

**Cultural ecosystem service delivery from green-space: impact of urbanisation, green-space visits and landscape-scale restoration**

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**General Abstract**

Research on the importance of the natural world for the delivery of benefits that make human life both possible and worth living is ever mounting. There are, however, a number of uncertainties about the relationship between natural settings and the benefits they deliver, especially regarding non-material cultural benefits, limiting our ability to protect, preserve and enhance their continued delivery in the future.

Here we explore the relationship between different types of environmental settings, primarily urban green-spaces and the countryside, and the delivery of three cultural benefits; knowledge of nature, conservation support and mental well-being while at the same time addressing the commonly made assumption central to conservation policy that more frequent nature engagement improves knowledge and understanding of the natural word and willingness to protect it. We also consider the impacts of two key drivers of change, urbanisation and landscape-scale restoration on the relationships between cultural ecosystem services and cultural benefit delivery. This was achieved using two approaches. The first consisted of door-to-door surveys with over 200 participants in three pairs of large and small urban areas across England. The second approach involved conducting face-to-face surveys with over 1000 visitors to sites within a landscape-scale restoration programme using a before and after experimental design with controls.

We found increased nature engagement was associated with enhanced levels of nature knowledge, conservation support and mental well-being but that these differed between environmental settings. Knowledge of nature and conservation support were only associated with visits to the countryside and not urban green-spaces and while some indicators of mental well-being were associated with both settings, others differed between the two. Concerns regarding impacts of urbanisation on cultural benefit delivery appear to be well founded with residents from areas of high urbanisation intensity visiting the countryside less frequently and having lower levels of nature knowledge and support for conservation though there was no negative impact of city size. We found limited evidence to suggest that landscape-scale restoration impacts negatively on the visitor experience with the vast majority of respondents reporting no impact of conservation management on site quality and cultural benefit delivery remaining unaffected or enhanced.

Our findings suggest that to enhance people’s abilities to develop and maintain nature knowledge and support for conservation as well as their mental well-being, policies and action should focus on creating less intensively urbanised cities as well as improving access to, and engagement with both urban green-spaces and the countryside on a regular basis. Furthermore, the benefits derived from engagement with the countryside are unlikely to be negatively impacted by landscape-scale restoration activities. However, further work including experimental manipulations and sampling in both additional cities of different sizes and restoration studies in different landscape types are required to address the limitations of our research and determine the generalisability of our findings.

**Table of Contents**

[**1 General introduction** 14](#_Toc481416130)

[1.1 Ecosystem services 14](#_Toc481416131)

[1.2 Cultural ecosystem services 15](#_Toc481416132)

[1.2.1 Human health and well-being benefits 16](#_Toc481416133)

[1.2.2 Social capital benefits 20](#_Toc481416134)

[1.2.3 Educational benefits 21](#_Toc481416135)

[1.3 Limitations of existing research on cultural ecosystem service delivery 22](#_Toc481416136)

[1.4 Impacts of urbanisation and ecological restoration on cultural ecosystem service delivery 23](#_Toc481416137)

[1.5 Thesis aims and framework 24](#_Toc481416138)

[1.6 Ethics statement 29](#_Toc481416139)

[1.7 Declaration of Authorship 29](#_Toc481416140)

[**2** **Green-space engagement and urbanisation - impacts on biodiversity knowledge and conservation support**  31](#_Toc481416141)

[2.1 Abstract 31](#_Toc481416142)

[2.2 Introduction 31](#_Toc481416143)

[2.3 Methods 36](#_Toc481416144)

[2.3.1 Survey sites and urbanisation metrics 36](#_Toc481416145)

[2.3.2 Participant recruitment and sample size 40](#_Toc481416146)

[2.3.3 Green-space visitation rates and motivations 44](#_Toc481416147)

[2.3.4 Biodiversity knowledge 44](#_Toc481416148)

[2.3.5 Support for conservation 47](#_Toc481416149)

[2.3.6 Socio-economic and demographic information 51](#_Toc481416150)

[2.3.7 Statistical analysis 54](#_Toc481416151)

[2.4 Results 56](#_Toc481416152)

[2.4.1 Participants 56](#_Toc481416153)

[2.4.2 Levels of engagement and with urban green-spaces and the countryside 58](#_Toc481416154)

[2.4.3 Green-space visit rates and biodiversity knowledge 60](#_Toc481416155)

[2.4.4 Green-space visit rates and conservation support 64](#_Toc481416156)

[2.4.5 Association between biodiversity knowledge and conservation support 64](#_Toc481416157)

[2.4.6 Urbanisation and green-space visit rates 67](#_Toc481416158)

[2.4.7 Urbanisation and biodiversity knowledge 73](#_Toc481416159)

[2.4.8 Urbanisation and conservation support 73](#_Toc481416160)

[2.5 Discussion 74](#_Toc481416161)

[2.5.1 Engagement with green-space and motivation 74](#_Toc481416162)

[2.5.2 Biodiversity knowledge 74](#_Toc481416163)

[2.5.3 Levels of conservation support 75](#_Toc481416164)

[2.5.4 Relationships between greenspace visitation, biodiversity knowledge and conservation support 76](#_Toc481416165)

[2.5.5 Relationship between knowledge and support 78](#_Toc481416166)

[2.5.6 Influence of socio-demographic factors on biodiversity knowledge and conservation support 78](#_Toc481416167)

[2.5.7 Relationship between urbanisation and green-space visitation rates, biodiversity knowledge and conservation support 79](#_Toc481416168)

[2.5.8 Limitations 81](#_Toc481416169)

[2.5.9 Conclusion 84](#_Toc481416170)

[Appendix 2.1 85](#_Toc481416171)

[Appendix 2.2 86](#_Toc481416172)

[**3 Mental well-being is positively associated with visiting green-space in cities and the countryside, but not actual or perceived levels of local urbanisation**  87](#_Toc481416173)

[3.1 Abstract 87](#_Toc481416174)

[3.2 Introduction 87](#_Toc481416175)

[3.3 Methods 90](#_Toc481416176)

[3.3.1 Survey sites, participant recruitment and sample size 90](#_Toc481416177)

[3.3.2 Local surroundings - actual and perceived levels of urbanisation 91](#_Toc481416178)

[3.3.3 Green-space visitation rates 92](#_Toc481416179)

[3.3.4 Mental well-being 93](#_Toc481416180)

[3.3.5 Biodiversity knowledge 94](#_Toc481416181)

[3.3.6 Holidays, socio-economic and demographic information 94](#_Toc481416182)

[3.3.7 Statistical analysis 97](#_Toc481416183)

[3.4 Results 99](#_Toc481416184)

[3.4.1 Participants 99](#_Toc481416185)

[3.4.2 Local surroundings - association between perceived and actual levels of local urbanisation 100](#_Toc481416186)

[3.4.3 Mental well-being models - associations between perceived and actual levels of local urbanisation 102](#_Toc481416187)

[3.4.4 Mental well-being models - countryside and urban green-space visit rates and short-term versus long-term visitation measures 106](#_Toc481416188)

[3.4.5 Interaction between biodiversity knowledge and green-space visitation rates and additional predictors of mental well-being 107](#_Toc481416189)

[3.5 Discussion 110](#_Toc481416190)

[3.5.1 Perceptions of local surroundings 110](#_Toc481416191)

[3.5.2 Mental well-being, local surroundings and green-space visits 111](#_Toc481416192)

[3.5.3 Importance of the ‘duration of the dose’ of green-space visit rates and type 112](#_Toc481416193)

[3.5.4 Biodiversity knowledge and green-space visit interaction 113](#_Toc481416194)

[3.5.5 Limitations 114](#_Toc481416195)

[3.5.6 Conclusion 115](#_Toc481416196)

[Appendix 3.1 117](#_Toc481416197)

[Appendix 3.2 120](#_Toc481416198)

[**4 Landscape-scale restoration and the visitor experience** 121](#_Toc481416199)

[4.1 Abstract 121](#_Toc481416200)

[4.2 Introduction 122](#_Toc481416201)

[4.3 Methods 124](#_Toc481416202)

[4.3.1 Survey sites, participant recruitment and sample size 124](#_Toc481416203)

[4.3.2 Awareness of the NIA and support for the key NIA management objectives 128](#_Toc481416204)

[4.3.3 Perceptions of changes in site quality, reasons for this and perceived changes in species richness 128](#_Toc481416205)

[4.3.4 Cultural benefit delivery 134](#_Toc481416206)

[4.3.5 Statistical analysis 138](#_Toc481416207)

[4.4 Results 143](#_Toc481416208)

[4.4.1 Awareness of the NIA and support for the key NIA objectives 143](#_Toc481416209)

[4.4.2 Perceptions of changes in site quality, reasons for this and perceived changes in species richness 145](#_Toc481416210)

[4.4.3 Cultural benefit delivery 156](#_Toc481416211)

[4.5 Discussion 170](#_Toc481416212)

[4.5.1 Awareness of the NIA and support for the key NIA objectives 170](#_Toc481416213)

[4.5.2 Perceptions of changes in site quality, reasons for this and perceived changes in species richness 170](#_Toc481416214)

[4.5.3 Cultural benefit delivery 174](#_Toc481416215)

[4.5.4 Limitations 176](#_Toc481416216)

[4.5.5 Conclusion 179](#_Toc481416217)

[Appendix 4.1 181](#_Toc481416218)

[**5 General Discussion** 183](#_Toc481416219)

[5.1 Key findings 183](#_Toc481416220)

[5.1.1 Relationships between cultural ecosystem services and cultural benefits 183](#_Toc481416221)

[5.1.2 Relationships between drivers of change and cultural benefit delivery 187](#_Toc481416222)

[5.2 Limitations and future work 190](#_Toc481416223)

[5.3 Relevance for policy 191](#_Toc481416224)

[**Bibliography** 192](#_Toc481416225)

[**Appendix A** 216](#_Toc481416226)

[**Appendix B** 250](#_Toc481416227)

[**Appendix C** 25](#_Toc481416228)5

**List of Figures**

|  |  |  |
| --- | --- | --- |
| **Chapter 1** |  |  |
| Figure 1.1 | Environmental settings and cultural benefits | 16 |
| Figure 1.2 | Conceptual Framework | 26 |
| **Chapter 2** |  |  |
| Figure 2.1 | The potential gap in educational ecosystem service provision between rural and urban green-spaces | 34 |
| Figure 2.2 | Satellite imagery depicting the extremes of local urbanisation scores included within the study | 39 |
| Figure 2.3 | The distributions of the Index of Multiple Deprivation scores for (a) Lower Super Output Areas (LSOAs) within three kms of each urban area centre and (b) of the LSOAs within which each respondent lives for the same urban area | 42 |
| Figure 2.4 | Visitation rates to urban green-spaces and the countryside | 59 |
| Figure 2.5 | Relationships between countryside visitation rates and (a) biodiversity knowledge, and (b) behavioural conservation support | 62 |
| Figure 2.6 | Associations between (a) countryside visitation rate and local urbanisation score, (b) biodiversity knowledge and local urbanisation score, (c) behavioural conservation support and size of urban area, and (d) financial conservation support and local urbanisation score | 69 |
| Figure 2.7 | Associations between (a) countryside visitation rates and local urbanisation score, (b) urban green-space visitation rate and size of the urban area, and (c) behavioural conservation support and size of the urban area | 72 |
| **Chapter 4** |  |  |
| Figure 4.1 | The mean percentages of Dark Peak NIA visitor survey respondents reporting perceived changes in site quality across treatment and control sites in both early and late phases of the programme | 146 |
| Figure 4.2 | Perceived changes in site quality at Burbage in response to the felling of most of a conifer plantation before and after participants were told that the plan was for it to be replaced with native, broadleaf woodland | 152 |

**List of Tables**

|  |  |  |
| --- | --- | --- |
| **Chapter 1** |  |  |
| Table 1.1 | Definitions of key terms | 28 |
| **Chapter 2** |  |  |
| Table 2.1 | Urban land cover of paired large and small urban areas | 36 |
| Table 2.2 | The number of completed questionnaires at each site | 43 |
| Table 2.3 | The twelve native species used to assess respondents’ knowledge of species identification and conservation status | 46 |
| Table 2.4 | Charitable organisations participants were members of and/or donated to | 49 |
| Table 2.5 | Conservation support principal component analysis | 50 |
| Table 2.6 | Socio-economic and demographic indicator answer categories | 52 |
| Table 2.7 | Socio-demographic categorical principal component analysis | 53 |
| Table 2.8 | Socio-economic and demographic summary of respondents | 57 |
| Table 2.9 | Model output of biodiversity knowledge and conservation support as a function of visitation rates to urban green-space and the countryside | 61 |
| Table 2.10 | Model output of biodiversity knowledge and conservation support as a function of both green-space visitation rates and potentially confounding factors | 64 |
| Table 2.11 | Model output of conservation support as a function of biodiversity knowledge | 66 |
| Table 2.12 | Model output of green-space visitation rates, biodiversity knowledge, and conservation support as a function of local scale urbanisation intensity and city size, without controlling for socio-economic and demographic factors | 68 |
| Table 2.13 | Model output of impact of urbanisation on visits to green-spaces, biodiversity knowledge and conservation support when incorporating socio-economic and demographic variables | 70 |
| **Chapter 3** |  |  |
|  |  |  |
| Table 3.1 | Socio-economic and demographic indicators answer categories | 96 |
| Table 3.2 | Marital status of respondents | 99 |
| Table 3.3 | Relationship between perceived built-up land and perceived greenery | 101 |
| Table 3.4 | Model output of impacts on mental well-being constructed with response variables treated as continuous data | 103 |
| Table 3.5 | Impacts of the interaction between biodiversity knowledge and green-space visitation rates on well-being | 108 |
| **Chapter 4** |  |  |
| Table 4.1 | Sample site habitat type and NIA management activities, and number of completed questionnaires | 126 |
| Table 4.2 | Categories and examples of visitor statements for changes in site quality at NIA restoration sites | 129 |
| Table 4.3 | The most popular categories of best and most disappointing aspect of visits with example answers | 131 |
| Table 4.4 | Additional questions asked at Burbage during September 2015 | 133 |
| Table 4.5 | Socio-economic and demographic indicator answer categories | 136 |
| Table 4.6 | Model summary | 140 |
| Table 4.7 | Respondents’ awareness of the NIA and support for its objectives | 144 |
| Table 4.8 | Perceived changes in site quality over the previous two years | 147 |
| Table 4.9 | Perceived changes in site quality related to NIA conservation restoration activities | 149 |
| Table 4.10 | Model output of impacts on perceived species richness | 155 |
| Table 4.11 | Socio-economic and demographic summary of NIA respondents and resident Sheffield reference population | 157 |
| Table 4.12 | Model output of impacts on visitor numbers | 159 |
| Table 4.13 | Model output of impacts on site visitation rate | 161 |
| Table 4.14 | Model output of impacts on psychological well-being (all sites) | 163 |
| Table 4.15 | Model output of impacts on psychological well-being (Burbage only) | 165 |
| Table 4.16 | Model output of impacts on conservation support (all sites) | 167 |
| Table 4.17 | Model output of impacts on conservation support (Burbage only) | 169 |
|  |  |  |

# General introduction

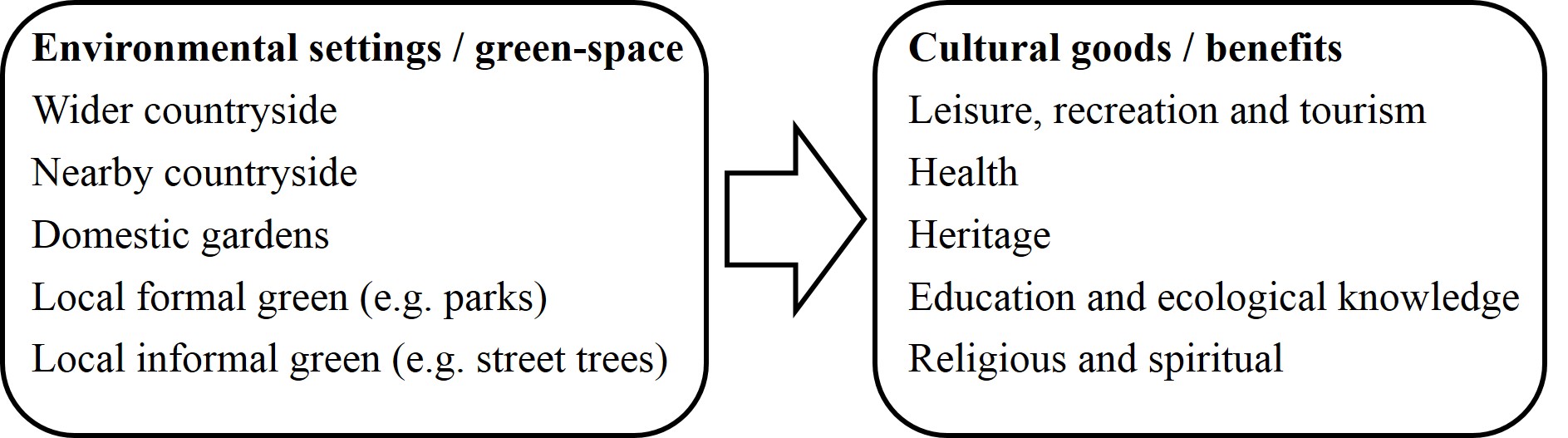
## Ecosystem services

The Millennium Ecosystem assessment (MA; Millennium Ecosystem Assessment 2005) was the first global assessment of the state of the world’s ecosystems with a focus on the links between ecosystem change and human well-being. We use the term ‘well-being’ in a broad sense, following the DEFRA (2007) definition as a positive physical, social and mental state, and not just the absence of pain, discomfort and incapacity. The MA described how our well-being is reliant on the delivery of multiple benefits from ecosystems and termed them ecosystem services (Millennium Ecosystem Assessment 2005). Although research on various aspects of ecosystem services have been carried out for decades, it was not until more recently that the concept of ecosystem services along with all of the related terminology exploded into the literature (de Groot, Wilson and Boumans, 2002). The ecosystem service concept promotes the conservation and health of ecosystems as a whole, contrasting with more traditional individual species-based approaches to conservation, with an important shift in emphasis to the impact of ecosystem change on human health and well-being. The MA classifies ecosystem services into four categories, i) provisioning services such as the supply of food, water and fibre, ii) regulating services including pollination, water purification and climate regulation, iii) cultural services such as health enhancements, educational value, spiritual enrichment and recreation, and iv) supporting services that are required for all other ecosystem services, soil formation and nutrient cycling for example. Although other classifications do exist, with differences in relation to supporting services in particular, these categories are commonly used (Boyd and Banzhaf, 2007; Wallace, 2007; Haines-Young and Potschin, 2011). The UK National Ecosystem Assessment (NEA) builds on the MA framework, but incorporates some key differences arising from explorations of ecosystem service concepts and definitions in work that followed the MA (eg. Boyd & Banzhaf, 2007; Fisher & Turner, 2008; Wallace, 2007). Unlike the MA, the UK NEA describes ecosystem services as the outputs from ecosystems from which people derive benefits and are not the benefits themselves. Furthermore, the UK NEA, following the approach by Fisher and Turner (2008) defines two distinct types of ecosystem service, “ecosystem processes and intermediate ecosystem services” and “final ecosystem services”. Ecosystem processes and intermediate ecosystem services are the services that underpin final ecosystem services, such as primary productivity or nutrient cycling, that are not directly linked to the benefits or goods that people value. Final ecosystem services, however, directly deliver the goods or benefits people value. Trees, for example, are thus a final ecosystem service as they provide us with goods such as timber or carbon sequestration. Supporting services are therefore considered intermediate ecosystem services, regulating services can be both intermediate and final ecosystem services, whilst provisioning and cultural services are final ecosystem services. This distinction between the two ecosystem service types is argued to be more conducive to accurate valuing of services without the risk of double counting (Fisher and Turner, 2008; Mace *et al.*, 2011).

The ecosystem service concept has been widely adopted in the scientific community and policy arenas and has therefore begun to have a significant impact on conservation strategies. Much of the attention surrounding research on ecosystem services has, to date, focussed on provisioning, regulating and supporting ecosystem services with less attention on cultural ecosystem services which as a result, are least well understood (Millennium Ecosystem Assessment 2005). There is, however, increasing awareness of cultural ecosystem service importance and demand for improved understanding (Milcu *et al.*, 2013).

## Cultural ecosystem services

The MA defines cultural ecosystem services as “the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience” (Millennium Ecosystem Assessment 2005). The services described include cultural diversity, spiritual and religious values, educational values, inspiration, social relations, sense of place and recreation and tourism (Millennium Ecosystem Assessment 2005). Cultural ecosystem services have been recognized as being context specific and likely to vary substantially between different countries and cultures contributing to the difficulty in measuring and valuing these services (Millennium Ecosystem Assessment, 2005; Church *et al.*, 2011). Additional complications in establishing a consistent framework for understanding and assessing cultural ecosystem services has been attributed to the MAs lack of distinction between services and benefits (Boyd and Banzhaf, 2007; Wallace, 2007; Church *et al.*, 2011). One solution to ease clarification and assessment of cultural ecosystem services put forward by the UK NEA is the incorporation of “environmental settings” as a final ecosystem service that encapsulates where people interact, both actively and passively, with each other and with nature (Church *et al.*, 2011) resulting in the delivery of cultural goods or benefits that influence human well-being (see Fig. 1.1 for examples of environmental settings and goods/benefits described by the UK NEA). There is a vast literature linking exposure of people to different environmental settings with a variety of cultural benefits, some of which are described in further detail below. Much of this research took place before the environmental settings terminology was introduced into the literature and instead tends to refer to different types of green-space in a similar manner. For the purpose of this thesis, we therefore use green-space as an umbrella term that covers the variety of environmental settings listed in Fig. 1.1.



