perceived exertion	none	N	inconclusive	3	both
Song *et al.*	2013	physiological and psychological responses to walking in an urban park	Japan	urban	male university students	setting	**heart rate, heart rate variability,** POMS, STAI	none	N	positive	4	both
Song *et al.*	2014	association between exposure to green space and physical and mental health	Japan	urban	male university students	setting	**heart rate, heart rate variability**, psychological (adjective scale describing feelings), POMS, STAI	none	N	positive	5	both
Song *et al.*	2015	health effects of walking in natural or urban sites in autumn	Japan	urban	male university students	setting	**heart rate, heart rate variability,** POMS, STAI	none	N	positive	4	both
Stigsdotter *et al.*	2017	investigation of physiological and psychological effects of walking and viewing forest and urban environments	Denmark	both	female university students	setting	**blood pressure, heart rate variability,** POMS, PRS, PSS, general	none	N	inconclusive	6	both
Takayama *et al.*	2014	investigation of the well-being benefits of walking and viewing forest environments	Japan	both	male university students	setting	POMS, PANAS, ROS, psychological (vitality)	none	N	positive	4	mental
Triguero-Mas *et al.*	2017	effect of exposure to the natural environment on people with indications of psychological distress, and possible mechanisms mediating these effects	Spain	urban	people with indications of psychological distress	setting	Spanish POMS, psychological (attention), **salivary cortisol, blood pressure, heart rate, heart rate variability**	individual	N	positive	6	both

Tsutsumi *et al.*	2016	investigation of whether viewing preferred natural scene promotes relaxation	Japan	other	men	type	POMS, **heart rate, blood pressure, sleep-wake level**	none	N	positive	4	both
Twedt *et al.*	2016	investigation of the perceived restorativeness of different garden designs	USA	other		quality	psychological (perceived restorativeness)	individual	Y	postive	1	mental
Tyrväinen *et al.*	2014	psychological and physiological effects of short visits to urban nature	Finland	urban		setting	**salivary cortisol,** ROS/PRS, PANAS, psychological (subjective vitality, creativity)	none	N	positive	5	both
Ulrich *et al*.	1991	association between exposure to different environment types and recovery from stress	USA	other	university students	setting	ZIPERS, **heart rate, BP, skin conductance, muscle tension**	none	N	positive	5	both
van den Berg et al.	2014	association between environment type and stress relief	UK	other	university students	setting	POMS, RSS	none	N	positive	2	mental
van Herzele & de Vries	2011	mediators of the relationship between neighbourhood greenness and health	Belgium	urban		quantity, quality (GIS)	general, NS-14, psychological (stress and ability to concentrate), social cohesion	individual	N	positive	4	both
White *et al.*	2015	effect of exercising in different natural environment types for post-menopausal women	UK	other	post-menopausal women	setting, type	**blood pressure, heart rate,** psychological (affective responses)	none	N	positive	3	both
White *et al.*	2017	effect of biodiversity of coastal environments on their restorativeness	UK	other		quality	psychological (mood, recovery)	none	N	positive	2	mental
Wilkie *et al.*	2015	effect of environment preference and type on perceived restorativeness of natural environments	UK	other	university students	setting, type	psychological (directed attention, mood, fatigue, PRS)	none	N	positive	3	mental