**Fig.** 1.1 Examples of environmental settings / green-space where people interact with each other and nature and potential resulting cultural goods / benefits that can arise from doing so as outlined by the UK NEA (Church et al. 2011). Examples shown include only those related to green- and not blue-space.

### Human health and well-being benefits

The DEFRA (2007) definition of well-being incorporates an explicit statement regarding its inclusion of a positive physical state, i.e. physical health. The term well-being is frequently used in contexts that imply a distinction between physical health and mental well-being, in this section I thus use the combined term ‘human health and well-being’ as an expanded term that encapsulates the DEFRA (2007) well-being definition. The relationship between green-spaces and human health and well-being has received a significant amount of attention with a great number of studies now linking the two (Bowler *et al.*, 2010; van den Berg *et al.*, 2015). Although a few studies have found no associations between green-spaces and human health and well-being (e.g. Huynh et al. 2013), these are vastly outweighed by those that find positive relationships.

Many associations between general health and green-space have been reported (e.g. de Vries et al. 2003; Tzoulas et al. 2007). A large-scale study in the Netherlands, for example, discovered that self-reported general health (which incorporated both physical and mental aspects) improved with increasing neighbourhood green-space although individual access to these areas within neighbourhoods was not considered (de Vries *et al.*, 2003). Sugiyama et al. (2008) also found significant positive correlations between perceived neighbourhood greenness and physical health in a postal survey of nearly 2000 participants. In addition, people have been shown to visit their doctor less frequently if they use their local green-spaces compared to those who do not (Godbey *et al.*, 1998) and live longer in neighbourhoods with easily accessible walkable green-spaces (Takano, Nakamura and Watanabe, 2002).

These associations between human health and nature have, in part, been explained by the suggestion that greater accessibility to green-space will enhance levels of physical activity, be it a vigorous run or a gentle stroll, and the benefits that result from being more active (Penedo and Dahn, 2005). Numerous studies have shown that having greater access to green-spaces increases the likelihood of exercising (e.g. Sugiyama et al. 2008; Maas et al. 2008). An Australian study of over 1800 participants, for example, found that as distance to open public recreational facilities halved, their use doubled (Giles-Corti and Donovan, 2002). Research across eight European countries also indicated that residents of greener areas with little litter and graffiti were more than three times as likely to exercise than those in less green areas and residents of greener areas were also more than a third less likely to be overweight (Ellaway, Macintyre and Bonnefoy, 2005).

There is evidence to suggest that there are added benefits to exercising in natural environments beyond those of the exercise itself. Studies have repeatedly shown increased mental health benefits of exercising in green-spaces compared to indoor environments (Penedo and Dahn, 2005; Mitchell, 2013). Although many such studies suffer from methodological constraints (primarily short duration), there is a plethora of literature on the delivery of mental health and well-being benefits from green-space (as reviewed in Sandifer, Sutton-Grier, & Ward, 2015). Generally, the greater access people have to green-space, the lower the incidence of mental health related illnesses. There are two main theories as to how this is achieved. The first, described by Kaplan & Kaplan (1989), known as Attention Restoration Theory, suggests that nature provides recuperation from mental fatigue that arises from prolonged directed attention and concentration. This is thought to occur primarily through “soft fascination”, i.e. environmental stimuli that effortlessly capture attention thereby giving the mind a break from more arduous tasks allowing restoration and opportunities for reflection. Numerous studies support Attention Restoration Theory (e.g. van den Berg et al. 2003; Korpela et al. 2010; White et al. 2013b), many of which ask participants to perform a mentally taxing task before and after being exposed to images of either natural or urban environments. The results have shown that the more natural scenes do indeed restore attention and lead to improved cognitive function (e.g. Berto 2005; Berman et al. 2008). Similar studies, though fewer in number, have been conducted replacing the images of natural and urban environments with walks in nature reserves and city centres and have produced comparable results to virtual studies (Hartig *et al.*, 2003; Berman, Jonides and Kaplan, 2008). The effects of nature on children’s concentration has also been considered. A study of inner city children aged between seven and twelve indicated that self-discipline was positively associated with natural views from the home in girls but not boys (Faber Taylor, Kuo and Sullivan, 2002). There is also some evidence that engagement with the natural environment may help improve the symptoms of attention deficit/hyperactivity disorder, a disorder thought to affect five to ten percent of school children in the UK (Faber Taylor, Kuo and Sullivan, 2001).

Mental fatigue has also been suggested to increase likelihood of aggression (Kaplan, 1987) and studies have shown that levels of aggression can also be alleviated by green-space. Kuo & Sullivan (2001b), for example, conducted a study of 145 women from identical urban public housing buildings that differed only in the amount of surrounding vegetation to test the association between aggression and green-space. They found lower levels of mental fatigue (measured using indicators of attention functioning) was higher in residents from buildings with greater proportions of nearby vegetation compared to those with no vegetation and that this corresponded to reduced levels of aggression and violence towards family members.

The second leading theory of how nature contributes to reduced incidences of mental ill health focuses on stress alleviation (Ulrich, 1983). Ulrich’s “psycho-evolutionary” model proposes that our innate response to environments important for safety and survival trigger positive emotional states and reduce stress levels. A study by Grahn & Stigsdotter (2003) of over 900 participants found that proximity to urban green-spaces, as well as length and frequency of visits, were all correlated with reduced occurrence of self-reported stress-related illnesses. Other studies have shown physiological indicators of stress, such as heart rate and blood pressure, to improve after stressful experiences when being shown clips of natural environments but not urban settings (Ulrich *et al.*, 1991; Laumann, Gärling and Stormark, 2003). Hartig et al. (2003) conducted a study during which participants were asked to complete a task and then sit in a room with either views of trees or no view before then taking a walk through a natural or urban environment. Significant declines in blood pressure were recorded in both rooms with tree views and the initial half of the nature walk while the opposite was true for the viewless room and the urban walk. Patients in dentist waiting rooms with pictures of nature have also been shown to be calmer (Heerwagen, 1990).

Most studies, however, have compared health responses from natural environments with indoor or built up environments and have not considered different green-space types or features within them. One area of emerging interest is the role biodiversity has to play in the delivery of health benefits from natural environments. A review by Dean et al. (2011) found only one paper that truly tested the link between biodiversity and mental health (Fuller *et al.*, 2007) and only a few others have appeared in the literature since then (e.g. Luck et al. 2011; Dallimer et al. 2012). Both Fuller et al. (2007) and Dallimer et al. (2012) conducted interviews in green-spaces with participants assessing psychological well-being measures pertaining to cognitive restoration, positive emotional bonds and sense of identity in relation to both perceived and actual levels of species richness. Fuller et al. (2007) found that participants’ perceptions of plant, bird and butterfly species richness accurately reflected true species richness and that aspects of psychological well-being were positively associated with plant and bird species richness but not butterfly richness. Dallimer et al. (2012) however, found participants were not able to accurately judge species richness and that while perceived species richness of all three taxa was positively associated with well-being, there was no consistent relationship with actual species richness.

Dallimer et al. (2012) conclude the differences observed between these studies could be a result of the proxies it appeared participants were using to infer levels of species richness. Habitat diversity which is positively correlated with species richness (Kohn and Walsh, 1994; Tews *et al.*, 2004), seemed to be the cue used by participants in the Fuller et al. (2007) study whereas tree cover, which had a negative relationship with plant diversity in the Dallimer et al. (2012) study, appeared to be the proxy of choice by these participants. It remains to be investigated how the relationship between actual and perceived levels of biodiversity might vary with frequency of engagement with the natural environment. However, neither Fuller et al. (2007) nor Dallimer et al. (2012) controlled for demographic factors. When Luck et al. (2011) conducted a similar study and incorporated demographic factors, they found well-being measures were positively associated with species richness and vegetation cover but only for participants with at least an undergraduate degree and under the age of 55. Including demographic factors is thus essential for future studies considering cultural ecosystem service delivery.

### Social capital benefits

Social capital benefits have also been linked to natural environments, with these in turn being important contributors to people’s general well-being (Lohr, 2007; Barton and Pretty, 2010). Having strong social ties as an older adult, for example, has been shown to positively influence longevity, physical health, psychological well-being and sense of security (Kweon, Sullivan and Wiley, 1998). Evidence that green-spaces, particularly in urban environments, can play an important role in generating such social cohesion and sense of community via provision of areas for people to meet and interact in is increasing (Thompson, 2002). Many of these studies have been carried out at public social housing buildings in Chicago that are identical architecturally and house very similar populations socio-economically and demographically. The only feature to vary across the buildings is the presence and amount of vegetation in the surrounding common outdoor space making them an ideal test-bed for research into the effects of green-space on the social ties and sense of community residing with their residents. The presence, number and proximity of trees to the buildings have been shown to increase the use and amount of time spent in such outdoor spaces by residents of different ages and dramatically improve social ties and integration, sense of local community and sense of safety (Coley, Sullivan and Kuo, 1997; Kuo, Bacaicoa and Sullivan, 1998; Kuo, Sullivan and Coley, 1998; Kweon, Sullivan and Wiley, 1998).

Although dense vegetation is often assumed to provide cover for criminal activity and therefore increase crime rates, there is actually limited evidence for this (Kuo & Sullivan 2001b). Despite this, people have been shown to fear dense vegetation due to risk of danger and criminal activity (Talbot and Kaplan, 1984). But a study by Kuo and Sullivan (2001b) at a similar public social housing complex to that described in the previous paragraph revealed consistently negative relationships between the density of trees and grass surrounding buildings and the number of property and violent crimes reported to the police with the greener the space outside a building, the fewer crimes reported.

### Educational benefits

Educational benefits are also viewed as a form of cultural benefit with improved knowledge about nature thought to occur as a result of nature engagement (Millennium Ecosystem Assessment, 2005; Mace *et al.*, 2011). Potential enhancements in income as a result of greater knowledge as well as improved quality of life through more productive use of leisure opportunities have been suggested as well-being improvements that may result from educational benefits (Church *et al.*, 2011). Such educational benefits could arise as a result of formal educational programmes that take place in natural environments. There is some evidence for increases in knowledge resulting from such formal environmental outdoor education but it is difficult to attribute this knowledge to outdoor trips alone or know how long lasting any knowledge enhancements are (Lindemann‐Matthies, 2006; Church *et al.*, 2011). Alternatively, engaging with nature outside of formal educational activities could also lead to increased knowledge of nature. Indeed, it is widely assumed that engagement with the natural world increases knowledge of the natural world and support for its conservation (Schultz, 2000; Miller, 2005). The theory is that the more time people spend in natural environments, the more they learn about the natural world and form an attachment to it and are thus more likely to care about its protection and conservation. Conservation support is not officially considered an educational benefit delivered from interaction with nature, though we believe there is a case to be made for it given the likely improvements to human well-being that would result from enhanced conservation support through provision of better functioning ecosystems. A more specific example of how conservation support could lead to greater well-being would be through conservation volunteering which has been shown to have multiple beneficial impacts on well-being (O’Brien, Townsend and Ebden, 2010; Brown, Hoye and Nicholson, 2012).

There is, however, very limited robust evidence for the relationship between non-formal nature engagement and either knowledge of the natural world or conservation support. Evidence for increases in knowledge from non-formal educational nature engagement is rare and conflicting. Booth et al. (2009), for example, reported no association between visits to sites and knowledge of their protection status. Pilgrim, Smith, & Pretty (2007), however, found the frequency of visits to the countryside in the UK to be the greatest predictor of knowledge of local animal and plant species and Randler, Höllwarth, & Schaal (2007) found visits to a park in Germany to be associated with knowledge of local animal species. Cause and effect, however, could not be distinguished in these studies.

Although studies addressing the relationship between engaging with green-spaces and conservation support have reported conflicting results, more often than not they find a positive association between the two. However, while these studies have produced very useful insights, many are subject to limitations. Much of the research conducted on the relationship between time spent engaging with nature and the likelihood of conservation support has followed the methodology first practised by Tanner (1980). This involves asking people in environmental fields such as environmental conservation, education or even activism to look back on their lives and identify significant and formative life experiences that they felt contributed to their interest in, and concerns for the natural environment. Spending significant time in natural environments, particularly as a child is often identified in such studies as an important contributor to environmental interests and support (Chawla, 1999). However, concerns have been raised about the reliability of memory in retrospective studies such as these, as well as the subjectivity of participants (as reviewed in Chawla 2001) and the lack of comparison control groups. Studies which have used other methods to assess the relationship between green-space engagement and conservation support have suffered from biases such as only incorporating people from within green-spaces (therefore excluding those who never visit green-spaces; Larson et al. 2011b), only considering those undertaking a specific recreation activity (Cooper *et al.*, 2015) or by not controlling for socio-economic factors (Zaradic, Pergams and Kareiva, 2009).

## Limitations of existing research on cultural ecosystem service delivery

Although considerable insight has been gained from the studies outlined above, many have been subject to limitations and there are thus still gaps in our knowledge and understanding of cultural ecosystem services and their delivery from green-space. The vast majority of studies have defined green-space as a single uniform entity, without considering the impacts of different types of green-spaces or specific features of these green-spaces. Whether cultural ecosystem service delivery is influenced by different green-spaces types and how intrinsic site-based factors such as biodiversity contribute to their quantity and quality is therefore unknown.

Many studies have used virtual exposure or counterfactual scenarios to assess responses to, and benefits from natural environments. Although such studies are being increasingly replicated in the real world with similar findings to virtual and theoretical studies, there are concerns about these not being able to accurately capture the full sensory experience of the real world (Depledge, Stone and Bird, 2011; Toet and van Schaik, 2012) and their findings must be interpreted with some caution. Furthermore, in virtual or theoretical environments participants do not experience the focal area in the context of the wider landscape which could also influence results. Conducting rigorous empirical studies of this nature in situ with meaningful sample sizes can be difficult, but such studies are required to enhance understanding.

Many studies have robust sample sizes but use a correlative approach with no controls or without adequately accounting for potentially confounding factors meaning that causality cannot be determined (Keniger *et al.*, 2013). More rigorous empirical studies, however, often suffer from smaller, biased samples that only consider short-term impacts of nature engagement or exposure (e.g. Yamaguchi et al. 2006; Berman et al. 2008).

Other studies have taken a site-based approach focusing on particular green-spaces (e.g. Fuller et al. 2007; Dallimer et al. 2012). Doing so invariably biases the sample population towards those who visit green-space on a more regular basis and is unlikely to capture the full socio-economic spectrum given the known socio-economic biases in green-space users (Natural England, 2014). Socio-economic status and demographic variables can also influence cultural ecosystem service delivery (Mitchell & Popham 2008; Luck et al. 2011) and so it is important that broader scale studies are conducted to account for these as well as to improve representation of those who visit green-spaces infrequently.

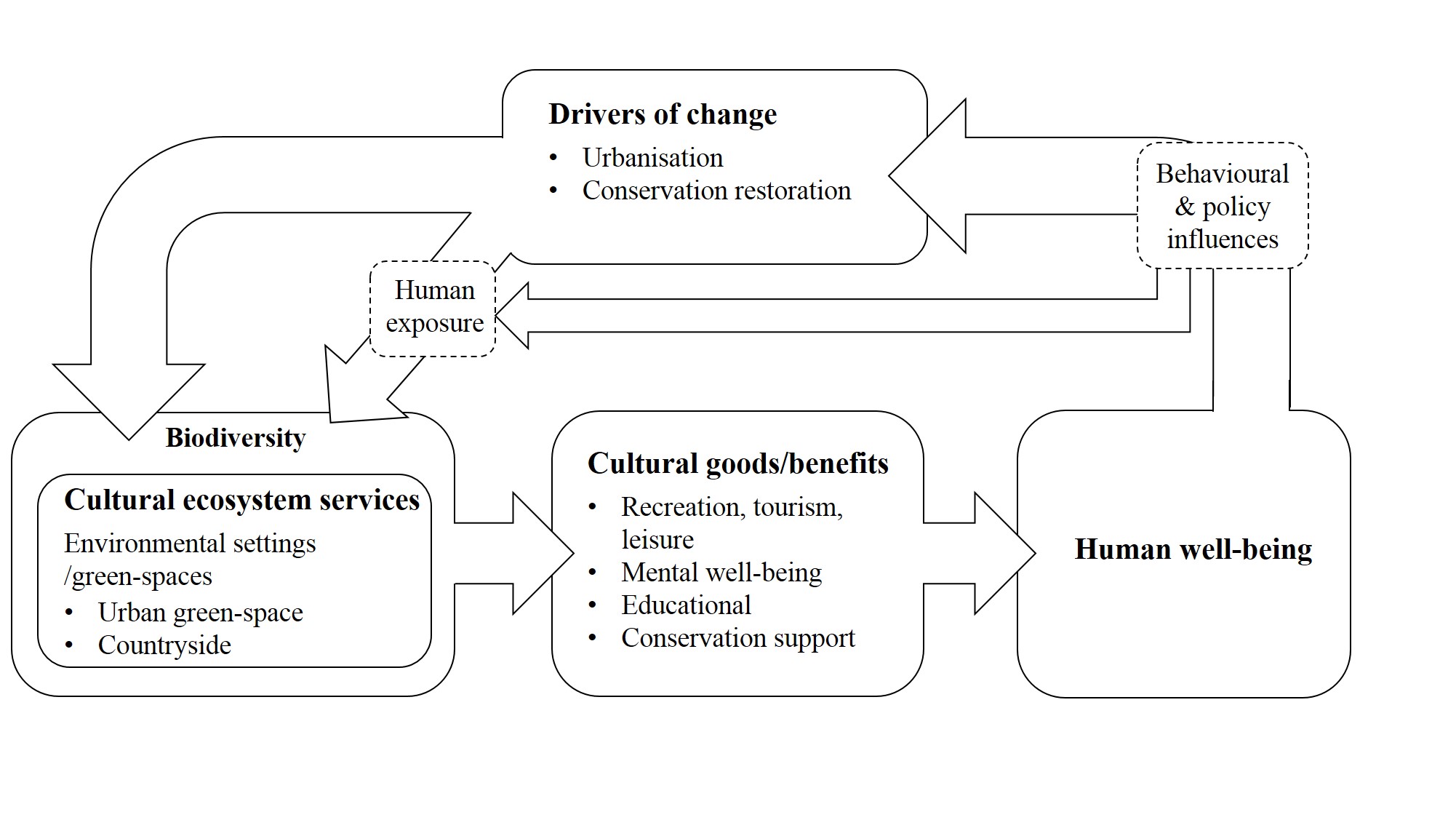
## Impacts of urbanisation and ecological restoration on cultural ecosystem service delivery

There is evidence to suggest that people are experiencing less of the natural world than in the past with, for example, nature-based recreation such as time spent hiking and camping as well as visits to national parks declining (Pergams & Zaradic 2008; Kareiva 2008; but see Balmford et al. 2009) and children spending more time playing indoors and having fewer outdoor schooling exercises (Chawla 2001; Orr 2002; Lindemann‐Matthies 2006; Lawton et al. 2010). With more than half the world’s population now living in urban areas and projections for this to increase to over 65% by 2050 (United Nations, 2014) there are rising concerns of people becoming further disconnected from nature (e.g. Miller 2005; Dunn et al. 2006; Depledge et al. 2011). This could lead to reduced opportunities to obtain health benefits associated with spending time in natural environments but could also result in a reduction in educational benefits; if people are unable to experience the natural world, they may have lower knowledge and understanding of it and be less interested in supporting its conservation (Schultz 2000; Dunn et al. 2006). There is, however, almost no empirical evidence to support the link between engagement with green-spaces and these educational benefits. Thus improving understanding of the relationships between green-space visits and both well-being and educational benefits and how these interactions are influenced by urbanisation is of vital importance.

Another emerging priority area for consideration by conservation managers is the impact of conservation policy and management on cultural ecosystem services and cultural benefit delivery. Conservation action is increasingly focussing on restoration activities across large swathes of land, often in areas that receive substantial numbers of visitors (Lindenmayer *et al.*, 2008; Hodder *et al.*, 2014). It is ever more important to understand the impacts of restoration on these visitors as public support of conservation has been shown to influence its success (Miller, 2005; Schenk, Hunziker and Kienast, 2007). In addition, managing land for ecosystem services is becoming more common but assessments of restoration impacts on visitors and cultural benefits are rarely conducted. Such assessments are thus urgently required to improve understanding of how best to manage landscapes for biodiversity and cultural benefit delivery alike.

## Thesis aims and framework

This PhD thesis aims to address some of the uncertainties regarding cultural ecosystem services in a UK setting as outlined above and depicted in the conceptual framework (Fig 1.2). I follow the approach of the UK NEA (Mace *et al.*, 2011) and consider environmental settings (or green-spaces as referred to here) as cultural ecosystem services from which cultural benefits can be obtained leading to potential increases in well-being. My focus is on the relationship between cultural ecosystem services and the delivery of cultural benefits and how these relationships are influenced by human derived drivers of change. I also aim to provide some insight into if and how the biodiversity value of these environmental settings influences cultural benefit delivery. I do not assess the overall impact on human well-being but discuss policy implications from my findings that could be considered for potential increases in cultural benefit delivery.

**Fig. 1.2.** Conceptual framework showing the key themes from this thesis. I focus on the relationships between two key drivers of change and the associated impacts on cultural ecosystem services in the form of environmental settings (or green-spaces as generally referred to in this thesis) and the delivery of cultural benefits. The underlying framework is based on that of the UK NEA (Mace *et al.*, 2011).

I consider two drivers of change, urbanisation (at two scales; size of the urban area and urbanisation intensity around the home) and landscape-scale restoration. For the urbanisation study (Chapters 2 and 3), a survey of over 200 residents from six urban areas (three pairs of large and small urban areas) was conducted across England using a rigorous sampling method ensuring that respondents were selected in a manner that was unbiased with regard to use of green-spaces and socio-economic profiles. The restoration study (Chapter 4) took advantage of a major landscape-scale restoration programme within the Peak District National Park and captured over 1000 visitor questionnaires using a before and after experimental design at both control and treatment sites.

Urbanisation and restoration could theoretically influence cultural benefit delivery in two ways. Firstly, urbanisation and restoration could physically change the green-spaces from which cultural benefits are derived. I address this in the urbanisation study by considering whether urban green-spaces differ in their delivery of cultural benefits (educational, conservation support and mental well-being) compared to the countryside (see Table 1.1 for definitions). In the restoration study, I consider the impacts of active conservation management on multiple aspects of the visitor experience including recreation, mental well-being and conservation support (see Table 1.1 for definitions).

**Table 1.1.** Definitions of key terms used in the text.

|  |  |
| --- | --- |
| *Term* | *Definition* |
| Urban green-space | Public green/vegetated areas within cities and towns (excluding domestic gardens as these are controlled for) e.g. public park, allotment |
| Countryside | Rural land outside of the city/town |
| Educational benefit | Knowledge of nature, specifically ability to identify a variety of species and recognise habitats of value to wildlife |
| Conservation support | Supportive of conservation aims and actions, specifically both pro-environmental attitudes and actual and theoretical donations to conservation charities |
| Mental well-being | A state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community (WHO, 2004) |
| Recreation | Activity done for enjoyment when not working (used in the context of natural environments in this context) |

Secondly, urbanisation and landscape management could affect cultural benefit delivery by influencing human exposure to green-spaces through reducing the amount of green-spaces in urban areas or conducting access works respectively for example. As outlined above, it is commonly assumed that engaging with nature improves educational benefits and conservation support (Schultz, 2000; Miller, 2005) but there is limited robust evidence for this. Though the association with mental well-being is much more established, less is known about how long lasting such benefits are. It is therefore essential to establish whether there are indeed relationships between nature engagement and cultural benefit delivery and so I consider the relationships between frequency of green-space visits and cultural benefit delivery in both the urbanisation and restoration studies. I then also consider associations between green-space visit rates and both urbanisation and landscape-scale restoration.

Chapter five discusses my findings in relation to the themes outlined in the conceptual framework and the implications for policy. I discuss the limitations of the work presented and provide suggestions for future research.

Additional data I collected during the urban study has also been incorporated into a manuscript led by colleagues at Exeter University regarding the relationship between pro-environmental attitudes and both household behaviours and air travel. The paper is currently under review after re-submission in response to reviewers comments at the journal of Global Environmental Change and is included in Appendix A. Please note as this is currently under review it is not to be cited.

## Ethics statement

Ethical approval was granted by the University of Sheffield’s Research Ethics Committee and informed oral consent obtained from all participants. Actions were taken to ensure compliance with the Data Protection Act including ensuring all completed questionnaires were anonymous, kept in locked drawers in a locked office, and the computer used for analyses was both encrypted and password protected.

## Declaration of Authorship

Chapters two and three have been submitted as papers. Both studies were designed by myself in collaboration with Dr Karl Evans with additional support from Dr Ross Cameron for Chapter three. I collected all the data with help from field assistants. I processed and analysed all data and took the lead in writing the papers with some assistance from Dr Karl Evans. Chapter two was published in March 2017 (Coldwell and Evans, 2017).

# Green-space engagement and urbanisation - impacts on biodiversity knowledge and conservation support (published in PLoS ONE; Coldwell & Evans 2017)

## Abstract

Conservation policy frequently assumes that increasing people’s exposure to green-space enhances their knowledge of the natural world and desire to protect it. Urban development is, however, considered to be driving declining connectedness to nature. Despite this the evidence base supporting the assumption that visiting green-spaces promotes biodiversity knowledge and conservation support, and the impacts of urbanisation on these relationships, is surprisingly limited. Using data from door-to-door surveys of nearly 300 residents in three pairs of small and large urban areas in England we demonstrate that people who visit green-space more regularly have higher biodiversity knowledge and support for conservation (measured using scales of pro-environmental behaviour). Crucially these relationships only arise when considering visits to the countryside and not the frequency of visits to urban green-space. These patterns are robust to a suite of confounding variables including nature orientated motivations for visiting green-space, socio-economic and demographic factors, garden-use and engagement with natural history programs. Despite this, the correlations that we uncover cannot unambiguously demonstrate that visiting the countryside improves biodiversity knowledge and conservation support. We consider it likely, however, that two mechanisms operate through a positive feedback loop in at least some respondents - with increased visits to green-space promoting an interest in and knowledge of biodiversity and support for conservation, which in turn further increase the desire to visit green-space and experience nature. The intensity of urbanisation around peoples’ homes, but not city size, is negatively associated with their frequency of countryside visits. Designing less intensely urbanized cities with good access to the countryside, combined with conservation policies that promote access to the countryside thus seems likely to maximize urban residents’ biodiversity knowledge and support for conservation.

## Introduction

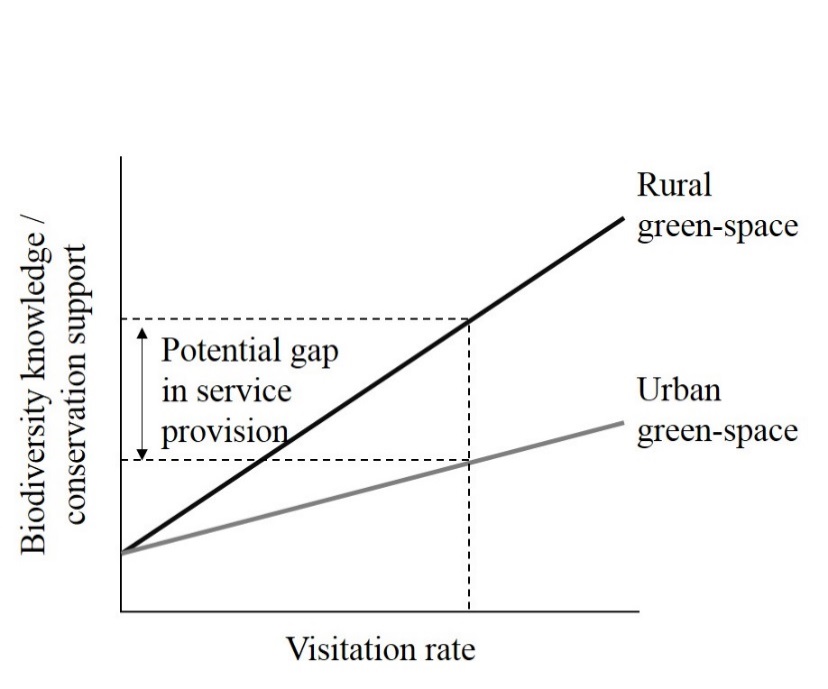
Conservation biologists have long assumed that engagement with the natural world increases understanding and knowledge of biodiversity, and thus willingness to protect it (Leopold 1949; Carson 1965; Kareiva 2008; Wright & Matthews 2014). This is of concern as engagement with the natural world, assessed by metrics such as green-space visitation rates or nature based recreation, such as time spent hiking and camping as well as visits to national parks, is declining (Kareiva 2008; Pergams & Zaradic 2008; but see Balmford et al. 2009). These declines are frequently linked to increasing urbanisation and associated factors such as more sedentary lifestyles and greater use of electronic devices (Louv, 2005). The conservation community is concerned that reduced engagement with nature will lead to declines in biodiversity knowledge and conservation support (Pyle 2003; Moss 2012), giving rise to the ‘pigeon paradox’ (Dunn *et al.*, 2006). This states that ultimately global conservation will mainly be reliant on peoples’ connection with a small number of common urban species, such as the feral pigeon *Columba livia*, that are of limited conservation concern (Shwartz *et al.*, 2014). These perceptions are driving much investment in conservation initiatives and policies to reconnect people with nature at local, regional and national scales (Natural England 2010; RSPB 2013; Trzyna 2014).

The hypothesis that engagement with the natural world increases biodiversity knowledge and conservation support is intuitively logical, but receives surprisingly little robust empirical support given its dominance in conservation literature and policy. Useful progress has been made in assessing biodiversity and environmental knowledge amongst the general public (Balmford et al. 2002; Lindemann-Matthies & Bose 2008; Pilgrim et al. 2008). Whilst knowledge appears to be limited, this may partly be an artefact of using hard scientific definitions of knowledge rather than testing the ability of participants to form more abstract complex mental constructs of biodiversity (Fischer and Young, 2007; Buijs and Elands, 2013). Moreover, the relationship between biodiversity knowledge and engagement with nature, through activities such as visiting green-space, has rarely been quantified and is poorly understood (Church *et al.*, 2011). This insufficient knowledge may in part arise from the difficulties of disentangling cause and effect as people with more knowledge, such as dedicated naturalists, may be motivated to visit green-spaces frequently. Documenting relationships between green-space visitation rates and potential outcomes is further complicated because many studies recruit participants in green-spaces, and thus do not adequately sample people with very low or zero visitation rates to green-space.

Research has been conducted assessing whether engagement with nature is positively associated with environmental attitudes (Lohr 2007; Thompson et al. 2007). Such studies are often based on potentially unreliable long-term memories of respondents, who are actively engaged in conservation and thus have an inherent self-interest in the study (reviewed by Chawla 2001), and environmental attitudes are frequently poor predictors of actual behaviour (Frick, Kaiser and Wilson, 2004; Whitmarsh, 2009; Frederiks, Stenner and Hobman, 2015). Studies that assess how nature engagement influences pro-environmental behaviours and conservation support are infrequent. They typically compare people that engage in outdoor recreational activity with those who do not, and thus do not enable the relationship between engagement and conservation support to be fully quantified as they focus only on the extremes of very low and very high engagement levels (Teisl & O’Brien 2003; Larson et al. 2011; Cooper et al. 2015).

The impacts of urbanisation on engagement with nature, ecological knowledge and conservation support are rarely explicitly quantified, and those studies that do so provide conflicting evidence (Pyle, 2003). Much of the early research in this field concluded that environmental support was greater amongst urban than rural residents, proposedly because such people are better educated, have greater access to pro-environmental facilities (e.g. recycling), and experience more degraded environments (Tremblay & Dunlap 1978; Liere & Dunlap 1980). In contrast, more recent studies have found fewer differences in environmental attitudes between urban and rural populations (Berenguer et al. 2005; Huddart-Kennedy et al. 2009). The reasons for this shift are unclear, but may include methodological artefacts, such as more recent work taking greater care to control for confounding socio-demographic variables, and real temporal shifts in attitudes. These findings contrast with the concern that increasing urbanisation is reducing engagement with, and concern for, nature.

An important aspect of how urbanisation influences engagement with nature which has received surprisingly little attention is whether visits to urban green-space can compensate fully for reduced frequency of visits to the countryside. Green-space in highly developed urban environments typically supports fewer and less specialist species than more natural environments (Evans *et al.*, 2011; Aronson *et al.*, 2014). Assuming that exposure to biodiversity plays a causal role in generating biodiversity knowledge and conservation support, a given visit rate to urban green-space may contribute less to knowledge and support than an equivalent visitation rate to more natural green-space (Fig. 2.1).

****

**Figure 2.1.** The slopes of the relationship between green-space visitation rate and biodiversity knowledge and conservation support may be shallower for visits to urban than rural green-space, generating a gap in provision of educational ecosystem services between urban and rural green-space. This divergence in service provision may arise from exposure to less diverse biotic assemblages in urban areas that typically comprise generalist species of limited conservation concern.

Despite much progress being made there is clearly an insufficient evidence base concerning a central assumption of conservation theory and policy, i.e. engaging with nature by visiting green-spaces increases biodiversity knowledge and conservation support, and how these relationships are influenced by urbanisation. Here, we provide a rigorous assessment of the relationships between engagement with nature, biodiversity knowledge and conservation support. We interviewed nearly 300 people from three pairs of large and small urban areas in England, and selected respondents in a manner that is unbiased with regard to their use of green-spaces and their socio-economic profile. We test the hypotheses that there are positive associations between green-space visitation rates, biodiversity knowledge and conservation support, and that the form of these relationships varies depending on whether visits are to urban green-space or the countryside. Finally, we assess how the magnitude of urbanisation around people’s homes and the size of urban areas influence green-space visitation rates, biodiversity knowledge and conservation support.

## Methods

### Survey sites and urbanisation metrics

Urban areas can change in two ways to accommodate the increasing number of people living within them. They can expand in size and/or increase in intensity (e.g. by increasing the amount of housing within a given area). Our study design was thus based around being able to address the impacts of these two aspects of urbanisation. Surveys were conducted from July to early October 2013. We compare pairs of small and large urban areas across England in order to capture the contrast between the different sizes. An alternative approach would have been to have selected a gradient of city sizes but this would have likely required a larger sample size to determine any patterns and given the labour intensive sampling strategy necessary to ensure a representative sample (see 2.3.2) it would not have been logistically possible within the scope of this PhD. We selected pairs of cities in roughly similar geographical areas in order to control for area differences. We defined the urban area size by the number of 1km grid cells with >25% coverage of impervious surface as described by (Gaston *et al.*, 2005). Starting with the largest urban areas in the UK, we selected pairs according to the following criteria:

* Selected urban areas had to be distinct from other major urban areas (Birmingham, for example, was excluded because of the merging of conurbations with Wolverhampton)
* Paired large and small urban areas also had to be distinct from one another and separated by at least 12km of countryside, ensuring that they were not part of the same conurbation and that residents had approximately similar access to countryside.
* The smaller urban area was at least three times smaller than their paired larger urban area

Once appropriate urban area pairs had been identified, we selected the three pairs that gave the best geographical spread across England; Manchester and Blackburn, Leeds and Harrogate, and Bristol and Bath. Large urban areas comprised between 32 and 122km2 of urban land while small urban areas had a spatial extent of 10-18km2 (Table 2.1). Whilst we do not include mega-cities our focal urban areas are similar in spatial extent to numerous European cities. City size is our first urbanisation metric.

**Table 2.1.** Urban land cover (1x1km grid cells > 25% hard surface) of paired large and small urban areas (based on Google Earth images). When selecting paired sites differences in unemployment levels were minimised as far as possible using data from the Office for National Statistics (2011).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Large Urban Area* | | *Small Urban Area* | | |
| *Name* | *Urban land cover (km2)* | *Name* | *Urban land cover (km2)* |
| Manchester | 112 | Blackburn | 18 |
| Leeds | 34 | Harrogate | 10 |
| Bristol | 32 | Bath | 11 |

To address the impact of urbanisation intensity, we consider the area surrounding people’s homes for two key reasons. Firstly, there is a significant amount of evidence to suggest that the amount of greenery where people live is associated with other benefits such as improved health and longevity (van den Berg *et al.*, 2015) and determining whether this is also the case for other cultural benefits could help inform discussions of trade-offs/added value in urban design. Secondly, given that people spend a significant proportion of time around the home, we would expect the amount of informal (e.g. street trees and road verges) and formal green-spaces (e.g. public parks, allotments) in the area to influence educational benefits and conservation support if the association between nature exposure and delivery of these benefits holds true. Any definition of the distance that is close to a respondent’s home will be somewhat arbitrary but we quantify local scale urbanisation within a 1km grid cell centered on the respondent’s post-code. This equates to a radius of 500m from the respondent’s home matching distances used in other studies (e.g. van Dillen et al. 2012; Kabisch & Haase 2014). Scores were calculated using image recognition software (Seress *et al.*, 2014) to generate a single metric of urbanisation based on a semi-automated assessment of the area of buildings, roads, other impervious surface, and vegetated green-space from google earth aerial photographs (Fig. 2.2). The aerial images used in our analyses were taken between one month and five years prior to the door to door surveys (Leeds: September 2008; Harrogate: May 2009; Manchester: June 2009; Blackburn: May 2009; Bristol: July 2013 and Bath: July 2013). Ground truthing did not reveal any major changes in land-cover type between the imagery dates and those of the surveys.

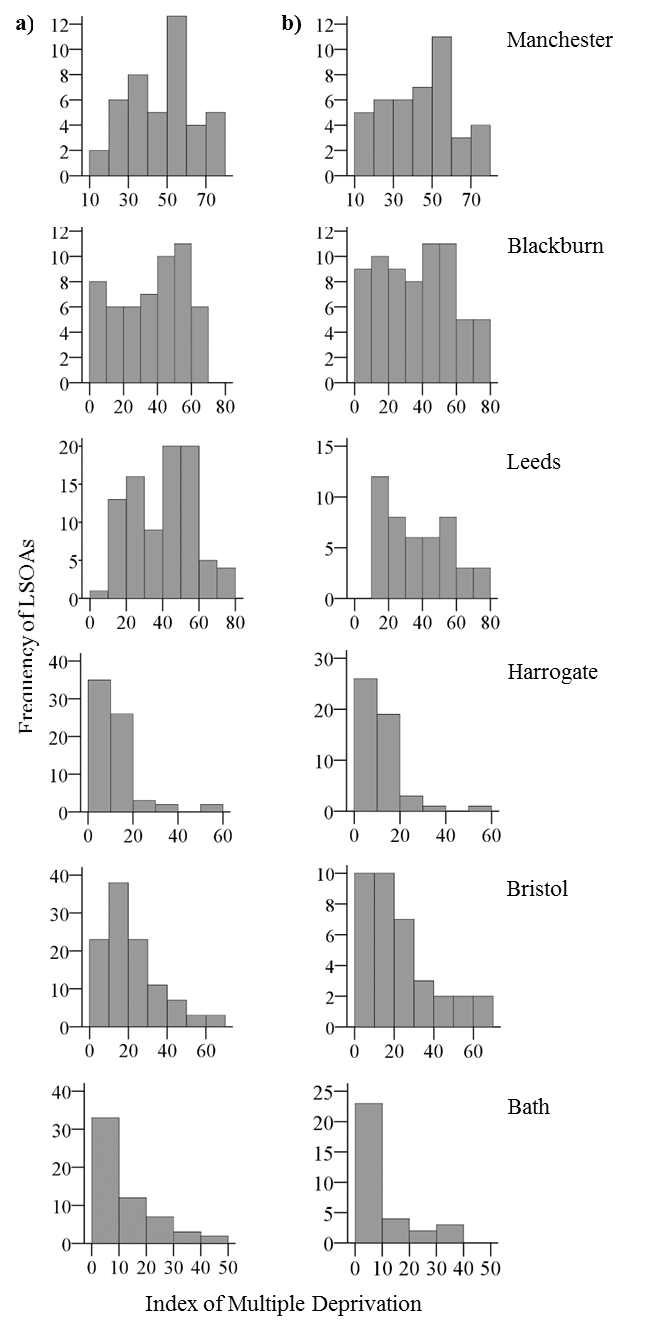


**Figure 2.2.** Satellite imagery depicting the extremes of local urbanisation scores included within the study with a) the postcode with the lowest surrounding local urbanisation score (-6.21) and b) the postcode with the highest surrounding local urbanisation score (3.05). Scores are calculated using image recognition software (Seress et al. 2014) to generate a single metric of urbanisation based on a semi-automated assessment of the area of buildings, roads, other impervious surface, and vegetated green-space from google earth aerial photographs. Ground truthing confirmed that images accurately represented land cover at the time of the door-to-door surveys.

### Participant recruitment and sample size

Door-to-door questionnaires were conducted face-to-face during weekday and weekend afternoons and evenings to ensure inclusion of participants from different workforces. Sampling was restricted to a 3km radius from the geographic centre of each of our six urban areas. This was because we wanted to make sure all respondents were still urban residents and sampling areas further than 3km from the centre in some of our smaller urban areas would have included those more rural in nature. Surveys were conducted in two stages. First, we obtained all postcodes from within the 3km radius of each urban area centre (from www.doogal.co.uk) and randomly selected 20 to 25 postcodes to sample. Postcodes with less than 15 households (Royal Mail, 2013) were not visited to ensure inclusion of only urban settings and for it to be logistically worthwhile visiting given the often low numbers of people at home. All households within each selected postcode were approached to take part in the survey.