Abbreviations

Health

Abbreviation	Measure
BMI	Body Mass Index
BSI	Brief Symptom Inventory (psychological)
CES-D	Center for Epidemiological Studies-Depression (CES-D) scale
DASS	Depression & Anxiety Stress Scale
GHQ-12	General Health Questionnaire - 12 questions (minor psychiatric disorders)
GHQ-28	General Health Questionnaire - 28 questions (severe depression)
ICPC	International Classification of Primary Care
K6	Kessler psychological distress Scale
K10	Kessler psychological distress Scale
LS	Level of Stress
MHI-5	Mental Health Inventory
NS-14	Number of symptoms in last 14 days
OHS	Overall Happiness Scale
POMS	Profile of Mood States
PAAS	Physical Activity Affective Scale
PHQ-2	2-item Patient Health Questionnaire
PRS	Perceived Restorativeness Scale
PSS	Perceived Stress Scale
ROS	Restorative Outcome Scale
RSES	Rosenberg Self-Esteem Scale
RSS	Restorative State Scale
SF-12	Short Form Health Survey - 12
SF-36	Short Form Health Survey - 36
STAI	State-Trait Anxiety Inventory
WBI	Gallup-Healthways Well-being Index
WEMWBS	Warwick-Edinburgh Mental Well-being Scale
ZIPERS	Zuckerman's Inventory of Personal Reactions

Environment

Abbreviation	Measure
CORINE	Coordination of Information on the Environment
GIS	Geographic Information Systems
GLUD	(UK) General Land Use Database
LCM	(UK) Land Cover Map
LNG	(Dutch) National Land Cover Classification database
LSOA	lower layer super output area
NDVI	Normalised Difference Vegetation Index
NLCD	(US) National Land Cover Dataset
POST	Public Open Space Tool
SGS	Scania Green Score

SEP Measures

Abbreviation	**Measure**
IMD	(UK) Index of Multiple Deprivation

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Appendix 2 Full logistic regression models for Chapter 3

Table 1 Logistic regression analysis estimates for visiting a blue space frequently (≥once a month) rather than infrequently or never (pseudo-R^2 = 0.05)

	Adjusted OR	95% CI
Gender		
Male	1	
Female	0.89	0.69-1.17
Age		
16 to 24	1	
25 to 44	1.00	0.59-1.70
45 to 64	0.93	0.52-1.67
65 and over	1.27	0.65-2.49
Cohabiting status		
Married/cohabiting	1	
Single	0.93	0.61-1.42
Widowed	1.43	0.75-2.75
Divorced/separated	1.00	0.64-1.57
Dependent children		
Yes	1	
No	0.86	0.63-1.19
Car ownership		
Yes	1	
No	1.35	0.94-1.92
Level of higher education[*]		
Degree or equivalent	1	
Below degree level	0.71	0.51-0.98
Other qualifications	0.91	0.56-1.46
None	0.66	0.43-1.02
Limiting long term illness		
Yes	1	
No	1.10	0.78-1.56
Urbanity[*]		
Yes	1	
No	3.01	1.91-4.76

[*]$p<0.05$

Table 2 Logistic regression analysis estimates for visiting a blue space in a built-up area rather than the countryside, excluding respondents who have never visited a blue space (pseudo-R^2 = 0.10)

	Adjusted OR	95% CI
Gender		
Male	1	
Female	0.90	0.68-1.20
Age		
16 to 24	1	
25 to 44	0.95	0.53-1.68
45 to 64	0.99	0.53-1.85
65 and over	1.09	0.53-2.24
Cohabiting status		
Married/cohabiting	1	
Single	1.18	0.75-1.87
Widowed	1.25	0.61-2.58
Divorced/separated	1.08	0.67-1.75
Dependent children		
Yes	1	
No	0.83	0.59-1.16
Car ownership[*]		
Yes	1	
No	1.73	1.16-2.57
Level of higher education[*]		
Degree or equivalent	1	
Below degree level	0.73	0.52-1.02
Other qualifications	0.53	0.32-0.88
None	0.52	0.32-0.86
Limiting long term illness		
Yes	1	
No	1.02	0.69-1.50
Urbanity[*]		
Yes	1	
No	0.23	0.14-0.37

[*]$p<0.05$

Table 3 Multinomial logistic regression analysis estimates for the most important benefit received on the respondents' last visit to blue space (compared with psychological benefits), excluding respondents who have never visited a blue space (pseudo-R^2 = 0.17)