The second survey phase was used to ensure we had a sample that was representative of the 3km radius area as a whole. This was a particularly important step to take given our low response rate which increases the risk of a biased sample. We wanted to ensure we captured the full range of levels of nature engagement amongst our respondents and so key to this was including those known to rarely engage with nature. Natural England’s Monitor of Engagement with the Natural Environment (MENE) surveys have shown that those on lower incomes, not in employment, from Black and Minority Ethnic populations and from more deprived areas visit natural environments less frequently (Natural England, 2013). The Index of Multiple Deprivation (IMD; Office for National Statistics, 2010) is the official measure of relative deprivation for small areas in England which is derived from seven different dimensions of deprivation, including several of those identified as contributing to low levels of nature engagement (the seven dimensions being income, employment, health deprivation and disability, education skills and training, barriers to housing and services, crime and living environment). Thus ensuring a representative sample based on the IMD reduced the risk of a sample biased towards only those who regularly engage with nature. We achieved this by taking the IMD of all respondents lower super output area (the smallest spatial unit used in the National Census, and typically slightly larger than the area represented by a full postcode) from the first round of surveys and comparing the distribution of these to the distribution of IMD scores of the entire 3km urban area to check that data were representative of this area. Comparing the two profile distributions allowed us to identify target deprivation scores needed to make our sample more representative. We then randomly selected postcodes from those within the target IMD range and sampled all households in the postcode the profiles of IMD scores roughly matched (Fig. 2.3). Respondents who had lived at their current address for less than three months were excluded, together with postcodes where the safety of the interviewers was a major concern. Sampling was, however, still conducted along the vast majority of the deprivation score gradient present in each urban area (Fig. 2.3). We obtained 286 completed questionnaires (Table 2.2) with a final overall response rate of 19.8%.



**Figure 2.3.** The distributions of the Index of Multiple Deprivation scores for (a) Lower Super Output Areas (LSOAs) within 3km of each urban area centre and (b) of the LSOAs within which each respondent lives for the same urban area. Distributions of both are similar indicating that questionnaire participants were selected in an unbiased manner.

**Table 2.2.** The number of completed questionnaires at each site.

|  |  |  |  |
| --- | --- | --- | --- |
| *Large urban area* | | *Small urban area* | |
| *Name* | *No. Questionnaires* | *Name* | *No. Questionnaires* |
| Manchester | 41 | Blackburn | 55 |
| Leeds | 53 | Harrogate | 68 |
| Bristol | 37 | Bath | 32 |

### Green-space visitation rates and motivations

Participants were asked how often they visited i) the countryside and ii) urban green-spaces on average in a year on an eight point scale from daily to never (see Fig. 2.4 for all response options). If clarification was requested, countryside was defined as “rural land outside of the city” and urban green-space as “public green/vegetated areas within cities and towns such as public parks (excluding your garden)”. Participants were also asked in an open ended question to state their main reasons for visiting each type of green-space. These motivations were later categorized as those not related to engagement with nature (such as “just to get out in the fresh air” or “exercise”) and those that were likely to be directly associated with biodiversity knowledge or conservation support (such as watching wildlife, conservation volunteering or gardening). Allocation of responses to categories was informed through the use of existing literature (Irvine *et al.*, 2013) as well as expert judgement by six members of staff (in addition to myself) from two different departments at the University of Sheffield. Where these judgements different, we used the category selected by the majority. We use these data to exclude from our analyses people who may have high visitation rates to green-space as a consequence of activities directly associated with biodiversity knowledge and conservation support, thus helping to disentangle cause and effect in relationships between these variables. Participants were also asked how often they spend time in their garden (nine point scale from no garden, never to daily) and watch or listen to natural history programmes (eight point scale from never to daily) on average in a year to account for any further confounding effects on biodiversity knowledge and conservation support.

### Biodiversity knowledge

We used photo elicitation of 12 native species and of three habitat types to assess participants’ biodiversity knowledge along three domains: i) species identification (scored 0-12, one point awarded per correct species level identification, and a half mark awarded for correct identification to a group of similar species e.g. tit rather than blue tit *Cyanistes caeruleus*); ii) knowledge of species’ conservation status (scored 0-12, one mark per correct answer; UK Biodiversity Action Plan priority species were coded as being of conservation concern); iii) habitat quality assessment, respondents ranked three images per broad habitat type (arable farmland, wetland and woodland) according to their perceived value for wildlife (scored 0-9, one mark per correct position as assessed by three independent experts, all of which gave identical rankings. Habitat quality assessment was incorporated to include relatively complex mental constructs rather than more simple scientific facts, as advocated by Fischer & Young (2007).

The first two domains were scored following presentation of one photograph of 12 native species (see Table 2.3 for focal species). All species are distributed across the entire survey area, enabling direct comparison between different locations, but within each taxonomic group two species are common in urban areas and two are typically confined to rural areas. Two bird and two mammal species were BAP priority species. No BAP plants were included as all such species have very local distributions rendering it impossible for respondents from all survey locations to have had equal opportunity of encountering them.

**Table 2.3.** The twelve native species used to assess respondents’ knowledge of species identification and conservation status (Biodiversity Action Plan priority species). All species are distributed across the entire survey area, enabling direct comparison between different locations, but within each taxonomic group two species are common in urban areas and two are typically confined to rural areas. Two bird and two mammal species were BAP priority species. No BAP plants were included as all such species have very local distributions rendering it impossible for respondents from all survey locations to have had equal opportunity of encountering them.

|  |  |  |  |
| --- | --- | --- | --- |
| *English name* | *Scientific name* | *Common in urban areas?* | *BAP species* |
| Blue tit | *Cyanistes caeruleus* | Yes | No |
| Starling | *Sturnus vulgaris* | Yes | Yes |
| Nuthatch | *Sitta europaea* | No | No |
| Linnet | *Carduelis cannabina* | No | Yes |
| Red Fox | *Vulpes* | Yes | No |
| Hedgehog | *Erinaceus europaeus* | Yes | Yes |
| Mole | *Talpa europaea* | No | No |
| Water vole | *Arvicola amphibius* | No | Yes |
| Daisy | *Bellis perennis* | Yes | No |
| Dandelion | *Taraxacum officinale* | Yes | No |
| Wood sorrel | *Oxalis acetosella* | No | No |
| Yellow Rattle | *Rhinanthus minor* | No | No |

The arable farmland images used in assessments of habitat quality differed in the size and floristic diversity of arable field margins. Wetland images differed in the amount of natural habitat at the land/water interface (moving from concrete, to intensively grazed pasture, to more natural emergent vegetation). The woodland images differed in tree species diversity and naturalness (moving from conifer plantation, to conifer plantation with some silver birch *Betula pendula*, to a diverse native broad-leaved woodland).

We wanted to establish whether our separate indicators of biodiversity knowledge could be combined into a single metric representing a more holistic measure of biodiversity knowledge incorporating both the more scientific assessment (species identification and knowledge of conservation status) with more general understanding of ecological systems (habitat quality assessment). We thus conducted linear principal component analysis (PCA) with direct oblimin rotation (as recommended by Tabachnick & Fidell (2001) given the correlation coefficient of component scores was greater than 0.32), following standardisation of variables using z-scores using SPSS version 21 to determine whether respondents’ scores along the three axes could be condensed into unified metrics of biodiversity knowledge. The three axes loaded on to one dimension (eigenvalue 1.91; component loadings: identification score 0.86; conservation status score 0.78; habitat quality score 0.75) which accounted for 63.8% of the variation. This axis was used as a single unified metric of biodiversity knowledge in all subsequent analyses.

### Support for conservation

Given the known action gap between pro-environmental attitudes and environmentally friendly behaviours (Frick, Kaiser and Wilson, 2004; Whitmarsh, 2009; Frederiks, Stenner and Hobman, 2015) as outlined in the introduction, we wanted to capture both aspects in our measures of conservation support. We used four domains of conservation support to achieve this. The ‘commitment to environmental sustainability (CESS)’ and ‘willingness to sacrifice (WTS)’ scales relate to environmental attitudes and theoretical behaviours (Davis, Le and Coy, 2011; Cotton and Alcock, 2013). We used the three question version of CESS which measures pro-environmental attitudes on a five point Likert scale using questions such as “the environment is a low priority for me compared with a lot of other things in my life” (see Q18 of Appendix B). WTS measures theoretical willingness of respondents to change their behaviour in order to protect the environment based on five questions on a nine point Likert scale (e.g. “I am willing to give things up that I like doing if they harm the natural environment”, see Q21 of Appendix B). We chose these indicators over other scales that measure environmental attitudes and behaviours (Milfont and Duckitt, 2010) for several reasons. Both scales measure personal as opposed to governmental or societal commitment and behaviours which was our key interest. Furthermore, these scales do not refer to specific terms or behaviours that might not be applicable to some groups (e.g. car-related behaviour being of no relevance to non-car owners). Both scales were also shown to have reliability and validity in a UK adult context (Davis, Le and Coy, 2011; Cotton and Alcock, 2013). Finally, both scales have relatively few items compared to some other indicators (Milfont and Duckitt, 2010) which was of benefit to keeping the questionnaire at an acceptable length for door-to-door surveying.

Our third domain of conservation support comprised actual financial conservation support, i.e. monthly expenditure on memberships and donations to environmental and nature conservation organizations (Table 2.4). Respondents’ donations were limited to four of the categories provided in the questionnaire (zero, £1-5, £6-10 and £11-20) the mid-points of which were used to calculate expenditure. Finally, as actual donations may be constrained by competing financial pressures, we measured hypothetical financial conservation support; we asked respondents to distribute £600 across five charitable sectors: medical research, animal welfare, protecting/helping vulnerable people, environmental protection and animal/plant conservation – we summed donations to the last two sectors as a measure of conservation support. Ninety-eight percent of respondents did not volunteer for environmental or conservation organizations so these data were not used as they did not allow adequate separation of respondents. To determine whether our different measures of conservation support could be combined into fewer, more comprehensive indicators of conservation support, linear PCA analysis was conducted using z-score standardised data with varimax rotation (as recommended by Tabachnick & Fidell (2001) due to component correlations of less than 0.32). This identified two axes of conservation support. WTS and CESS scales loaded onto the first axis (termed behavioural conservation support) with an eigenvalue of 1.88, and explained 47.1% of the variation (Table 2.5). The second axis (termed financial conservation support) loaded onto actual and hypothetical financial contributions and explained 22.1% of the variation (Table 2.5). We included this axis to enable more complete exploration of our data although its eigenvalue (0.89) was lower than the desirable threshold score of 1 recommended for axis retention.

**Table 2.4.** Charitable organisations participants were members of and/or donated to.NationalTrust costs were evenly split across the environmental and non-environmental groups to account for their dual focus to conserve both landscapes and historic buildings.

|  |  |
| --- | --- |
| *Environmental and conservation organisations* | *Non-environmental or conservation organisations* |
| |  | | --- | | British Ecological Society | | Butterfly Conservation | | Campaign For Nuclear Disarmament | | Forestry Commission | | Friends of the Earth | | Greenpeace | | Marine Conservation Society | | National Trust | | RSPB | | Soil Association | | Surfers Against Sewage | | Sustrans | | Whale and Dolphin Conservation Society | | Wildlife Trust | | Woodland Trust | | WWF | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | | |  | | --- | | Animal Welfare | | RSPCA | | International Fund for Animal Welfare | | Animal sanctuaries | | Gardening | | Royal Horticultural Society | | Historical | | Historical buildings | | National Trust | | Medical Research | | Cancer Research | | Leukaemia and Lymphoma Research | | British Heart Foundation | | Macmillan | | Marie Curie | | Meningitis Trust | | Motor Neurone Disease Association | | Smile | | Outdoor pursuits | | Ramblers | | Sea Cadets | | Helping vulnerable people & human rights | | Action for Children | | Air Ambulance | | Amnesty International | | Arthritis Care | | Barnardos | | Crisis | | Help for Heroes/British legion | | Mothers Against Violence | | National Childbirth Trust | | Oxfam | | Rape Crisis | | Red Cross | | Royal National Lifeboat Institution | | Save the Children | | Shelter | | UNICEF | | Water Aid | | Religious charities | | Other | |

**Table 2.5**. Conservation support was measured using four domains which loaded onto two axes in a linear PCA (varimax rotation). Pro-environmental attitudes and reported behaviour loaded onto the first axis (eigenvalue 1.88) and is termed behavioural conservation support. Financial donations loaded primarily onto the second axis and (despite its lower than ideal eigenvalue of 0.89) is retained to enable more complete exploration of conservation support and due to its very strong loading onto actual financial contributions.

|  |  |  |
| --- | --- | --- |
| *Conservation support indicator* | *Component loadings* | |
| *Axis 1* | *Axis 2* |
| Commitment to environmental sustainability | 0.778 | 0.241 |
| Willingness to sacrifice | 0.868 | 0.012 |
| Actual financial contribution to conservation (memberships and donations) | 0.027 | 0.927 |
| Hypothetical financial contribution to conservation (£600 distributed across at least one of six charitable sectors) | 0.452 | 0.538 |

### Socio-economic and demographic information

Previous studies have shown that socio-economic and demographic factors can influence levels of environmental knowledge and conservation support. Key factors such as income and level of education have been consistently associated with greater environmental knowledge, for example, while others such as age and gender often have an effect though the direction of the relationship varies between studies (Buijs and Elands, 2013; Lückmann and Menzel, 2013; Timur, Timur and Karakas, 2014). Other factors, such as ethnicity, appear to have shown a shift in direction with older studies suggesting lower levels of conservation support from ethnic minorities while more recent research shows support amongst minority groups to be greater (Gifford and Nilsson, 2014; Liu, Vedlitz and Shi, 2014). It was therefore important to control for the effect of socio-economic and demographic variables in the present study though a full assessment of their impact on biodiversity knowledge and conservation support was not our intention. We thus recorded participants’ employment status, highest level education qualification, tax band, age (treated as a continuous variable using the mid-points of our categories), gender and ethnicity (Table 2.6).

As we were primarily interested in controlling for the effects of these socio-economic and demographic variables and not the impact of each factor individually, combining them in to fewer metrics would help reduce issues of collinearity between these variables when used as model predictors as well as increase statistical power of analyses by reducing the number of degrees of freedom taken up by multiple categorical predictor variables. Thus categorical principle component analysis (CATPCA) was conducted in SPSS version 21 using employment status, education, tax band (as an indicator of wealth) and ethnicity data together with discretized scores of the Index of Multiple Deprivation (Office for National Statistics, 2010) for the lower super output area within which the participant’s home was located. These scores were discretized to enable inclusion in the CATPCA. Age and gender were not included in the CATPCA as they are largely independent of employment status, education, wealth, ethnicity and deprivation and were thus used as additional predictor variables. The CATPCA identified two axes. Employment, education and tax band loaded onto axis one (eigenvalue 1.95, explains 38.9% of the variation; Table 2.7), which we term socio-economic status. Ethnicity and deprivation scores loaded on to axis two (eigenvalue 1.49, explains 29.8% of the variation; Table 2.7) which we term the ethnicity-deprivation index.

**Table 2.6.** The categories available to respondents when answering questions concerning socio-economic and demographic indicators.

|  |  |
| --- | --- |
| *Socio-economic / demographic indicator* | *Answer categories* |
| Employment | Retired, Unemployed, Full-time education, Full-time paid employment, Part-time paid employment, Self-employed, Home maker/bringing up family |
| Education | None, O level/GCSE or equivalent, A level or equivalent, Undergraduate degree or equivalent, Higher degree or equivalent |
| Tax band | No tax (<£9,440 taxable income), Basic rate (£9,440-£32,010), Higher rate (£32,011-£150,000), Top rate (£>150,000) |
| Ethnicity | Office for National Statistics guidelines were used for ethnic group selection (http://ons.gov.uk/ons/guide-method/measuring-equality/equality/ethnic-nat-identity-religion/ethnic-group/index.html) but for analysis purposes these were categorised as white British, white non-British and non-white |
| Age | 16-18, 19-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85-94 |
| Gender | Male, Female |

**Table 2.7.** A categorical PCA of five socio-demographic indicators identified two axes. Education, employment and tax band loaded primarily onto axis 1 (eigenvalue 1.95) and forms our indicator of socio-economic status. Ethnicity and the Index of Multiple Deprivation (which is a continuous variable and was thus discretised prior to analysis) loaded primarily onto axis 2 (eigenvalue 1.49).

|  |  |  |
| --- | --- | --- |
| *Socio-economic indicators* | *Component loadings* | |
| *Axis 1* | *Axis 2* |
| Highest level qualification | 0.819 | 0.102 |
| Employment status | 0.720 | 0.448 |
| Tax band | 0.719 | 0.155 |
| Ethnicity | -0.231 | 0.834 |
| Index of Multiple Deprivation | -0.434 | 0.749 |

### Statistical analysis

Ordinal data, such as visitation rate, can be modelled as a continuous or categorical predictor (Pasta 2009). The former estimates the linear component of a relationship and is recommended by Moses et al. (1984); treating ordinal data as discrete categories models more complicated relationships at the cost of using additional degrees of freedom. The diagnostic procedure advocated by Pasta (2009) for assessing which approach provided a better fit to the data provided consistent support for treating visit rates as continuous predictors – the results of these models are thus reported below, but using categorical visitation rates generated qualitatively similar results (Appendix 2.1).

We first classified respondents as visiting i) urban green-space and the countryside equally frequently, ii) urban green-space more frequently or iii) the countryside more frequently and then tested if the distribution of respondents across these three groups differed from random using a chi-squared test. Whilst all three biodiversity knowledge domains were positively associated, we then tested if knowledge varied across the three domains by converting all scores to a percentage (to take into account variation in maximum possible score) and conducted a repeated measures ANOVA in SPSSvs21. We used a Huynh-Feldt correction, due to inequality of variance, and a Bonferonni post-hoc test.

We used the lme4 package in R (Bates *et al.*, 2014) to construct linear mixed models to test the hypotheses that i) biodiversity knowledge, behavioural conservation support and financial conservation were positively associated with engaging with nature (measured by green-space visitation rates), and ii) the form of these relationships varied if visits were to urban green-space or the countryside. We used an information theoretic approach and for each response variable constructed three models that contained the following predictors: i) urban green-space visits, socio-demographic predictors (i.e. socio-economic status, ethnicity-deprivation, age and gender) and city (modelled as a random factor), ii) countryside visit rates, socio-demographic predictors and city, and iii) socio-demographic predictors and city. The correlation between visits to urban green-space and the countryside was too strong (rs = 0.50, *P* < 0.001) to include both predictors in the same model. Socio-demographic predictors are included in all models as our primary motivation is to take their effects into account rather than testing whether they are associated with our response variables.

To test the hypothesis that conservation support was positively associated with biodiversity knowledge we used the lme4 package to construct mixed models of behavioural and financial conservation support as a function of i) biodiversity knowledge, socio-demographic predictors and city (as a random factor), and ii) socio-demographic predictors and city. We used Akaike Information Criteria scores corrected for small samples sizes (AICc) to compare models, and report the results for all models with ΔAICc values < 4. Positive associations between green-space visit rates and biodiversity knowledge or conservation support may arise because visiting green-space increases knowledge/support or because people have high visitation rates to green-space as a consequence of activities that are directly associated with biodiversity knowledge and conservation support (e.g. bird-watching, conservation volunteering etc.). Respondents with these motivations for visiting green-space were thus excluded from analyses to help disentangle cause and effect, but these analyses generated qualitatively similar results (Appendix 2.2) to those conducted using the entire data-set.

It is plausible that other confounding factors drive increased visit rates to green-space whilst also promoting increased biodiversity knowledge or conservation support, thus contributing to a non-causal link between visitation rate and these outcome variables. Three of the most likely candidates for such confounding factors are garden use, natural history programme engagement and being a member of a conservation organization. We thus also modeled biodiversity knowledge and conservation support as a function of these explanatory variables (individually) as fixed factors whilst also taking into account socio-demographic variables and city (as a random factor) – the relationship between financial conservation support and membership of a conservation organization was not modeled as membership fees contribute to the measure of financial support.

Our third and final set of models tested the hypotheses that urbanisation reduces visitation rates to green-space, biodiversity knowledge, and conservation support. To describe the overall pattern of association between each response variable and urbanisation intensity we modelled response variables as functions of i) local scale urbanisation and city (as a random factor in all models), ii) city size and city, and iii) local scale urbanisation, city size and city. Because categorical variables can be modelled as continuous when there are at least six categorical levels (Rhemtulla, Brosseau-Liard and Savalei, 2012), our models with visit rate (eight point scale) as the response variable were analysed using mixed linear regression models in the lme4 package. We then repeated these analyses using socio-demographic variables (socio-economic status, ethnicity-deprivation index, age and gender) as additional predictors to assess if associations between our response variables and urbanisation still arise when taking into account variation in residents’ characteristics.

The approach taken in this study is observational rather than experimental meaning that cause and effect cannot be disentangled. Our statistical analyses are therefore describing the strength of relationships between our focal response variables and predictors. We use the term association to describe these relationships and do not imply causation.

## Results

### Participants

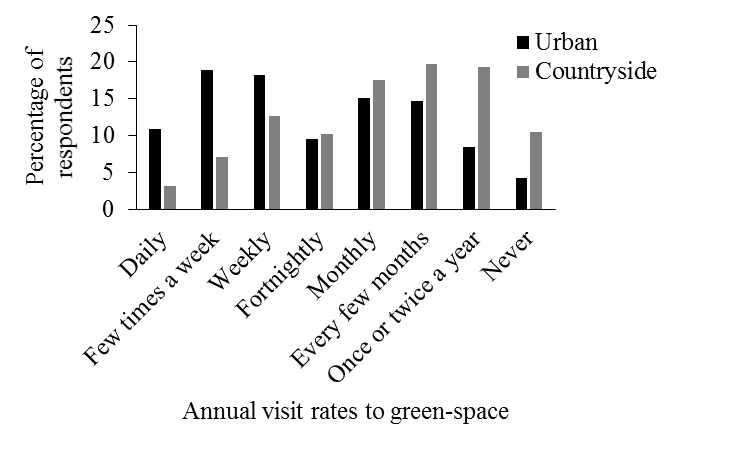
A summary table of socio-economic and demographic characteristics of respondents is given in Table 2.8.

**Table 2.8.** Socio-economic and demographic summary of respondents.

|  |  |  |  |
| --- | --- | --- | --- |
| *Category* | *N* | *n* | *%* |
| Age  16-18  19-24  25-34  35-44  45-54  55-64  65-74  75-84  85-94 | 286 | 10  36  42  39  46  39  47  22  5 | 3  13  15  14  16  14  16  8  2 |
| Education  None  GCSE  A level  Undergraduate degree  Higher degree | 282 | 47  51  80  64  40 | 17  18  28  23  14 |
| Employment  Retired  Unemployed  Full-time education  Full-time paid employment  Part-time paid employment  Self-employed  Home maker/bringing up family | 286 | 82  28  40  57  41  26  12 | 29  10  14  20  14  9  4 |
| Ethnicity  White British  White non-British  Non-white | 285 | 212  17  56 | 74  6  20 |
| Gender  Male  Female | 286 | 144  142 | 50  50 |
| Tax band  No tax (<£9,440)  Basic rate (£9,440-£32,010)  Higher rate (£32,011-£150,000)  Top rate (£>150,000) | 235 | 62  122  48  3 | 26  52  20  1 |

### Levels of engagement and with urban green-spaces and the countryside

Visitation rates to urban green-spaces and the countryside were highly variable across respondents (Fig. 2.4). The majority of respondents (58%) visited urban green-space more frequently than the countryside, with 33% visiting urban green-space and the countryside equally frequently, and just 9% visiting the countryside more frequently; the differences between these three groups were significant (χ2 = 100.29, *P* < 0.001). Whilst many respondents visited green-spaces regularly, 30% visited the countryside no more than twice a year, and 13% visited urban green-space no more than twice a year. A total of 7% of respondents obtained all their exposure to green-space in urban environments while the equivalent figure for the countryside was 1%.

**

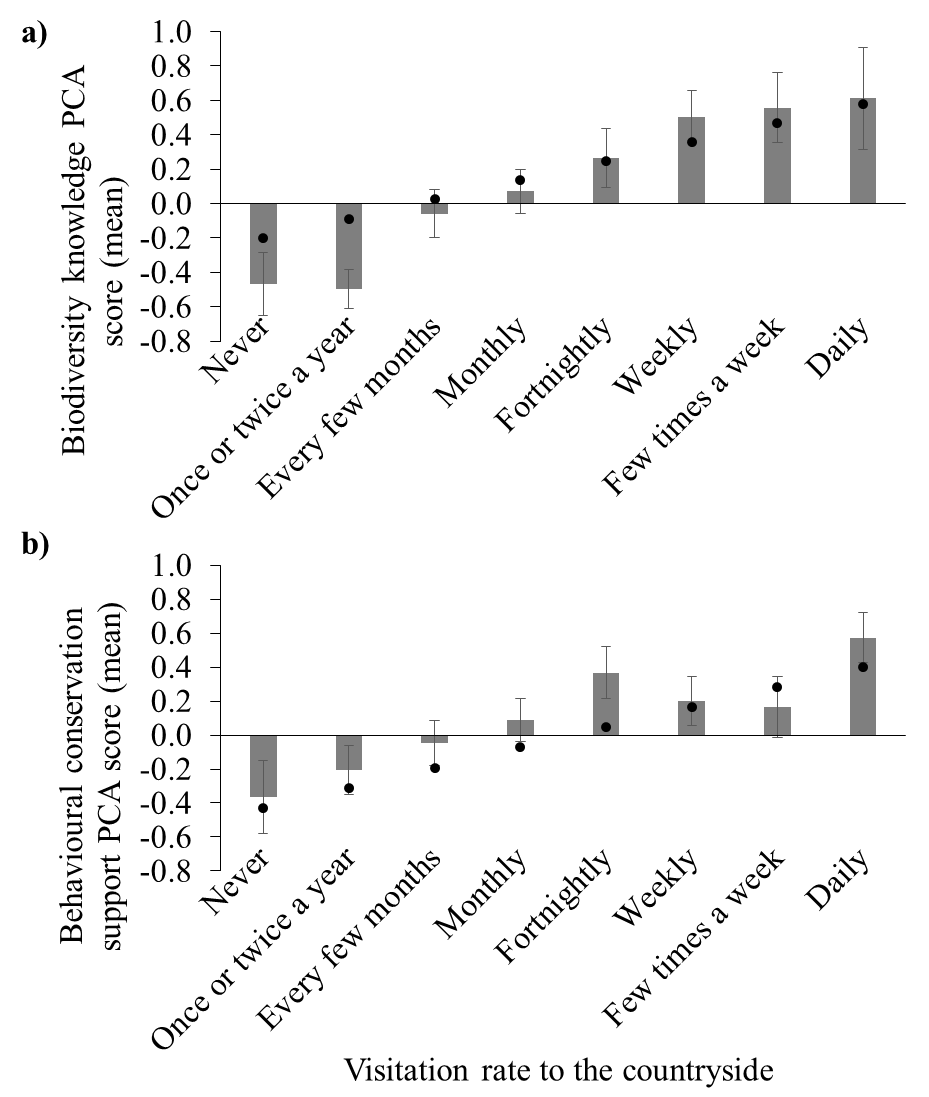
**Figure 2.4.** Many urban residents visit green-space, especially the countryside, infrequently.

### Green-space visit rates and biodiversity knowledge

Biodiversity knowledge scores were generally low with 40% of respondents unable to identify half of the species presented and 65% being unaware of the conservation status of half of the species. Respondents were better at assessing habitat quality (mean score 60.96%, SE 1.72), than identifying species (49.65%, SE 1.21) and knowing their conservation status (34.97%, SE 1.32; repeated measures ANOVA F1.7,491.9; *P* < 0.0001; all post hoc tests *P* < 0.0001). Biodiversity knowledge (the composite PCA derived metric of these three skills) was positively associated with countryside (but not urban green-space) visit rates and socio-economic status, and negatively associated with ethnicity-deprivation scores; age and gender had little influence (Table 2.9; Fig. 2.5a). Garden use, being a member of a conservation organization and time spent watching or listening to natural history programmes had comparably negligible influence on biodiversity knowledge with AICc values for these models being at least seven points higher than that for countryside visits (Table 2.10).

**Table 2.9.** Multiple regression models of biodiversity knowledge and conservation support as a function of visitation rates to urban green-space and the countryside. Models presented are all those with ΔAICc values < 4; city (random factor) and socio-economic and demographic variables (fixed factors) were incorporated into all models to control for their influence.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence intervals)* | | | | | | *AICc* | *ΔAICc* | *Model weight* |
| *Response variable* | *Countryside visits* | *Urban green-space visits* | *Socio-economic status* | *Ethnicity-deprivation index* | *Age* | *Gender* |
| Biodiversity knowledge | 0.11  (0.06 to 0.17) |  | 0.27  (0.17 to 0.37) | -0.23  (-0.34 to -0.12) | 0.02  (0.01 to 0.02) | 0.01  (-0.18 to 0.20) | 702.61 | 0 | 0.99 |
| Behavioural conservation support | 0.12  (0.06 to 0.18) |  | 0.14  (0.02 to 0.25) | 0.16  (0.04 to 0.28) | 0.00  (-0.01 to 0.00) | -0.19  (-0.41 to 0.02) | 763.66 | 0 | 0.89 |
| Financial conservation support |  | 0.05  (-0.00 to 0.10) | 0.18  (0.06 to 0.11) | -0.10  (-0.21 to 0.01) | 0.00  (-0.01 to 0.01) | -0.15  (-0.35 to 0.04) | 711.27 | 0 | 0.67 |
| " | 0.03  (-0.02 to 0.09) |  | 0.20  (0.09 to 0.31) | -0.10  (-0.21 to 0.01) | 0.00  (-0.01 to 0.01) | -0.15  (-0.35 to 0.04) | 713.49 | 2.23 | 0.22 |
| " |  |  | 0.22  (0.12 to 0.32) | -0.11  (-0.22 to -0.01) | 0.00  (-0.01 to 0.01) | -0.13  (-0.33 to 0.06) | 715.01 | 3.74 | 0.10 |

****

**Figure 2.5.** Relationships between countryside visitation rates and (a) biodiversity knowledge (a PCA derived score combining knowledge of species’ identification, conservation status and habitat quality assessment), and (b) behavioural conservation support (a PCA derived score combining commitment to the environment and willingness to sacrifice scales). Grey bars represent raw data; black dots are predicted scores from linear mixed-effects models that include socio-economic and demographic variables as fixed factors, and city as a random factor. Error bars represent standard errors.

**Table 2.10.** Regression models of biodiversity knowledge and conservation support as a function of both green-space visitation rates (countryside and urban green-space) and potentially confounding factors (garden use, natural history programme engagement and being a member of a conservation organization).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Response variable* | *Explanatory variable* | *Parameter estimate (95% confidence intervals)* | *AICc* | *ΔAICc* |
| Biodiversity knowledge | Countryside visits | 0.11 (0.06 to 0.17) | 702.61 | 0.00 |
|  | Garden use | 0.05 (0.01 to 0.09) | 709.36 | 6.75 |
|  | Urban greenspace visits | 0.06 (0.01 to 0.12) | 712.72 | 10.11 |
|  | Conservation organization member | -0.31 (-0.59 to -0.03) | 721.62 | 19.00 |
|  | Natural history programmes | -0.05 (-0.10 to -0.00) | 722.17 | 19.55 |
| Behavioural conservation support | Countryside visits | 0.12 (0.06 to 0.18) | 763.66 | 0.00 |
|  | Garden use | 0.06 (0.02 to 0.10) | 765.81 | 2.15 |
|  | Natural history programmes | -0.13 (-0.18 to -0.07) | 766.48 | 2.82 |
|  | Urban green-space visits | 0.09 (0.03 to 0.15) | 767.83 | 4.17 |
|  | Conservation organization member | -0.16 (-0.48 to 0.16) | 786.49 | 22.83 |
| Financial conservation support | Garden use | 0.01 (-0.03 to 0.05) | 711.26 | 0.00 |
| Urban green-space visits | 0.05 (-0.00 to 0.10) | 711.27 | 0.01 |
| Countryside visits | 0.03 (-0.02 to 0.09) | 713.49 | 2.24 |
| Natural history programmes | 0.02 (-0.03 to 0.07) | 716.40 | 5.14 |

### Green-space visit rates and conservation support

The monthly total given to all charities through membership subscriptions and donations was £2,914.50. Environmental and conservation charities was the third most popular sector, receiving 8%, with charities supporting vulnerable people (49.8%) and medical research (25.4%) receiving a much greater proportion. Conservation and environmental charities received 17.5% of respondents’ hypothetical spends of £600 per respondent across five charitable sectors, again coming third behind vulnerable people (31.4%) and medical research (29%).

Log transformed financial conservation support was positively associated with visitation rates to urban green-space and the countryside, but the parameter estimates’ 95% confidence intervals overlapped zero (Table 2.9). We thus conclude that there is negligible evidence for financial conservation support being influenced by green-space visitation rates. Higher socio-economic status was positively associated with financial conservation support while age, gender and ethnicity-deprivation scores had negligible associations (Table 2.9). The influence of garden use and natural history programmes on financial conservation support was negligible as confidence intervals overlapped zero (Table 2.10).

Behavioural conservation support was positively associated with countryside, but not urban green-space visit rates and with socio-economic status and ethnicity-deprivation scores; age and gender had negligible influences (Table 2.9; Fig 2.5b). Engaging with natural history programmes was negatively associated with behavioural conservation support, and being a member of a conservation group had no influence on behavioural conservation support (ΔAICc = 23, relative to a model containing countryside visit rates, Table 2.10). Behavioural conservation support was positively associated with garden use but the evidence for this relationship was lower than that for an association with countryside visit rates (ΔAICc > 2) and the parameter estimate was substantially smaller despite both predictors having equivalent scales Table 2.10).

### Association between biodiversity knowledge and conservation support

Behavioural and financial conservation support were positively associated with biodiversity knowledge, with the magnitude of the parameter estimate in the Behavioural support model being double that of the financial support model (Table 2.11). Behavioural conservation support was positively associated with the ethnicity-deprivation index; whilst also positively associated with socio-economic status, 95% confidence intervals overlapped zero suggesting negligible influence (Table 2.11). Financial conservation support was positively associated with socio-economic status and negatively associated with the ethnicity-deprivation index. Age and gender had negligible influence on either measure of conservation support.

**Table 2.11.** Multiple regression models of conservation support as a function of biodiversity knowledge. Models presented are all those with ΔAICc values < 4; city (random factor) and socio-economic and demographic variables (fixed factors) were incorporated into all models to control for their influence.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence intervals)* | | | | |  |  |  | |
| *Response variable* | *Biodiversity knowledge* | *Socio-economic status* | *Ethnicity-deprivation index* | *Age* | *Gender* | *AICc* | *ΔAICc* | *Model weight* |
| Behavioural conservation support | 0.36  (0.24 to 0.49) | 0.09  (-0.03 to 0.20) | 0.21  (0.09 to 0.33) | -0.01  (-0.02 to 0.00) | -0.18  (-0.39 to 0.03) | 756.22 | 0 | 0.99 |
| Financial conservation support | 0.18  (0.06 to 0.29) | 0.16  (0.05 to 0.27) | -0.07  (-0.07 to -0.06) | 0.00  (-0.01 to 0.00) | -0.13  (-0.33 to 0.06) | 711.27 | 0 | 0.67 |

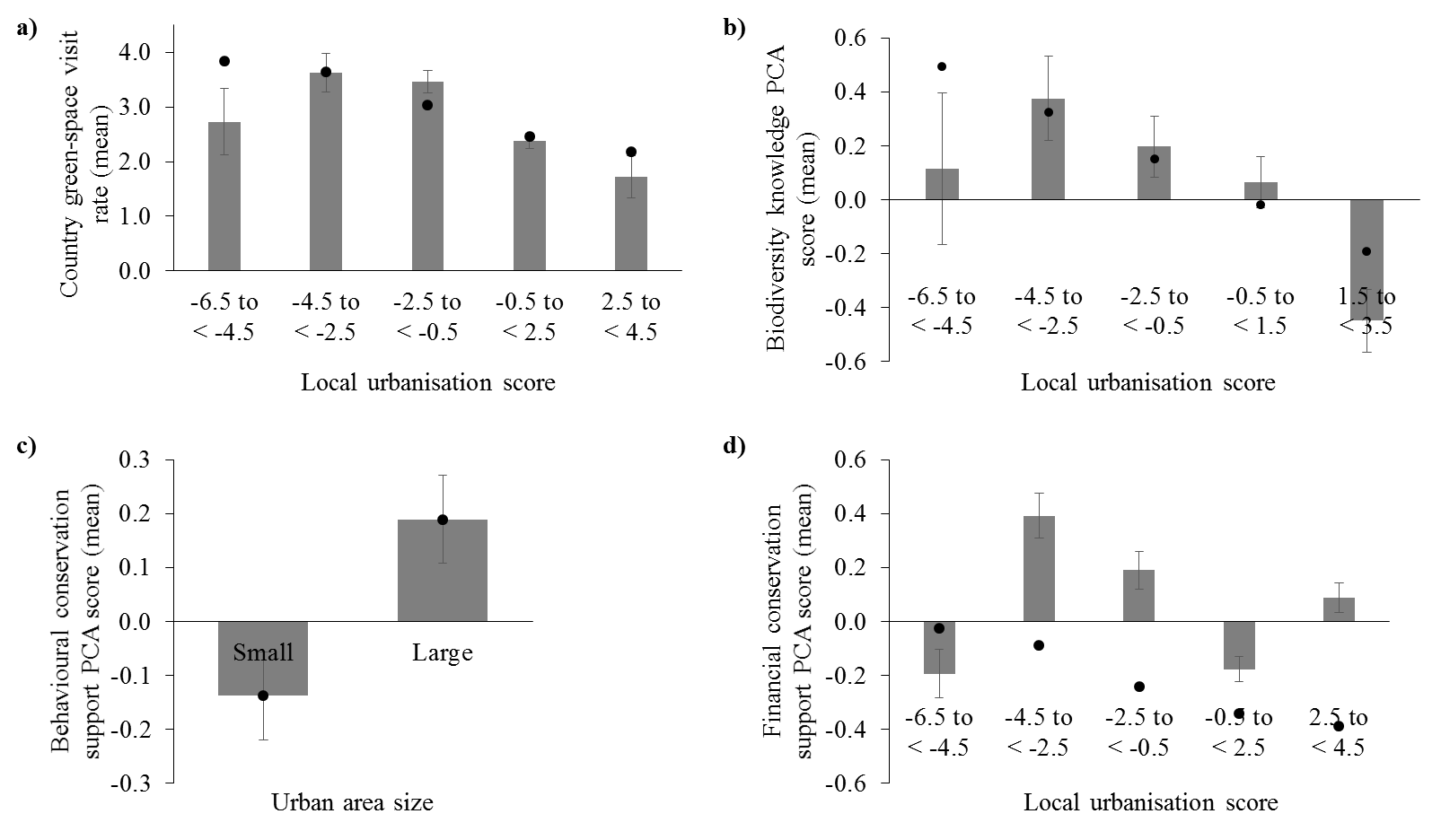
### Urbanisation and green-space visit rates

More intense urbanisation around respondents’ home was negatively associated with countryside visitation rates both when excluding socio-demographic factors (Table 2.12; Fig. 2.6a) and when accounting for them (Table 2.13; Fig. 2.7a). Countryside visitation rates were positively associated with socio-economic status and negatively related to the ethnicity-deprivation index; age and gender had negligible influence (Table 2.13).

**Table 2.12.** Multiple regression models of green-space visitation rates, biodiversity knowledge, and conservation support as a function of local scale urbanisation intensity and city size, without controlling for socio-economic and demographic factors (see Table 2.14 for equivalent models that take socio-economic and demographic factors into account). We present all models with ΔAICc values < 4 of the best performing model except when these models have higher ΔAICc values than a model that only contains city as a random effect.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence intervals)* | |  |  |  |
| *Response variable* | *Local urbanisation* | *City size (small)* | *AICc* | *ΔAICc* | *Model weight* |
| Countryside visit rate | -0.22  (-0.33 to -0.12) |  | 1161.49 | 0 | 0.54 |
| " | -0.21  (-0.32 to -0.11) | 0.34  (-0.14 to 0.82) | 1161.82 | 0.32 | 0.46 |
| Urban green-space visit rate | -0.96  (-0.21 to 0.02) |  | 1208.18 | 0 | 0.41 |
| " *a* |  |  | 1208.88 | 0.70 | 0.29 |
| Biodiversity knowledge | -0.09  (-0.14 to -0.03) |  | 788.99 | 0 | 0.62 |
| " | -0.08  (-0.14 to -0.03) | 0.24  (-0.24 to 0.73) | 790.14 | 1.15 | 0.35 |
| Behavioural conservation support  " |  | -0.33  (-0.56 to -0.10) | 797.20 | 0 | 0.61 |
| 0.02  (-0.04 to 0.08) | -0.30  (-0.54 to -0.06) | 798.67 | 1.48 | 0.29 |
| Financial conservation support  " | -0.07  (-0.12 to -0.02) |  | 725.28 | 0 | 0.68 |
| -0.07  (-0.12 to -0.02) | 0.00  (-0.30 to 0.31) | 727.35 | 2.07 | 0.11 |

*a This model only contains city as a random effect.*

****

**Figure 2.6.** Associations between (a) countryside visitation rate and local urbanisation score (urbanisation intensity near respondents’ homes, higher scores represent greater urbanisation), (b) biodiversity knowledge and local urbanisation score, (c) behavioural conservation support and size of urban area, and (d) financial conservation support and local urbanisation score. Grey bars represent raw data; black dots are predicted scores from linear mixed-effects models that include city as a random factor but not socio-economic and demographic variables. Error bars represent standard errors. Note the poor fit of the predicted and observed financial conservation support data.