	Exercise or physical activity		Spending time with family or friends		Other	
	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
Gender						
Male	1		1		1	
Female	1.48	0.99-2.20	1.27	0.91-1.77	1.13	0.70-1.82
Age[+]						
16 to 24	1		1		1	
25 to 44	0.59	0.24-1.47	0.86	0.44-1.67	0.82	0.31-2.11
45 to 64	0.77	0.30-1.98	0.48	0.23-1.00	0.64	0.23-1.78
65 and over	0.73	0.26-2.06	0.34	0.14-0.80	0.38	0.12-1.25
Cohabiting status						
Married/cohabiting	1		1		1	
Single	0.52	0.26-1.05	0.71	0.41-1.22	0.65	0.31-1.39
Widowed	1.53	0.64-3.63	1.09	0.45-2.68	0.38	0.07-2.10
Divorced/separated	0.77	0.39-1.49	0.81	0.45-1.47	0.87	0.39-1.96
Dependent children[+]						
Yes	1		1		1	
No	1.14	0.70-1.88	0.40	0.27-0.59	1.27	0.71-2.28
Car ownership						
Yes	1		1		1	
No	0.85	0.46-1.56	1.18	0.74-1.87	1.04	0.53-2.06

Level of higher education[+]						
Degree or equivalent	1		1		1	
Below degree level	0.71	0.44-1.125	1.35	0.91-2.02	1.49	0.85-2.63
Other qualifications	0.94	0.51-1.75	0.76	0.41-1.43	0.80	0.32-2.01
None	0.63	0.31-1.28	1.97	1.09-3.57	1.55	0.67-3.57
Limiting long term illness[*]						
Yes	1		1		1	
No	2.49	1.36-4.54	1.23	0.77-1.97	1.43	0.72-2.82
Urbanity						
Urban	1		1		1	
Not urban	1.17	0.70-1.94	0.64	0.38-1.06	1.47	0.79-2.71

[*]p<0.05

[+] p<0.05

Table 4 Logistic regression analysis estimates for whether people found nature to be very important when visiting a blue space, excluding respondents who have never visited a blue space (pseudo-R^2 = 0.06)

	Adjusted OR	95% CI
Gender[*]		
Male	1	
Female	1.38	1.05-1.82
Age[*]		
16 to 24	1	
25 to 44	1.54	0.87-2.71
45 to 64	2.43	1.31-4.51
65 and over	3.48	1.70-7.11
Cohabiting status		
Married/cohabiting	1	
Single	1.05	0.67-1.64
Widowed	1.00	0.49-2.06
Divorced/separated	0.97	0.60-1.57
Dependent children		
Yes	1	
No	0.95	0.68-1.32
Car ownership		
Yes	1	
No	0.82	0.55-1.21
Level of higher education[*]		
Degree or equivalent	1	
Below degree level	0.79	0.58-1.10
Other qualifications	1.07	0.65-1.76
None	0.55	0.34-0.90
Limiting long term illness		
Yes	1	
No	1.03	0.70-1.52
Urbanity		
Yes	1	
No	0.98	0.66-1.45

[*]$p<0.05$

Table 5 Multinomial logistic regression analysis estimates for the most important benefit received on the respondents' last visit to blue space (compared with psychological benefits), excluding respondents who have never visited a blue space (pseudo-R^2 = 0.20)

	Exercise or physical activity		Spending time with family or friends		Other	
	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
Gender[*]						
Male	1		1		1	
Female	1.51	1.01-2.26	1.29	0.92-1.81	1.13	0.70-1.82
Age[+]						
16 to 24	1		1		1	
25 to 44	0.52	0.21-1.32	0.82	0.42-1.61	0.85	0.33-2.23
45 to 64	0.65	0.25-1.70	0.44	0.21-0.92	0.67	0.24-1.88
65 and over	0.57	0.20-1.64	0.30	0.12-0.71	0.40	0.12-1.33
Cohabiting status[*]						
Married/cohabiting	1		1		1	
Single	0.48	0.24-0.98	0.67	0.39-1.16	0.67	0.31-1.43
Widowed	1.57	0.65-3.79	1.09	0.44-2.69	0.39	0.07-2.11
Divorced/separated	0.75	0.38-1.48	0.81	0.45-1.47	0.87	0.39-1.97
Dependent children[+]						
Yes	1		1		1	
No	1.19	0.72-1.96	0.41	0.28-0.61	1.25	0.69-2.25
Car ownership						
Yes	1		1		1	
No	0.85	0.46-1.58	1.17	0.73-1.87	1.06	0.53-2.10