**Table 2.13*.*** Summary of retained models developed to assess the impact of urbanisation on visits to green-spaces (modelled as a continuous variable), biodiversity knowledge and conservation support when incorporating socio-economic and demographic variables into all models. Models presented are all those with ΔAICc values < 4 of the best performing model except when these models have higher ΔAICc values than a model that only contains city; city (random factor) and socio-economic and demographic variables (fixed factors) were incorporated into all models to control for their influence. City size is a binary fixed factor with large city size used as the reference category.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence intervals)* | | | | | | *AICc* | *ΔAICc* | *Model weight* |
| *Response variable* | *Local urbanisation* | *City size (small)* | *Socio-economic status* | *Ethnicity-deprivation index* | *Age* | *Gender* |
| Countryside visits | -0.14  (-0.24 to -0.03) |  | 0.55  (0.34 to 0.76) | -0.33  (-0.56 to -0.09) | 0.00  (-0.01 to 0.01) | 0.35  (-0.05 to 0.75) | 1133.61 | 0 | 0.61 |
| " | -0.13  (-0.24 to -0.03) | 0.14  (-0.30 to 0.58) | 0.54  (0.33 to 0.75) | -0.32  (-0.56 to -0.08) | 0.00  (-0.01 to 0.01) | 0.35  (-0.05 to 0.75) | 1135.35 | 1.74 | 0.25 |
| " |  |  | 0.59  (0.37 to 0.80) | -0.45  (-0.67 to -0.23) | 0.00  (-0.01 to 0.02) | 0.34  (-0.07 to 0.74) | 1137.52 | 3.91 | 0.09 |
| Urban green-space visits |  | -0.54  (-0.99 to -0.08) | 0.76  (0.54 to 0.99) | -0.39  (-0.62 to -0.15) | 0.00  (-0.01 to 0.02) | 0.26  (-0.16 to 0.69) | 1169.63 | 0 | 0.57 |
| " | -0.03  (-0.14 to 0.09) | -0.55  (-1.02 to -0.09) | 0.76  (0.53 to 0.98) | -0.37  (-0.62 to -0.11) | 0.00  (-0.01 to 0.02) | 0.26  (-0.16 to 0.69) | 1171.57 | 1.94 | 0.22 |
| " |  |  | 0.72  (0.49 to 0.95) | -0.32  (-0.56 to -0.08) | 0.00  (-0.01 to 0.01) | 0.26  (-0.17 to 0.69) | 1172.23 | 2.59 | 0.16 |
| Biodiversity knowledge |  |  | 0.27  (0.17 to 0.37) | -0.23  (-0.34 to -0.12) | 0.02  (0.01 to 0.02) | 0.01  (-0.18 to 0.20) | 726.15 | 0 | 0.21 |

**Table 2.13*.*** Continued.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence intervals)* | | | | | | *AICc* | *ΔAICc* | *Model weight* |
| *Response variable* | *Local urbanisation* | *City size (small)* | *Socio-economic status* | *Ethnicity-deprivation index* | *Age* | *Gender* |
| Behavioural conservation support |  | -0.28  (-0.51 to -0.05) | 0.22  (0.11 to 0.34) | 0.08  (-0.04 to 0.20) | 0.00  (-0.01 to 0.00) | -0.16  (-0.38 to 0.05) | 782.01 | 0 | 0.60 |
| " | 0.01  (-0.05 to 0.07) | -0.27  (-0.51 to -0.03) | 0.23  (0.11 to 0.34) | 0.07  (-0.06 to 0.20) | 0.00  (-0.01 to 0.00) | -0.17  (-0.38 to 0.05) | 783.93 | 1.9 | 0.23 |
| " |  |  | 0.21  (0.09 to 0.32) | 0.11  (-0.01 to 0.23) | 0.00  (-0.01 to 0.00) | -0.17  (-0.39 to 0.05) | 785.31 | 3.30 | 0.11 |
| Financial conservation support | -0.05  (-0.10 to 0.00) |  | 0.20  (0.10 to 0.31) | -0.07  (-0.19 to 0.05) | 0.00  (-0.01 to 0.00) | -0.13  (-0.31 to 0.06) | 713.67 | 0 | 0.49 |
| " |  |  | 0.22  (0.12 to 0.32) | -0.11  (-0.22 to -0.01) | 0.00  (-0.01 to 0.01) | -0.13  (-0.33 to 0.06) | 715.01 | 1.34 | 0.25 |

|  |
| --- |
|  |

**Figure 2.7.** Associations between (a) countryside visitation rates and local urbanisation score, (b) urban green-space visitation rate and size of the urban area, and (c) behavioural conservation support and size of the urban area. Grey bars represent raw data; black dots are predicted scores from linear mixed-effects models that include socio-economic and demographic variables as fixed factors, and city as a random factor. See Table 2.14 for full results.

When socio-demographic factors were excluded from analyses urban green-space visit rates were not associated with city size or local urbanisation (whilst retained in the top model the AICc value was very close to the null model and 95% confidence intervals overlapped zero; Table 2.12). When accounting for socio-demographic factors, however, participants from larger cities reported higher visitations rates to urban green-spaces than those from smaller urban areas (Table 2.13; Fig. 2.7b). Visitation rates to urban green-space were positively associated with socio-economic status and negatively related to the ethnicity-deprivation index; age and gender had negligible influence (Table 2.13).

### Urbanisation and biodiversity knowledge

Biodiversity knowledge was negatively associated with urbanisation at the local scale when excluding socio-demographic factors from analyses (Table 2.12; Fig. 2.6b) but not when including them (Table 2.13); city size consistently had no influence (95% parameter estimates overlapped zero; Tables 2.12 and 2.13). Biodiversity knowledge was positively associated with socio-economic status and age, and negatively associated with the ethnicity-deprivation index (Table 2.13).

### Urbanisation and conservation support

Behavioural support for conservation was greatest amongst respondents from larger urban areas when excluding (Table 2.12, Fig. 2.6c) and including (Table 2.13; Fig. 2.7c) socio-demographic factors from models. In both cases the intensity of local urbanisation was negligible (parameter estimate’s 95% confidence intervals overlapped zero). Behavioural conservation support was positively associated with socio-economic status, with other socio-demographic factors having negligible influence (Table 2.13).

Financial conservation support was negatively associated with urbanisation at the local scale when excluding socio-demographic variables from models (Table 2.12) though the predictive power of the model was low (Fig. 2.6d). When socio-demographic factors were incorporated, the association between financial conservation support and local urbanisation became negligible (Table 2.13). City size consistently had negligible influence on financial conservation support (Tables 2.12 & 2.13). Socio-economic status was positively associated with financial support while all other socio-demographic factors had negligible influence (Table 2.13).

## Discussion

### Engagement with green-space and motivation

Our estimates of urban green-space visitation rates by urban residents are comparable to those of a larger study (Swanwick et al. 2003). Whilst countryside visitation rates were somewhat lower than national estimates (e.g. Natural England 2014) this is unsurprising given our focus on urban residents. Urban residents visited the countryside significantly less frequently than urban green-space, with approximately one in three people visiting the countryside twice a year or less. Moreover, one in ten urban residents did not visit any form of green-space more than twice a year. People rarely stated that they were primarily motivated to visit green-space for observing wildlife (5.2%), which is comparable with previous estimates of 3.4% (Irvine et al. 2013) and 3.5% (Bell et al. 2004), but slightly more people (8.4%) did visit green-space for activities that were linked to nature (watching wildlife, gardening, fishing etc.).

### Biodiversity knowledge

Respondents’ knowledge of species identification and conservation status was also low (nearly one in two participants were unable to name more than half of the species and 65% knew the conservation status of less than half the species). These findings concur with other evidence that the general public’s biodiversity knowledge is poor (Lindemann-Matthies & Bose 2008). However, respondents were significantly more capable of assessing the relative biodiversity value of different habitat types than naming species or assessing their conservation status. This is encouraging as appreciation of habitat quality is more likely to relate to conservation action, e.g. management of garden or other habitats, than being able to name species. Ranking habitat quality requires rapid assessment of environmental quality that takes into account the diversity of species that can utilise a range of resources; it is therefore a complex mental construct. Our results thus support claims that studies reporting poor biodiversity knowledge could be influenced by focusing on precise scientific knowledge rather than more general mental constructs and understanding of ecological processes (Fischer and Young, 2007; Buijs and Elands, 2013). Interestingly, however, all three measures of biodiversity knowledge loaded onto the same axis during principal component analysis, thus studies reporting just one of these metrics are still likely to provide a useful surrogate measure of a wider more holistic metric of biodiversity knowledge.

### Levels of conservation support

Previous studies have used three broad groups of metrics relating to attitudes and behaviour that reflect environmental concern, i.e. pro-environmental attitudes, self-reported or hypothetical behaviours (expressed in absolute terms or relative to other priorities in life) and actual actions (Kollmuss and Agyeman, 2002; Gifford and Nilsson, 2014). There is increasing evidence of a gap between attitudes and behaviour as behaviours are determined by complex, interacting and confounding factors that partly trade-off against each other (Theodori, Luloff and Willits, 1998; Frick, Kaiser and Wilson, 2004; Whitmarsh, 2009; Frederiks, Stenner and Hobman, 2015), and even self-reported and actual environmentally friendly behaviours are not always tightly correlated (Kormos and Gifford, 2014). We thus focused on measuring conservation support using self-reported behavioural statements and assessment of hypothetical behaviour that take other priorities into account, and respondents’ actual behaviour (donations of time or money). Respondents’ self-reported statements typically indicated commitment to environmental sustainability and willingness to make some personal sacrifices to achieve this. Despite this, actual and hypothetical behaviours, which more fully capture trade-offs, indicated lower levels of conservation support, with much greater support for charities that supported vulnerable people or medical research (only 17.5% of theoretical charitable donations were allocated to conservation, actual monetary donations in the month prior to the survey totalled just £235.78 across 56 people (20% of respondents), and only six people (2%) donated time to conservation activities).

Different types of behaviours are, however, not directly comparable. Donating actual time and money has a real clear cost to the respondent that is likely to be much higher than other behaviours that could be perceived to support conservation, such as participating in recycling and re-using plastic bags. Indeed the CESS and WTS scales are not specific with regard to the behaviours that they capture and questions such as ‘I am willing to do things for the environment, even if I’m not thanked for my efforts’ (part of the WTS) could be interpreted very differently by respondents. This is especially likely if respondents’ vary in their perceptions or knowledge of the environmental impact of specific behaviours, and such contextual variation alters scores on other scales that measure environmental attitudes (e.g. the New Ecological Paradigm (NEP) scale; Pienaar et al. 2015). Further evidence for this divergence in the type of conservation support measured by our metrics is provided by the failure of scores on the CESS and WTS scale to load onto the same PCA axis as our measures of hypothetical and actual financial donations to the charitable conservation sector.

### Relationships between greenspace visitation, biodiversity knowledge and conservation support

We found evidence to support the long made assumption that engaging with nature through visits to green-space, is positively associated with biodiversity knowledge and conservation support and that these themselves are linked. Of the very few studies to have tested the relationship between biodiversity knowledge and visits to green-spaces, some have concluded no association (Booth, Gaston and Armsworth, 2009) while others found the frequency of visits to the countryside in the UK to be the greatest predictor of knowledge (Pilgrim, Smith and Pretty, 2007) and visits to a park in Germany to be associated with knowledge of local animal species (Randler, Höllwarth and Schaal, 2007). Cause and effect could not be distinguished in these studies. We found that associations between nature engagement and both biodiversity knowledge and conservation support remained when taking into account potentially confounding variables relating to motivations for visiting green-space that are associated with nature. We also found that biodiversity knowledge and conservation support were more strongly associated with countryside visitation rates than other potentially confounding variables, i.e. garden use and engagement with natural history programs. Observational studies cannot, however, unambiguously demonstrate causality. It thus remains plausible that the positive relationships we describe arise in part because people with greater biodiversity knowledge and conservation support visit green-space more regularly, rather than visiting green-space increasing knowledge and conservation support. Indeed, we consider it likely that the associations we describe arise through both of these mechanisms due to a positive feedback loop, at least in some respondents - with increased visits to green-space promoting an interest in and knowledge of biodiversity and support for conservation, which in turn further increase the desire to visit green-space and experience nature.

Although studies addressing the relationship between engaging with green-spaces and conservation support have reported conflicting results, more often than not they find a positive association between the two. However, while these studies have produced very useful insights, many are subject to limitations such as biased samples by only incorporating people from within green-spaces (therefore excluding those who never visit green-spaces; Larson et al. 2011b), those undertaking a specific recreation activity (Cooper *et al.*, 2015), by not controlling for socio-economic factors (Zaradic, Pergams and Kareiva, 2009) or specifically relating only nature based recreation activities (rather than just green-space engagement in general) to levels of support (Larson, Whiting and Green, 2011). We addressed such limitations by sampling door-to-door, thereby incorporating a wide range of green-space visitation rates and usage as well as by including socio-demographic factors in our analyses and found some measures of conservation support to be positively associated with green-space visitation.

We considered visits to urban and country green-spaces separately to determine whether they differ in their delivery of both biodiversity knowledge and conservation support services, something which has not been done, as far as we are aware, with indicators similar to ours. Importantly, both biodiversity knowledge and our behavioural conservation support metric were only associated with visits to the countryside and not urban green-spaces. Our financial conservation support metric was not associated with green-space visits of any kind. This highlights a concerning service provision gap with urban green-spaces delivering no benefits regarding biodiversity knowledge and conservation support (the worst case scenario in Fig. 2.1). We suspect that this provisioning gap arises from the more limited range of species occurring in urban green-spaces relative to the countryside (Evans *et al.*, 2011). Indeed, other studies find that the magnitude of cultural ecosystem services provided by urban green-space is related to perceived or actual species richness (Sandifer, Sutton-Grier and Ward, 2015), which suggests that the ecosystem service provisioning gap that we identify may apply to other services.

It is, however, important to keep in mind that there are a wide diversity of both urban green-spaces and countryside that will vary in the variety and abundance of species they support (Chamberlain *et al.*, 2007; Harris *et al.*, 2016). Thus we cannot assume that all urban green-spaces will be of lower biodiversity value than areas of the countryside. Capturing the biodiversity value of the many different natural environments our participants will have visited over the course of a year was beyond the scope of this PhD thus further work is required to determine if, and what role biodiversity value of sites has in delivering educational benefits and conservation support.

Definitions of urban green-space and the countryside were only provided if participants asked for clarification. Asking how often respondents visited urban green-spaces and the countryside consecutively helped trigger participants to ask if they were unsure what the difference was. However, it is possible that some confusion may still have occurred with what might be classed as urban green-space by some being considered countryside by others and vice versa which may have influenced our results.

### Relationship between knowledge and support

Another major assumption of conservation policy is that enhanced biodiversity knowledge leads to increased pro-environmental behaviours. Although numerous studies have considered the relationship between knowledge of environmental issues and pro-environmental behaviours (Hines et al. 1987; Kollmuss & Agyeman 2002; Bamberg & Möser 2007), very few have considered biodiversity knowledge specifically. In doing so, we found biodiversity knowledge to be positively associated with both our behavioural and financial conservation support metrics, though the latter was a much weaker relationship. These results are consistent with studies that found zoo visitors with higher knowledge of species threat status allocated greater sums of theoretical money to conservation charities (Balmford *et al.*, 2007) and that being a member of a conservation organisation was the greatest predictor of knowledge of a sites’ conservation designation (Booth, Gaston and Armsworth, 2009).

### Influence of socio-demographic factors on biodiversity knowledge and conservation support

Socio-economic status and ethnicity-deprivation were the main socio-demographic factors to be associated with our educational ecosystem services. In all models, as socio-economic status increased, so did our respondents’ levels of biodiversity knowledge and conservation support. As levels of our ethnicity-deprivation index increased, however, our participants’ knowledge of biodiversity declined, behavioural conservation support improved and financial conservation support either declined or was unaffected. These findings are largely consistent with the literature though in all cases there is evidence of some studies that have found no such relationships or the opposite to be true (e.g. Ambrosius & Gilderbloom 2014; Gifford & Nilsson 2014; Liu et al. 2014). Despite studies having reported on the effects of age and gender on biodiversity knowledge and conservation support measures, the direction of the effect of these factors, if there at all, is highly variable (Lückmann and Menzel, 2013; Ambrosius and Gilderbloom, 2014; Gifford and Nilsson, 2014). We found almost no evidence of age and gender being associated with biodiversity knowledge or conservation support.

### Relationship between urbanisation and green-space visitation rates, biodiversity knowledge and conservation support

Another major assumption often made is that urbanisation is a leading causal factor in reducing people’s engagement with nature, their knowledge of biodiversity and willingness to support conservation but the literature is once again limited and conflicting. We tested these relationships across a range of city sizes representative of many found throughout the UK and Europe (including some of the largest urban areas in England), both with and without accounting for socio-demographic factors to determine whether any associations found were a result of urbanisation itself or the socio-demographic structure of residents along the urbanisation gradient. We found that participants living in more intensely urbanised areas within 500m, i.e. a short walk, of their homes, visited the countryside less, had lower levels of biodiversity knowledge and donated less financial support to conservation.

Reduced country visits was, in part, driven by lower socio-economic status and higher ethnicity-deprivation scores consistent with previous studies (Natural England, 2013) but the relationship with local urbanisation still held once socio-demographic factors were accounted for suggesting local urbanisation itself was indeed a causal factor. Potential explanations for this could be that i) the more intensely urban areas are inner city areas and thus further to travel to the countryside, ii) that people living in these areas have never engaged with the countryside and so do not consider it an option, or iii) that the contrast with urban green-spaces is enough to meet their needs.

The reduced levels of biodiversity knowledge and financial conservation support observed, however, were driven predominantly by socio-demographic factors of residents living within these areas of high intensity urbanisation. Lower biodiversity knowledge was associated with lower levels of socio-economic status and higher ethnicity-deprivation. The only other similar studies we have found comparing biodiversity knowledge between urban and rural residents also concluded urban provenance to be negatively associated with biodiversity knowledge (Pilgrim, Smith and Pretty, 2007; Lückmann and Menzel, 2013). However, these studies did not account for many socio-demographic factors such as deprivation and ethnicity which might have been driving the relationship with urbanisation. Reduced rates of financial support were driven by lower socio-economic status suggesting it is the lower incomes, level of education and employment status associated with densely urbanised areas that is responsible.

Urbanisation at the larger scale of city size was only associated with visits to urban green-spaces and our behavioural conservation support metric. Participants from larger urban areas were shown to be visiting urban green-spaces more frequently and reported greater behavioural conservation support. Socio-demographic factors were playing a role, with both visits and support positively associated with socio-economic status and ethnicity-deprivation negatively related to visit frequency. However, city size itself appeared to be having a greater influence. Possible reasons that respondents from larger cities visit urban green-spaces more frequently than those from smaller urban areas are that they are more accessible than the countryside and/or that they are more utilised to aid recuperation from the hustle and bustle of larger, busier and more stressful urban environments. Existing research has compared differences in levels of pro-environmental attitude and behaviour between urban and rural residents, and whilst results are somewhat equivocal, it is the urban residents who tend to have more pro-environmental attitudes and behaviours (Arcury & Christianson 1993; Berenguer et al. 2005; Huddart-Kennedy et al. 2009; Gifford & Nilsson 2014; Ambrosius & Gilderbloom 2014) which is consistent with our findings. Suggested theories for this are that people from more urban environments tend to be more educated and have greater access to pro-environmental facilities (though these discrepancies are increasingly diminishing; Huddart-Kennedy et al. 2009) or that those within urban environments are more exposed to higher levels of environmental degradation and are less utilitarian regarding the natural environment (Tremblay and Dunlap, 1978).

Thus it would appear that concerns about urbanisation impacting on engagement with nature and resulting knock-on effects to biodiversity knowledge and conservation support are justified, however, somewhat surprisingly our results suggest this is only at the local scale and not the wider city scale. This has interesting implications for the land sparing / land sharing debate as the latter, creating less densely urban areas, would be preferable should these educational ecosystem services be taken into consideration. However, we must remember that although our large urban areas are some of the largest in England, they are considerably smaller than mega-cities and projected cities of the future thus whether our findings can be extrapolated to such cities or not remains to be researched.

### Limitations

The approach taken in this study was subject to a five key limitations that could have influenced our findings and compromise the ability to generalise these beyond the included sample of urban areas. These limitations are discussed in greater detail below along with alternative approaches that could have been taken had greater resources been available with recommendations for future research.

*Causality*

All analyses conducted in this study are observational and we cannot therefore be certain of causality in any of the relationships described. Such an approach is an important first step in discovering novel patterns and determining whether additional experimental work, which can be much more resourcefully demanding and difficult to achieve in socio-ecological studies, is warranted. We believe that the discovery of an apparent benefit delivery gap from urban green-spaces with regards to educational benefits and conservation support does indeed justify further exploration. Potential future work could use a combination of more detailed monitoring of green-space use by participants with assessments and manipulation of different green-space types and quality (e.g. biodiversity value) as well as more controlled exposure to experimental manipulations of different levels of biodiversity (e.g. high versus low species richness) to determine what factors influence cultural benefit delivery. Doing so will provide important insight into the cause of the benefit delivery gap from urban green-spaces and inform management of urban green-space management.