Level of higher education[+]						
Degree or equivalent	1		1		1	
Below degree level	0.73	0.46-1.17	1.39	0.93-2.08	1.50	0.85-2.65
Other qualifications	0.67	0.51-1.82	0.78	0.41-1.47	0.82	0.32-2.06
None	0.70	0.34-1.44	2.10	1.16-3.82	1.53	0.66-3.56
Limiting long term illness[*]						
Yes	1		1		1	
No	2.66	1.45-4.89	1.27	0.79-2.04	1.42	0.72-2.82
Urbanity						
Urban	1		1		1	
Not urban	1.20	0.71-2.00	0.62	0.37-1.05	1.48	0.80-2.74
Importance of nature[*+]						
Very important	1		1		1	
Less important	2.80	1.83-4.28	1.69	1.21-2.37	0.88	0.54-1.41

[*] $p<0.05$

[+] $p<0.0$

Appendix 3 Focus Group Protocol

Welcome & Introduction (5 minutes)

- Provide name badges and refreshments (available prior to focus group discussion).
- Ask for consent and demographic forms to be filled in.
- Thank participants for coming, check consent, confirm timings, explain how focus group will work and what it is about (how people use and feel about local parks, things they like and don't like).
- Answer any questions relating to session.
- Set out ground rules eg. all participants have a chance to talk, only one person to talk at a time.
- Let's start by introducing ourselves.

Use of the Park

Give everyone a card and ask them to tick their answer.

On average, how often do you spend time in Philip's Park and/or Clayton Vale?

	Philip's Park	Clayton Vale
(1) Every day/most days		
(2) Once a week		
(3) Once a month		
(4) Once every few months		
(5) Two or three times a year		
(6) Once a year or less		
(7) Never visit		

Discussion of answers on cards:

How often do you visit Philip's Park and Clayton Vale?

Do you visit one park more often than the other?

- May be dependent season/weather, week/weekend, school holidays.

Views of Local Park

Do you like going to the park? Why?

Do you avoid going to the park? Why?

Are there particular areas you like to visit or avoid visiting? (may be discussed in why)

Reasons for Visiting

Give everyone a card and ask them to tick their answer

Please indicate the most important reason for your visits to Philip's Park and Clayton Vale.		
	Philip's Park	Clayton Vale
(1) Exercise or keeping fit		
(2) Spending time with friends or family		
(3) Relaxation or stress reduction		
(4) Other – please describe		

Discussion of answers on cards:

Why do you visit Philip's Park and Clayton Vale?

Do you visit for more than one reason?

What is your most important reason for visiting?

Do you have different reasons for visiting Philip's Park or Clayton Vale?

Health Benefits

I'd like you to look at these pictures and think about visiting the park by yourself. If you were visiting to exercise or keep fit which would you most like to visit? Why?

Which would you least like to visit? Why?

If you were visiting to relax or reduce stress, which you most like to visit? Why?

Which would you least like to visit? Why?

I'd like you think about your visits to the park then look at these cards as a group and discuss where to place them on the scale (Velcro board with 'When I visit the park…' and a scale with 'I feel' at one end and 'I don't feel' at the other).

- Happy
- Calm and relaxed
- Refreshed and revitalised
- Anxious and stressed

Prompt as to why they have placed the cards as they have on the scale.

How important is nature in enhancing your visits?

Which aspects of nature are most important in enhancing your visit?

Prompt on which aspects they notice.

- Importance of different aspects (plants, birds, wildlife).

Restoration

Before

During

After

I'd like to talk about the restoration of the river Medlock in Clayton Vale. Here are some pictures of the river: before it was restored, during the process of restoration, and as it looks now.

Did you visit the river before it was restored?

- Why did you visit the river?
- Did you enjoy visiting the river?

Do you remember the restoration? How long did it take?

Did you use the park differently due to it?

- Did you visit more or less often?
- Did you enjoy visiting more or less?
- Did you visit for different reasons or activities due to it?

Do you visit the river now that it has been restored?

- Do you visit more or less often?
- Do you enjoy visiting more or less?
- Do you visit for different reasons or activities?

Blue Spaces

The pictures we've been talking about show the river running through Clayton Vale. I'd like talk about water –streams and ponds – in parks. Looking at these pictures:

Which would you rather visit? Why?

These are pictures of the river in Clayton Vale and Philip's Park:

Which would you rather visit? Why?

How do you use blue spaces in Philip's Park and Clayton Vale?

- Prompt on river Medlock, nature ponds, duck pond.
- Prompt on different activities.

Looking back at the cards on which you ticked your reasons for visiting Philip's Park and Clayton Vale, I'd like you to think about your visits to areas of Philip's Park and Clayton Vale with water. Are your reasons for visiting areas with water the same or different to visiting the parks as a whole?
Give everyone a card and ask them to tick an answer.
Discussion of answers on cards.

I'd like you to look at the board where you placed the different feelings you have when visiting the parks. Thinking about your visits to areas with water in Philip's Park and Clayton Vale would you change where any of the cards are placed?

Prompt as to why if any changes are made.

How important is nature in enhancing your experience of blue spaces?
Which aspects of nature are most important in enhancing your visit?

- Prompt on which aspects they notice.
- Importance of different aspects (plants, birds, wildlife).

Queen's Park and Blackley Forest
Substitute restoration section for:
Do you visit the river?
Why do you visit the river? (prompt on reasons/activities)
Do you enjoy visiting the river?
How do you feel about the river in its current condition?

Appendix 4 Interview Protocol

I am studying the ecological restoration of the Medlock, an urban freshwater blue space in Manchester, and the impact the restoration has had on the ecological health of this river and the human health of the local community.

I'd like to share some initial findings from the study and ask for your insight and opinions. The aim of the interview is to explore the data I've already collected and the impact that ecological restoration can have on ecological health and human health and well-being.

Overview of the study: to measure ecological health I sampled macroinvertebrates at six sites along the river in spring and autumn 2015. (show table with locations of sites, see end of document) On the river Medlock these were an unrestored downstream site, the restored site, and an upstream comparison site. On the Irk, a river in the same catchment with a similar source to the Medlock, two unrestored sites and an upstream comparison were sampled. I then identified the macroinvertebrates in the lab.

To investigate how the restoration impacted the local community I conducted focus groups. I recruited 12 participants, all users of green spaces around the rivers, and discussed topics including the use of green space, views of the restoration, and preferences for features in green and blue space.

Structure of interview: I'd like to start by talking about the ecological health of urban green spaces and freshwater blue spaces and their use by local communities then I would like to share data on the river restoration project and ask some questions about this and ecological restoration in general, bringing in quotes from the focus groups for discussion throughout the interview. Before we start, do you have questions about the interview or the research project?

Could you tell me a bit about yourself, your background, how you've come to work in this area? (for people involved with the park/river) How are you involved with the park/river? How long have you worked in the area/with the park?

Talking in terms of nature/the environment, what would a healthy urban park/freshwater blue space in this area (Manchester) look like to you? What ecological properties would it have?

What do you think an urban park/freshwater blue space should look like in terms of people interacting with it?

(table showing the locations of the sites) One issue that arose in the focus groups was defining a park and what its environment should look like:

> I think the Vale is a more natural place…Philips is a park and that's what people end up going for because they know they can walk through the park…but you know if you're going through the Vale you are going to go more onto a natural thing.
>
> I think that's what people go for; they go for that natural look…on the Vale. The park I think they just like to be a little bit more y'know regimented…if that's the right word.
>
> It [nature] is important but it depends what you're looking at and I haven't got a clue.