*Urban area selection*

Ideally we would have selected urban areas along a gradient of sizes to determine the impacts of urbanisation but doing so would have required sampling a larger number of cities than was logistically feasible during the course of this PhD. As a result, we opted to focus on urban areas of markedly contrasting sizes with an emphasis on the extremes as a preliminary analysis of the effects of urbanisation. This approach also had its practical constraints as conducting surveys in the largest urban areas, such as London, would have required a greater sampling effort than possible to obtain a representative sample within the constraints of this PhD. Large and small urban areas inevitably vary in numerous characteristics, which may include the socio-economic profiles of residents, and the availability of accessible green-spaces. As our focus was on the overall pattern of urbanisation impacts rather than the underlying mechanisms driving these patterns, urban area pairs were not selected to match each other regarding these multiple characteristics.

However, future research that considers a larger number of urban areas from all regions of the UK representing the full continuum of urban areas sizes is required to ensure our findings hold true and are not an artefact of the urban areas selected here.

*Sampling area*

We chose to limit the sampling area within each of our urban areas to a radius of 3kms from its geographic centre. This was primarily to ensure that all respondents were still urban residents and going further than 3kms from the centre of some of our smaller urban areas would have incorporated participants from areas that were much more rural in nature. This approach may have exaggerated the impacts of urban area size as residents who live outside of the central areas of the larger urban areas were not included. Such residents would, for example, have less distance to travel to access the countryside and be more likely to live in less densely urban areas (e.g. Radford & James 2012). Once again, incorporating the extremes of urbanisation by comparing the central areas of larger urban areas is more likely to expose potential patterns of urbanisation. However, we found no impact of urban area size on our response variables implying that our sampling strategy did not bias our results. Nonetheless, future work should incorporate residents from the entire urban area to ensure the observed patterns from this study hold true.

*Green space accessibility*

The distance to green-spaces is known to influence use (e.g. Thompson 2008; Natural England 2013). Although the proportion of green-space in UK cities has been shown to be similar across a range of city sizes (Fuller and Gaston, 2009) we cannot be certain that this is the case amongst our selected urban areas as we did not incorporate the availability of green-spaces beyond the local area surrounding the home. Having included some measure of distance to both urban green-space and the countryside into our analyses would have provided us with greater insight into the underlying mechanisms driving impacts of urbanisation on green-space visit rates, educational benefits and conservation support observed in this study. For example, we found that increased local urbanisation was associated with reduced visits to the countryside. Presumably the fact that more intensely urban areas tend to be more central (though not exclusively; Radford & James 2012) will have contributed to this finding. However, we found no association between city size and countryside visit rate suggesting that distance alone is not the sole contributing factor (as we would have expected countryside visit rates to be lower from larger urban areas if so). Thus we do not believe having incorporated a measure of green-space accessibility would have influence our results but it would have been useful in helping to understand underlying mechanisms of the patterns observed and so should be incorporated into future studies.

*Response bias*

The response rate for this study was only 19% and so our results may be subject to non-response bias with increased risk that the sampled populations are not representative of each urban area population as a whole (Berg, 2005). Recruiting participants from areas of high deprivation can be difficult and drive low response rates (Parry *et al.*, 2001). Indeed, we found after the initial round of surveys using randomly selected postcodes that response rates were lower from areas of higher deprivation (*r2* = 0.10, *P* < 0.0001) as measured using the Index of Multiple Deprivation (Office for National Statistics, 2010). We then took a more targeted sampling approach to ensure we included participants from the full spectrum of deprivation indices represented in each urban area. Thus the difficulty of recruiting participants from areas of high deprivation will have contributed to our low response rates. Hopefully having included participants from such areas as a result of our targeted sampling approach will have reduced any non-response bias but as no follow up work was conducted we cannot be certain this was the case. Although the relationship between response rate and deprivation was highly significant, the coefficient of correlation was low suggesting that other factors were also contributing to the low response rate. Although some socio-economic aspects are incorporated into the Index of Multiple Deprivation, we were unable to compare the socio-demographics of our participants with those from the urban areas as a whole and so we cannot decipher any such bias in our sample (though we did control for influences of these factors). It is also possible, that our sample is biased towards those with an interest in the subject matter but with no non-response bias assessment we cannot determine whether this was the case and what the impacts on our findings may be if so.

### Conclusion

We provide a vital first step in the provision of evidence that engaging with nature by visiting green-spaces is associated with enhanced biodiversity knowledge and conservation support as predicted by conservation policies that aim to increase peoples’ exposure to green-space. These relationships, however, only arose from visiting the countryside and not urban green-spaces. We have thus uncovered a previously undescribed mechanism through which urban development may reduce biodiversity knowledge and conservation support. This is concerning as many urban dwellers visit the countryside very infrequently. Larger cities were not associated with reduced biodiversity knowledge and conservation support, but the intensity of urban development around respondent’s homes was associated with reduced countryside visit rates and biodiversity knowledge. Our results thus suggest that conservation policies that aim to maximize urban residents’ abilities to develop and maintain biodiversity knowledge and support for conservation should focus on creating less dense cities, rather than smaller but more intensely urbanized ones, whilst enhancing access to the countryside though further research is necessary to address the limitations outlined above and to ensure our findings are representative of a larger suite or urban areas across the UK.

## Appendix 2.1

Summary of retained models that assess the impact of visit rates to the countryside and urban green-space on biodiversity knowledge and conservation support when visits are modelled as a categorical variable. The models confirm the results obtained when modelling visitation rates as continuous variables (Table 2.8), i.e. that biodiversity knowledge and behavioural conservation support are positively associated with countryside visitation rates but have negligible associations with visits to urban green-space, and that financial conservation support is not strongly associated with visits to the countryside or urban green-space. Models presented are all those with ΔAICc values < 4; city (random factor) and socio-economic and demographic variables (fixed factors) were incorporated into all models to control for their influence.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence interval)* | | | | | | | | | | | |  |  |  |
| *Response variable* | *Green-space visit type* | *Green-space visit rate* | | | | | | | *Socio-economic status* | *Ethnicity-deprivation index* | *Age* | *Gender* | *AICc* | *ΔAICc* | *Model weight* |
| *Once/twice a year* | *Every few months* | *Monthly* | *Fortnightly* | *Several times a week* | *Weekly* | *Daily* |
| Biodiversity knowledge | Countryside | 0.07 (-0.29 to 0.43) | 0.26 (-0.11 to 0.63) | 0.26 (-0.13 to 0.65) | 0.46 (0.03 to 0.89) | 0.57 (0.16 to 0.98) | 0.69 (0.23 to 1.16) | 0.66 (0.04 to 1.27) | 0.27 (0.16 to 0.38) | -0.23 (-0.34 to -0.12) | 0.02 (0.01 to 0.02) | 0.01 (-0.18 to 0.20) | 714.82 | 0 | 0.98 |
| Behavioural conservation support | Countryside | 0.02 (-0.39 to 0.43) | 0.18 (-0.24 to 0.59) | 0.30 (-0.14 to 0.74) | 0.64 (0.15 to 1.13) | 0.53 (0.06 to 1.00) | 0.51 (-0.02 to 1.04) | 0.92 (0.23 to 1.61) | 0.13 (0.01 to 0.25) | 0.17 (0.04 to 0.29) | 0.00 (-0.01 to 0.00) | -0.22 (-0.43 to 0.00) | 774.19 | 0 | 0.70 |
|  | Urban green-space | 0.09 (-0.56 to 0.73) | 0.10 (-0.49 to 0.69) | 0.19 (-0.41 to 0.79) | 0.64 (0.00 to 1.27) | 0.33 (-0.26 to 0.93) | 0.64 (0.04 to 1.24) | 0.50 (-0.12 to 1.13) | 0.14 (0.02 to 0.26) | 0.14 (0.02 to 0.26) | 0.00 (-0.01 to 0.00) | -0.15 (-0.37 to 0.07) | 775.92 | 1.73 | 0.30 |
| Financial conservation support |  |  |  |  |  |  |  |  | 0.22 (0.12 to 0.32) | -0.11 (-0.22 to -0.01) | 0.00 (-0.01 to 0.01) | -0.13 (-0.33 to 0.06) | 715.01 | 0 | 0.84 |

## Appendix 2.2

Summary of retained models developed to assess the impact of green-space visitation (modelled as a continuous variable) on biodiversity knowledge and conservation support when excluding all participants who stated nature or nature related activities as their primary motivation for visiting green-space. Models presented are all those with ΔAICc values < 4; city (random factor) and socio-economic and demographic variables (fixed factors) were incorporated into all models to control for their influence.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Explanatory variable parameter estimate (95% confidence intervals)* | | | | | | *AICc* | *ΔAICc* | *Model weight* |
| *Response variable* | *Countryside visit rate* | *Urban green-space visit rate* | *Socio-economic status* | *Ethnicity-deprivation index* | *Age* | *Gender* |
| Biodiversity knowledge | 0.10  (0.04 to 0.15) |  | 0.30  (0.19 to 0.41) | -0.22  (-0.33 to -0.10) | 0.02  (-0.04 to 0.08) | 0.05  (-0.15 to 0.25) | 650.15 | 0 | 0.94 |
| Behavioural conservation support | 0.10  (0.03 to 0.16) |  | 0.14  (0.02 to 0.27) | 0.13  (0.01 to 0.26) | 0.00  (-0.01 to 0.00) | -0.22  (-0.44 to 0.01) | 697.81 | 0 | 0.61 |
| " |  | 0.09  (0.03 to 0.15) | 0.14  (0.01 to 0.26) | 0.12  (0.00 to 0.24) | 0.00  (-0.01 to 0.00) | -0.20  (-0.42 to 0.02) | 698.74 | 0.93 | 0.39 |
| Financial conservation support |  | 0.05  (0.00 to 0.11) | 0.17  (0.06 to 0.28) | -0.10  (-0.22 to 0.01) | 0.00  (-0.01 to 0.00) | -0.11  (-0.31 to 0.09) | 637.16 | 0 | 0.58 |
| " | 0.05  (-0.01 to 0.10) |  | 0.18  (0.06 to 0.28) | -0.10  (-0.22 to 0.01) | 0.00  (-0.01 to 0.00) | -0.09  (-0.31 to 0.08) | 638.28 | 1.10 | 0.33 |
| " |  |  | 0.21  (0.10 to 0.31) | -0.12  (-0.24 to -0.01) | 0.00  (-0.01 to 0.01) | -0.09  (-0.29 to 0.11) | 640.96 | 3.80 | 0.09 |

# Mental well-being is positively associated with visiting green-space in cities and the countryside, but not actual or perceived levels of local urbanisation (in review with the journal Landscape and Urban Planning)

## Abstract

Exposure to green-space, a dose of nature, promotes mental well-being but there are uncertainties regarding this relationship. Using door-to-door surveys of urban residents across six English cities, we assess if mental well-being is more closely associated with composition of respondents’ local surroundings (perceived and actual) or visiting green-space (in urban areas and the countryside). We assess whether green-space visitation rates measured over short or long time scales, i.e. duration of the dose of nature, are stronger predictors of mental well-being. Finally, mental well-being has been linked to perceived biodiversity so we assess if respondents’ biodiversity knowledge influences relationships between well-being and green-space visitation rates. People perceive the amount of greenery and built-up land surrounding their home fairly accurately, but perceptions do not directly match standard urbanisation metrics. Mental well-being is positively associated with the frequency of visits to urban green-space and the countryside, but not the composition of local surroundings (perceived or actual) or garden use. Feeling that life is worthwhile is associated more strongly with visiting the countryside than urban green-space, but reduced anxiety is more strongly associated with urban green-space visits. Prolonged doses of nature exposure (frequent green-space visits over a year rather than two weeks) typically have greater well-being impacts. There was negligible evidence that people with higher biodiversity knowledge gain greater well-being benefits from visiting green-space. Experiencing nature through regular visits to urban green-space and the countryside over long time scales, rather than increasing greenery in local surroundings, thus appears to maximise urban residents’ mental well-being.

## Introduction

Poor mental well-being is one of the leading disease burdens globally (World Health Organization, 2008). For example, during a typical year, one in four adults in the UK are expected to have mental health problems (Mental Health Foundation, 2015). Current evidence suggests that maintaining mental health and well-being in urban environments is especially challenging (Srivastava, 2009; Lederbogen *et al.*, 2011). A vast literature has now come to the fore suggesting that exposure to green-space and natural environments can promote well-being and thus alleviate or prevent mental health problems. Multiple comprehensive reviews address the evidence for relationships between human health and exposure to green-space and report numerous benefits including positive psychological, cognitive, physiological and social impacts (e.g. Bowler et al. 2010; Hartig et al. 2014; Romanelli et al. 2015; Sandifer et al. 2015; van den Berg et al. 2015).

There are, however, a number of uncertainties regarding the form of the relationships between green-space and mental well-being and the mechanisms that drive these patterns. Many studies of these relationships focus on local environments and take an empirical measure of the amount of green-space, and assess how variation in this measure is associated with health metrics. Such studies provide substantial evidence for positive associations between greenery and health (e.g. White et al. 2013; van den Berg et al. 2015). These studies are extremely useful but people’s perception of a given situation, which can be rather different to the actual situation, can have a strong impact on mental well-being (Conversano *et al.*, 2010; Korn *et al.*, 2014). This form of cognitive bias could play a role in linkages between exposure to green-space and psychological well-being. Notably, studies indicate that the perceived amount of greenery in a neighbourhood can positively influence mental well-being (Sugiyama *et al.*, 2008), but the evidence that such perceptions are accurate is highly equivocal; Leslie et al. 2010). There is thus a need for additional research assessing the accuracy of people’s perceptions of their local environment, and whether the actual or perceived amount of green-space is a better predictor of mental well-being.

Given the particular challenge of addressing mental health and well-being issues in urban environments (Srivastava, 2009; Lederbogen *et al.*, 2011), including reduced engagement with green-space amongst urban residents (Kareiva, 2008), it is particularly important to assess the ability of urban green-space to promote well-being compared to other forms of green-space outside cities. It is plausible that visits to the countryside have a greater impact on mental health and well-being than visits to urban parks as i) whilst there are some exceptions, broadly speaking biodiversity is much lower in highly developed urban areas than elsewhere (Tratalos *et al.*, 2007; Aronson *et al.*, 2014) which is important given the potential link between biodiversity and well-being (Fuller et al. 2007; Dallimer et al. 2012) and ii) visit rates to the countryside and urban green-space appear to have differential impacts on other intrinsic traits linked to biodiversity, including people’s knowledge of and willingness to protect biodiversity (Chapter 2). Very few studies, however, have assessed if urban green-space performs as well as other more natural types of green-space, such as the countryside, in promoting well-being and mental health. De Vries et al. (2003) found greater delivery of health benefits from agricultural land than both urban green-space and forest/nature areas, but proposed that this was simply a function of the greater abundance of agricultural land. Notably, Korpela et al. (2010) found that urban areas provide fewer restorative benefits than more natural settings, and Tyrväinen et al. (2014) concluded that forest areas perform better than urban parks and urban woodlands in reducing negative feelings and enhancing restoration.

There is also increasing interest in assessing how much exposure to biodiversity is required to generate benefits of a given magnitude, and such dose-response curves are being constructed to assess the association between connecting with nature and mental well-being (Shanahan *et al.*, 2015). Assessing the form of the relationship between green-space visitation rates and mental well-being is an important part of this agenda. An additional important component that receives less attention is the timescale over which connectedness to nature needs to be enhanced to deliver benefits, i.e. does visiting green-space more frequently over a period of just a few weeks improve mental well-being, or does increased engagement need to occur over much longer time periods, e.g. an entire year. It is thus important to assess how variation in the duration of the dose, and not just its magnitude, influence mental health but much of the work addressing the impacts of green-space engagement on health and well-being considers a single intervention over a short time period (e.g. Laumann et al. 2003; Berman et al. 2008).

It is also uncertain if visiting green-space regularly can compensate for negative mental well-being impacts associated with living in locations with little green-space. There is some indirect evidence for this from a study in the Netherlands which found that mental health benefits were not associated with the amount of greenery within the local environment of people’s homes (defined as a 1km radius), but were associated with greenery within a 3km radius of the home (van den Berg, Maas, *et al.*, 2010). The authors interpret these data as evidence that visits to larger areas of green-space that allow for deeper forms of restoration are required to deliver mental well-being benefits.

Finally, given that biodiversity might mediate the relationship between green-space and mental well-being it is plausible that people’s biodiversity knowledge may alter the relationship between exposure to green-space and mental well-being. Moreover, the nature of this relationship could be context dependent. In biodiversity rich environments greater knowledge of biodiversity may enhance perception of environmental quality leading to greater well-being benefits from exposure to green-space. Conversely, in environments that are relatively poor in biodiversity it is plausible that having greater biodiversity knowledge will limit appreciation of the environment (as its poor quality is recognised) and thus reduce the beneficial impact of green-space on well-being. We are not aware of previous studies assessing how mental well-being is influenced by these interactions between biodiversity knowledge and exposure to green-space.

Despite a significant evidence base for the mental well-being benefits delivered by green-space, it is clear that many aspects of these relationships require additional exploration. Here, we test whether i) people accurately perceive the composition of their local environment, ii) perceived or actual composition of local surroundings has a greater impact on mental well-being, iii) mental well-being is positively associated with visits to green-spaces but that green-space type (urban green-space versus the countryside) and use of short-term and long-term visitation rates (i.e. duration of the dose) influence the strength of the relationship and iv) knowledge of biodiversity influences the relationship between green-space visits and mental well-being. We do so using interview data from over 200 people from six urban areas in England, in which respondents are selected in a manner that is unbiased with regard to their use of green-spaces and their socio-economic profile.

## Methods

### Survey sites, participant recruitment and sample size

Detailed description and justification of survey site choice and participant recruitment is given in Chapter 2 (section 2.3). In brief, surveys were conducted from mid-July to early October 2013 in six urban areas located across England. These urban areas are located within three separate regions, within which we selected one large and one small urban area. Whilst we exclude megacities, our focal urban areas are thus otherwise broadly representative of the gradient of city sizes present in the UK and other European countries. Large urban areas consisted of those comprising at least 32km2 of urban land cover, defined following Smith et al. (2005) as 1km x 1km grid cells with at least 25% coverage of hard surface. Small urban areas covered less than 18km2 of urban land cover and were at least three times smaller than their paired larger urban area. The urban areas within each region were separated by at least 12km of countryside and their centres were within 18-35km from each other. This ensured that the two urban areas were distinct, yet residents had access to similar countryside. Our focal regions and cities were: Manchester and Blackburn in the north-west/Lancashire; Bristol and Bath in the south-west/Somerset; and Leeds and Harrogate in the north-east/Yorkshire.

Door-to-door interviews were conducted face-to-face during weekday and weekend afternoons and evenings in two stages. We first randomly selected 20 to 25 six figure (i.e. full resolution) postcodes from each urban area that were within 3km of its centre and contained at least 15 households. We attempted to interview all households within each postcode except when respondents had lived at their current address for less than three months, or the safety of the interviewers was a major concern. We then used the Index of Multiple Deprivation (Office for National Statistics, 2010) of each respondent’s lower super output area (the smallest spatial unit in the National Census, and typically slightly larger than the area represented by a six figure postcode) as an indicator of the respondents’ socio-economic profile. The distribution of these deprivation indices was compared to that for the entire urban area to assess if respondents were representative of the focal survey area and to guide selection of additional postcodes in which all households were asked to take part in the survey. Within each urban area the distribution of our final set of respondents’ deprivation scores were broadly representative of people living in the focal urban area (see Chapter 2, Fig. 2.3). The total number of analysable questionnaires ranged from 204 to 206 (100 to 101 men and 103 to 105 women) due to missing data and removal of respondents who had been on holiday in the previous two weeks for some analyses (see 3.3.6), with an overall response rate of 19.8%.

### Local surroundings - actual and perceived levels of urbanisation

We wanted to establish the relationship between the degree of both actual and perceived local-scale urbanisation on mental well-being and whether there was a contrast between the two. To gauge participants’ perceptions of their local surroundings we asked respondents how much i) built-up land and ii) greenery there was within a five minute walk from where they lived on a five point scale (none, very little, a fair amount, a lot and completely surrounded). As it was participants’ perceptions that were of importance here, we did not want to influence their responses by giving definitions of built up land and greenery. What would officially be classed as greenery in a participant’s local environment was not important, only what said participant would class as green. On piloting the questionnaire, however, respondents regularly requested clarification of the term “built up” and so we gave a few examples (“buildings, roads, carparks etc”) when asking this question during the surveys. Unfortunately we did not initially include the question relating to greenery in the questionnaire and so this data is missing for 76 respondents. The concept of greenery did not cause confusion for participants and so no definition was given.

The average walking speed is approximately 5kmhr-1 (Browning *et al.*, 2006), thus these estimates of the perceived amount of built-up land/greenery are approximately equivalent to the actual levels of urbanisation within a 1km grid-cell focused on the respondent’s home. We thus quantified the magnitude of local scale urbanisation within the 1km grid cell centered on each survey postcode. Scores were calculated using image recognition software (Seress *et al.*, 2014) to generate a single metric of urbanisation based on a semi-automated assessment of the area of buildings, other impervious surfaces and vegetation from google earth aerial photographs (see Chapter 2, Fig. 2.2). The aerial images used in our analyses were taken between one month and five years prior to the door-to-door surveys (Leeds: September 2008; Harrogate: May 2009; Manchester: June 2009; Blackburn: May 2009; Bristol: July 2013 and Bath: July 2013). Ground truthing did not reveal any major changes in land-cover type between the imagery dates and those of the surveys. Further details and justification of the local scale urbanisation metric is given in 2.3.1.