How do you think the ecosystem health of a park changes how people interact with it?

- Do you think that this would differ for different park users? Prompt: age, gender etc.

Are there aspects of ecological health/the natural environment you think are particularly important for park users?

- Prompt: features of parks or freshwater blue spaces.
- Are the features of the environment which are most beneficial for people the ones they think are most beneficial for them?

How do you think the ecosystem health of an urban freshwater blue space changes how people interact with it?

In the focus groups I asked people about their reasons for visiting the parks:

Reason	Number of people
Exercise or keeping fit	7
Spending time with family or friends	12
Relaxation or stress reduction	11
Other	1 – path to somewhere else 1 – recording wildflowers 3 – educational talks or demonstrations eg. foraging, orchard tree pruning 1 - adventure

Is this what you would expect? Why?

Is using the park for exercise/time with family and friends/relaxation impacted by the ecological health or ecological characteristics of the park? How/why?

What are your perceptions of how people's interactions with urban parks and freshwater blue spaces are beneficial to their health and well-being?

I'd like to show you some pictures of the different sites:

- (pictures of river pre-restoration) Do you think this freshwater blue space is ecologically healthy/unhealthy? Why do you think this?
- (pictures of restoration) What effect would you predict the restoration would have on the ecological health or ecological characteristics of this area?
- (pictures of all sites sampled post-restoration) Looking at the different sites do you have any opinions on which might be most/least healthy?

(table with BMWP index, graphs showing number of taxa and pictures of most common species at all sites) I'd like to show you some data on the river restoration:

- Are these what you would expect? Why? Prompt:
    - Restored site/unrestored sites
    - Restored river/unrestored river
- Do you have any comments on the:
    - Biodiversity/ BMWP of the sites
    - The most common species found at each site?
- Do you have comments on what the data shows about the effect of the restoration on the ecological health or characteristics of the river?

These are some quotes from the focus groups about freshwater blue spaces in urban parks:

> That one with the water, very tranquil, just the sound of the water, the birds…it's just sitting there listening to that. I love the flowers as well but…I think it's the sound, the sounds…it's very relaxing…the sound of water.
>
> I mean we've gone out into places…the rivers are open like that and the kids have paddled and sat in them.
>
> There used to be some industries down there…in some ways the industry is part of its heritage…although we moan about it and about the quality of the water for people I'm not sure it's as much of an issue. It might be if you want more fish and flowers and wildlife cause it may prohibit that…unless you're a fisherman is that an issue? Not for me, I find looking at the water quite pleasant even though I might not want to get in it.

Do you have any comments on these quotes? Which quote do you identify with most? Why?

(pictures of pre-restoration) How do you think people interacted with the river?

(pictures of post-restoration) Do you have any expectations about people's opinions of the restoration? How they would interact with it during/after? (prompt on time)

(pictures of all sites sampled post-restoration/river data) Do you think the sites which are most healthy are the ones people want to visit?

(for people involved with park/river) Have you noticed any differences in how people interact with the park/river over time, and potentially to their health and well-being? Are there any differences due to the restoration?

These are some quotes about the restoration:

> It all did look lovely and all of a sudden a kingfisher was fishing there and you could see little shoals of fish in the river…the next thing these three dragonflies just at the other side of the bridge all dancing over the river and it was if it was all putting on a display and it was really, really nice…they were just all in that area where it had all been redone…I think it has made a big difference when you look at it.
>
> I mean it took them a long long time and wagons going up and down and up and down but it didn't really impact on us too much from this end.
>
> I'm quite happy with what they've done…anything that improves the wildlife is good enough for me.
>
> That red brick is part of our history and we don't want it ripping out, we said alright maybe so far bring it back but make sure you do it right and it's not going to wear away sides and what have you but you must keep some of because it's part of the history part of the history of Philips Park, it's part of the history of Clayton.

(looking at the pictures and quotes) Do you have any comments? Which quote do you most identify with? Why?

Do you think it is important to restore/actively conserve nature in urban parks and freshwater blue spaces?

How important is it compared to getting people to actively use the space?

Can the two go together - how compatible is the conservation of nature in green and blue spaces with use by the local community?

- Does conservation work encourage use?
- Does how people interact with the park change the ecological health of the park (other than conservation activities)?
- Prompt: quotes on restoration and data on river health.

- Prompt - different types of use/interest, does it cater for everyone?

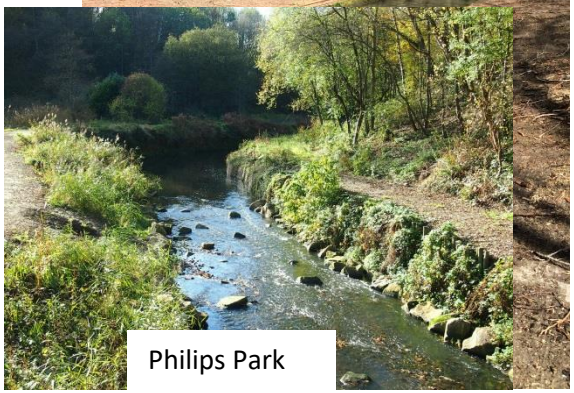
I've asked everything I would like to ask you, is there anything you would like to add on any of the topics we have discussed in the interview?

Table showing the location and restoration status of each site

River		Site	Status
Medlock		Philips Park	Unrestored
downstream	↑	Clayton Vale	Restored
		Brook Lane	Upstream comparison
upstream			
Irk		Queen's Park	Unrestored
downstream	↑	Blackley Forest	Unrestored
		Chadderton Hall	Upstream comparison
upstream			

Pictures of the restoration

Pictures of each site

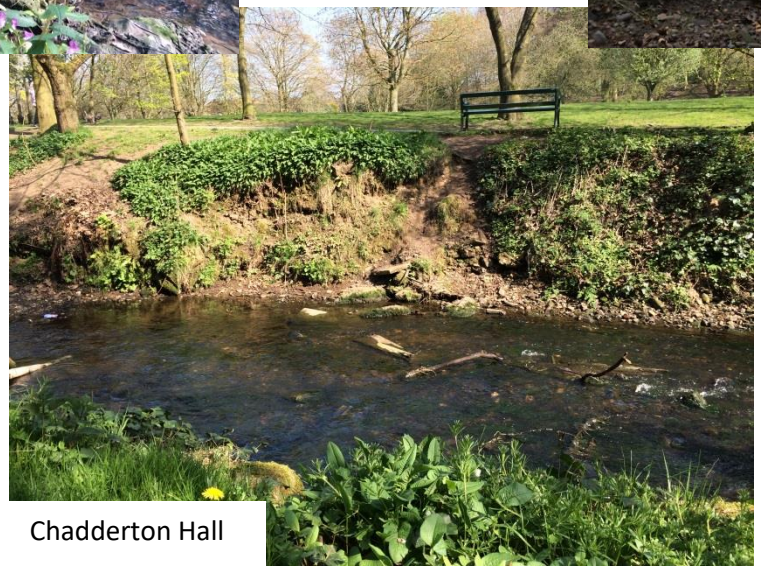


Philips Park

Brook Lane

Queen’s Park

Blackley Forest



Chadderton Hall

The most common taxa at each site:

1.

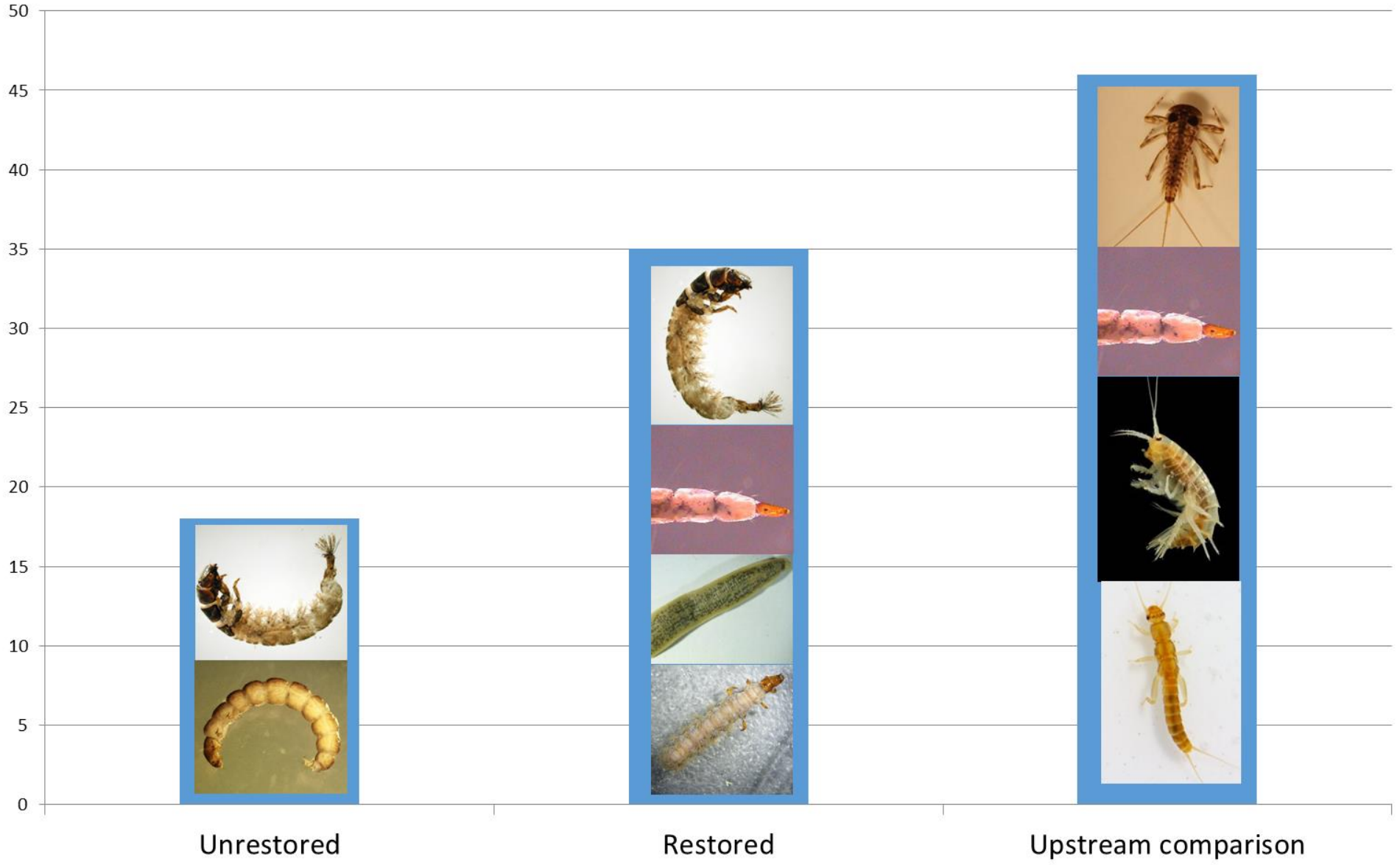
2.

3.

The BMWP score indicates the water quality of an area. The sites were sampled in spring and autumn 2015.

River	Site	BMWP Score	Interpretation
Medlock	**Philips Park**	44.3	poor
	Clayton Vale	103.8	very good
	Brook Lane	186.9	very good
Irk	**Queen's Park**	85.3	good
	Blackley Forest	106.4	very good
	Chadderton Hall	68.6	moderate

Total number of different taxa found at each site on the river Medlock



Total number of different taxa found at each site on the river Irk