### Green-space visitation rates

To address questions concerning how the type of green-space influences mental well-being we asked participants how often they visited i) the countryside and ii) urban green-spaces on average in a year on an eight point scale (never, once/twice a year, every two or three months, monthly, fortnightly, weekly, several times a week and daily). If clarification was requested, countryside was defined as “rural land outside of the city” and urban green-space as “public green/vegetated areas within cities and towns such as public parks (excluding your garden)”. These questions thus provide information on engagement with green-space over a long time period, i.e. duration of the dose. To contrast this with exposure over a short time period we also asked how many visits respondents made to the countryside and urban green-space in the previous two weeks. Well-being can also be influenced by having a garden (Cameron *et al.*, 2012) thus participants were asked how frequently they spent time in their gardens on average in a year on a nine point scale (no garden, never, once/twice a year, every two or three months, monthly, fortnightly, weekly, several times a week and daily). Having a garden but not using it (2% of respondents) was considered as different to having no garden (8% of respondents) as the former could still enhance green-space exposure through passive viewing of the garden.

### Mental well-being

There are a number of different approaches to measuring mental well-being (Dolan and Metcalfe, 2012). Given the links reported between nature exposure and general mental well-being (Bowler *et al.*, 2010) this is what we wanted to capture in the present study. Metrics used to diagnose both minor (e.g. GHQ-12; Goldberg & Williams 1991) and acute psychiatric disorders (e.g Beck Depression Inventory; Beck et al. 1996) were therefore not appropriate for our purpose. There are three core approaches to measuring broader, subjective well-being; evaluative, experience and eudemonic (Tinkler and Hicks, 2010). Some well-being metrics focus on just one of these aspects (e.g. life satisfaction indices assess only the evaluative aspect; Diener et al. 2012). We follow the approach recommended by Michaelson et al. (2012) and Self & Randall (2013) which combines two separate metrics of subjective well-being providing a balanced assessment of all three aspects of subjective mental well-being in a manner which has been shown to be theoretically rigorous, policy relevant and empirically robust in a UK context (Dolan and Metcalfe, 2012). The first approach is the Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) which focuses on the feeling and functioning aspects of positive mental well-being with an emphasis on the latter (Stewart-Brown et al. 2009). It consists of seven items, such as “I’ve been feeling useful” and “I’ve been dealing with problems well” (see Q23 in Appendix B), scored on a five point scale of agreement based on the respondent’s experience over the last two weeks, with responses ranging from ‘none of the time’ to ‘all of the time’. Responses are summed across all seven questions to give a single SWEMWBS score ranging from 7 (none of the time selected for each question) to 35 (all of the time selected for each question; Stewart-Brown et al. 2009). The second approach was to use a set of four questions that measure self-reported independent aspects of the respondents’ quality of life and are used across the UK by the Office for National Statistics (ONS; Tinkler & Hicks 2010; Self & Randall 2013). The four questions are i) overall, how satisfied are you with your life nowadays? (referred to as ‘satisfied’), ii) overall, to what extent do you feel that the things you do in your life are worthwhile? (referred to as ‘worthwhile’), iii) overall, how happy did you feel yesterday? (referred to as ‘happy yesterday’) and iv) overall, how anxious did you feel yesterday? (referred to as ‘anxious yesterday’). These are given a score from zero to ten where zero is ‘not at all’ and ten is ‘completely’.

### Biodiversity knowledge

We used a single measure of biodiversity knowledge that is a PCA-derived metric of three domains, i.e. respondents’ i) species identification skills, ii) knowledge of species conservation status and iii) ability to accurately assess the quality of wildlife habitats. This measure is fully described in Chapter 2 (section 2.5.2). In brief, we used high quality colour images of 12 native species that are widespread across England (four birds, four mammals and four plants) and asked respondents to identify them and state if the species was of conservation concern in the UK (i.e. a UK Biodiversity Action Plan priority species). Habitat quality assessment was measured by asking respondents to rank three images according to their habitat quality for each of three habitat types (arable farmland, wetland and woodland) and comparing these rankings to those of three independent experts (who all scored the images consistently). Linear principal component analysis (PCA) with direct oblimin rotation (as recommended by Tabachnick & Fidell (2001) due to the correlation coefficient of component scores being greater than 0.32) was conducted in SPSS version 21, following standardisation of variables using z-scores, resulted in scores for all three domains loading strongly and positively onto a single axis (eigenvalue 1.91; component loadings: identification score 0.86; conservation status score 0.78; habitat quality score 0.75) which accounted for 63.8% of the variation.

### Holidays, socio-economic and demographic information

Participants were asked whether they had been on holiday in the previous two weeks. Data from these respondents (55 people) formed part of the data used in analyses of the relationships between actual and perceived urbanisation, but were not used in analyses of the relationships between well-being and green-space visit rates as recent holidays are likely to influence well-being scores. Participants’ employment status, highest level education qualification, tax band, age (treated as a continuous variable using the mid-points of our categories), gender, ethnicity and marital status were also recorded (Table 3.1) as previous studies have shown these factors can influence subjective well-being (Oguz, Merad and Snape, 2013). Categorical principle component analysis (CATPCA) was conducted in SPSS version 21 using employment status, education, tax band (as an indicator of wealth), ethnicity data and scores of the Index of Multiple Deprivation (Office for National Statistics, 2010) of participants’ home locations. Age, gender and marital status were not included in the CATPCA as they are largely independent of employment status, education, wealth, ethnicity and deprivation and were thus used as additional predictor variables. The CATPCA identified two axes. Employment, education and tax band loaded onto the first axis (eigenvalue of 1.95) which we term socio-economic status. Ethnicity and deprivation scores loaded on to the second axis (eigenvalue of 1.49) which we term the ethnicity-deprivation index. For more information on these axes see Chapter 2 (section 2.3.6).

**Table 3.1.** The categories available to respondents when answering questions concerning socio-economic and demographic indicators. In addition respondents were asked for their postcode.

|  |  |
| --- | --- |
| *Socio-economic / demographic indicator* | *Answer categories* |
| Employment | Retired, Unemployed, Full-time education, Full-time paid employment, Part-time paid employment, Self-employed, Home maker/bringing up family |
| Education | None, O level/GCSE or equivalent, A level or equivalent, Undergraduate degree, Higher degree |
| Tax band | No tax (<£9,440 taxable income), Basic rate (£9,440-£32,010), Higher rate (£32,011-£150,000), Top rate (£>150,000) |
| Ethnicity | Office for National Statistics guidelines were used for ethnic group selection (http://ons.gov.uk/ons/guide-method/measuring-equality/equality/ethnic-nat-identity-religion/ethnic-group/index.html) but for analysis purposes these were categorised as white British, white non-British and non-white |
| Age | 16-18, 19-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85-94, 94+ |
| Gender | Male, Female |
| Marital status | Married/civil partnership, co-habiting, single, divorced, widowed |

### Statistical analysis

The diagnostic procedure advocated by Pasta (2009) which assesses whether ordinal predictor variables best fit the data when treated as categorical or continuous indicated that all ordinal predictor variables (i.e. perceived built-up land and annual green-space visitation rates) should be treated as continuous in our analyses. This allowed us to standardize all ordinal and continuous predictor variables using z-scores prior to subsequent analyses, thus enabling direct comparison of predictors’ parameter estimates.

To test the hypothesis that people accurately perceive the intensity of urbanisation in their local environment we first modelled the perceived amount of greenery as a function of the perceived amount of built-up land and vice versa. These analyses did not find a strong association between perceived greenery and perceived urbanisation (see results). We thus used both of these variables as response variables and modelled i) perceived amount of greenery and ii) perceived built-up land as functions of actual urbanisation. We restricted these analyses to the 205 people for which data on both these response variables were available (including those who had been on holiday in the previous two weeks) to ensure that any variation in the form of the resultant relationships was not due to variation in respondents’ characteristics or local environments. All analyses were conducted using mixed ordinal regression models with the CLMM2 function and a logit link in the ordinal package in R (Christensen, 2015). Postcode was included as a random factor to control for multiple participants from the same postcode.

We then follow Whittingham et al. (2006) and use a full model approach to test the rest of our core research questions. We assess if a) perceived or actual levels of urbanisation are more closely associated with mental well-being (these models use perceived built-up land rather than perceived greenery, due to the larger sample size for the former and preliminary analyses show no influence of perceived greenery on well-being; Appendix 3.1); b) if visitation rates to urban green-space and the countryside have different influences on mental well-being and if these relationships are influenced by measuring visitation rates over different time scales (i.e. the duration of the dose of green-space visits); and c) if interactions between biodiversity knowledge and green-space visitation rates influence mental well-being. All those who had been on holiday in the previous two weeks were removed from analyses as were participants who had not answered the well-being indicator being tested (N = 204 – 206 as missing values varied depending on which well-being indicator was being analysed).

We model each of our five indicators of well-being as a function of green-space visitation rate, actual urbanisation intensity, perceived built-up land, city size, garden use, socio-economic status, ethnicity-deprivation, marital status, age and gender (all fixed factors) and postcode as a random factor. For each well-being metric we initially construct four full models that vary only in the nature of the visitation rate measure, which was either i) countryside visitation rate in the last two weeks, ii) urban green-space visits in the last two weeks, iii) countryside visits per annum, and iv) urban green-space visits per annum. We adopted this approach rather than including multiple visitation rate metrics into the same model to avoid issues with collinearity between different measures of visitation rates (which ranged from rs = 0.39, *P* < 0.001 to rs = 0.70, *P* < 0.001). As we use a full model approach we focus on using the *P* values of our key predictors (such as visitation rates) for testing our hypotheses. However, because we construct equivalent models that vary only in their green-space visitation rate metric we also compare the Akaike Information Criteria scores corrected for small samples sizes (AICc values) and conditional r-squared values (calculated using R package piecewiseSEM; Nakagawa & Schielzeth 2013) across these models. We then constructed a second set of full models that contained all the above predictors but that also included respondents’ biodiversity knowledge and its interaction with green-space visitation rate. For each response variable we thus construct a total of eight full models (four visitation rate metrics with and without interactions with biodiversity knowledge) but follow the advice of Nakagawa (2004) and do not use Bonferroni corrections when assessing the significance of *P* values.

The SWEMWBS well-being measure should be treated as a continuous metric (Stewart-Brown *et al.*, 2009) and was thus modelled using a linear mixed model in the lme4 package in R (Bates *et al.*, 2014). ONS response variables are, in the strictest sense, ordinal data on a ten point scale, but best practice guidance and previous analyses of these response variables indicate that they can be treated as continuous data as this increases interpretability and does not alter conclusions (Ferrer-i-Carbonell and Frijters, 2004; Rhemtulla, Brosseau-Liard and Savalei, 2012; Oguz, Merad and Snape, 2013). We thus follow this advice and report in the main body of the chapter the results of linear mixed models constructed using the lme4 package (Bates *et al.*, 2014), but take a conservative approach and also constructed ordered mixed probit regressions using the ordinal package (Christensen, 2015). Ordinal models of worthwhile and anxious yesterday did not converge but for all other response variables the linear mixed models (reported in the main table, Table 3.4) and ordered mixed probit regressions (reported in Appendix 3.2) generated qualitatively similar results and thus model structure did not alter our conclusions.

## Results

### Participants

A summary table of socio-economic and demographic characteristics of respondents is given in Chapter 2 (section 2.8). Marital status was not incorporated into analyses for Chapter 2 as there is no evidence to suggest that it would influence knowledge of biodiversity or support for conservation. Marital status of respondents in this study is thus reported in Table 3.2.

**Table 3.2.** Marital status of respondents (N = 286).

|  |  |  |
| --- | --- | --- |
| *Marital status* | *n* | *%* |
| Married/civil partnership | 124 | 43 |
| Co-habiting | 22 | 8 |
| Single | 90 | 31 |
| Divorced | 26 | 9 |
| Widowed | 23 | 8 |

### Local surroundings - association between perceived and actual levels of local urbanisation

Respondents perceived there to be less greenery in their local environment when they perceived there to be more built-up land and vice versa (Table 3.3). Perceptions of the amount of built-up land and greenery are not, however, simply the converse of each other, for example comparing parameter estimates reveals that respondents perceived very similar amounts of greenery when they perceived a difference in the amount of built-up land (Table 3.3).

**Table 3.3.**Mixed ordinal regression models of perceived built-up land as a function of perceived greenery and postcode (as a random factor) and vice versa. “Completely surrounded” was the reference category for both predictors, note that no respondents perceived there to be no built-up land in their local environment.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Response variable* | *Predictor variable* | *Parameter estimate* ± *SE* | *P value* | *Overall P value* | *AIC* |
| Perceived greenery | Perceived built-up land  None | - | - | 0.000008 | 488.20 |
| Very little | 2.26 ± 0.60 | 0.0002 |  |  |
| A fair amount | 2.06 ± 0.46 | <0.0001 |  |  |
| A lot | 1.03 ± 0.43 | 0.0176 |  |  |
| Perceived built-up land | Perceived greenery  None | 2.38 ± 1.41 | 0.0915 | 0.000012 | 520.21 |
| Very little | 3.00 ± 1.09 | 0.0067 |  |  |
| A fair amount | 2.12 ± 1.09 | 0.0519 |  |  |
| A lot | 1.00 ± 1.03 | 0.3364 |  |  |

When comparing perceptions of greenery and built-up land with actual levels of local urbanisation respondents living in more urbanised areas perceived the area to be less green (*P* < 0.001; parameter estimate -0.36 ± 0.07) and more built-up (*P* < 0.001; parameter estimate 0.27 ± 0.08). Comparing these parameter estimates indicates that for a given change in actual urbanisation, a bigger reduction in perceived greenery occurs than increase in perceived built-up land.

### Mental well-being models - associations between perceived and actual levels of local urbanisation

Our models of mental well-being on average explained 13% of the variation (range across all models 5-18%). Actual levels of local urbanisation were not associated with any of our mental well-being indicators (Table 3.4). This was also the case for perceived amounts of built-up land though *P* values did approach significance for the SWEMWBS indicator when modelled with urban green-space visits (Table 3.4).

**Table** **3.4**. Multiple linear regression models of five different mental well-being indices constructed with response variables treated as continuous data. Each well-being indicator is modelled as a function of four different visitation rates, perceived and actual urbanisation intensity around the home, city size, garden use, socio-economic and demographic variables (all fixed factors) and postcode (random factor). The model with the lowest AICc value of the four visitation types for each well-being metric is highlighted in grey. \* P < 0.05, \*\* P < 0.01

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | | | | | | | | | | | | |
|  | *Visits* | | *City size* | | *Actual local urbanisation* | | *Perceived built-up land* | | *Garden use* | | *Socio-economic status* | | *Ethnicity deprivation index* | | *Marital status (reference = married,*  *C = co-habiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | | *Age* | | *Gender*  *(reference = male)* | | *Conditional R2* | | *AICc* | |
| ***SWEMWBS*** | | | | | | | | | | | | | | | | | | | | | | | |
| Countryside over last two weeks | 0.13,  0.93 ± 0.62 | 0.60,  0.28 ± 0.54 | | 0.15,  0.85 ± 0.59 | | 0.09,  -0.82 ± 0.48 | | 0.52,  -0.32 ± 0.49 | | 0.03\*,  1.14 ± 0.53 | | 0.92,  -0.07 ± 0.65 | | 0.99, C 0.20 ± 0.96, S 0.00 ± 0.66, D 0.03 ± 0.90, W 0.53 ± 0.98 | | 0.03\*,  1.57 ± 0.72 | | 0.98,  -0.01 ± 0.48 | | 0.13 | | 1065.6 | |
| Urban green-space over last two weeks | 0.87,  0.09 ±0.52 | 0.55,  0.28 ± 0.55 | | 0.18,  0.80 ± 0.60 | | 0.06,  -0.88 ± 0.48 | | 0.55,  -0.30 ± 0.50 | | 0.03\*,  1.19 ± 0.55 | | 0.79,  -0.17 ± 0.65 | | 0.99, C 0.13 ± 0.97, S 0.04 ± 0.99, D 0.06 ± 0.91, W 0.31 ± 0.97 | | 0.02\*,  1.66 ± 0.72 | | 0.93,  -0.04 ± 0.48 | | 0.11 | | 1067.9 | |
| Countryside per annum | 0.04\*,  0.29 ±0.15 | 0.53,  0.34 ± 0.54 | | 0.15,  0.84 ± 0.59 | | 0.10,  -0.78 ± 0.47 | | 0.53,  -0.31 ± 0.49 | | 0.12,  0.86 ± 0.55 | | 0.98,  0.01 ± 0.65 | | 0.99, C 0.20 ± 0.95, S-0.02 ± 0.66, D-0.04 ± 0.90, W 0.50 ± 0.97 | | 0.04\*,  1.47 ± 0.72 | | 0.93,  0.04 ± 0.48 | | 0.13 | | 1063.9 | |
| Urban green-space per annum | 0.01\*,  0.33 ± 0.13 | 0.97,  0.02 ± 0.55 | | 0.16,  0.83 ± 0.59 | | 0.07,  -0.84 ± 0.47 | | 0.30,  -0.52 ± 0.50 | | 0.19,  0.73 ± 0.56 | | 0.92,  0.07 ± 0.64 | | 0.99, C -0.08 ± 0.95, S0.09 ± 0.65, D 0.01 ± 0.90, W 0.54 ± 0.96 | | 0.03\*,  1.55 ± 0.71 | | 0.94,  0.04 ± 0.48 | | 0.15 | | 1061.5 | |
| ***Satisfied*** |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Countryside over last two weeks | 0.02\*,  0.82 ± 0.36 | 0.46,  -0.23 ± 0.30 | | 0.30,  -0.34 ± 0.32 | | 0.67,  -0.12 ± 0.27 | | 0.69,  -0.11 ± 0.29 | | 0.37,  0.28 ± 0.31 | | 0.12,  0.58 ± 0.37 | | 0.56, C 0.20 ± 0.58, S -0.51 ± 0.38, D -0.45 ± 0.51, W -0.30 ± 0.54 | | 0.21,  0.52 ± 0.41 | | 0.06,  0.52 ± 0.27 | | 0.10 | | 872.6 | |
| Urban green-space over last two weeks | 0.32,  0.30 ± 0.30 | 0.40,  -0.26 ± 0.31 | | 0.25,  -0.38 ± 0.33 | | 0.51,  -0.18 ± 0.27 | | 0.67,  -0.12 ± 0.30 | | 0.42,  0.26 ± 0.32 | | 0.18,  0.49 ± 0.37 | | 0.61, C 0.08 ± 0.59, S -0.47 ± 0.38, D -0.45 ± 0.52, W -0.48 ± 0.54 | | 0.17,  0.56 ± 0.42 | | 0.07,  0.51 ± 0.28 | | 0.08 | | 876.7 | |
| Countryside per annum | 0.00\*\*,  0.27 ± 0.08 | 0.54,  -0.18 ± 0.30 | | 0.30,  -0.33 ± 0.32 | | 0.74,  -0.09 ± 0.27 | | 0.73,  -0.10 ± 0.29 | | 0.96,  0.02 ± 0.32 | | 0.08,  0.64 ± 0.36 | | 0.53, C 0.18 ± 0.57, S -0.51 ± 0.38, D -0.48 ± 0.51, W -0.36 ± 0.53 | | 0.28,  0.44 ± 0.41 | | 0.04\*,  0.56 ± 0.27 | | 0.13 | | 867.4 | |
| Urban green-space per annum | 0.00\*\*,  0.24 ± 0.08 | 0.18,  -0.41 ± 0.31 | | 0.30,  -0.33 ± 0.32 | | 0.57,  -0.15 ± 0.27 | | 0.37,  -0.26 ± 0.29 | | 0.91,  -0.04 ± 0.33 | | 0.08,  0.64 ± 0.36 | | 0.68, C -0.09 ± 0.57, S -0.47 ± 0.38, D -0.51 ± 0.51, W -0.33 ± 0.53 | | 0.24,  0.48 ± 0.41 | | 0.04\*,  0.57 ± 0.27 | | 0.12 | | 867.9 | |

**Table** **3.4**. Continued.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | | | | | | | | | | | | |
|  | *Visits* | | *City size* | | *Actual local urbanisation* | | *Perceived built-up land* | | *Garden use* | | *Socio-economic status* | | *Ethnicity deprivation index* | | *Marital status (reference = married,*  *C = co-habiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | | *Age* | | *Gender*  *(reference = male)* | | *Conditional R2* | | *AICc* | |
| ***Worthwhile*** |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Countryside over last two weeks | 0.03\*,  0.69 ± 0.32 | 0.44,  0.21 ± 0.27 | | 0.62,  -0.14 ± 0.29 | | 0.50,  -0.16 ± 0.24 | | 0.18,  0.35 ± 0.26 | | 0.15,  0.40 ± 0.28 | | 0.22,  0.40 ± 0.33 | | 0.07, C 0.46 ± 0.51, S -0.42 ± 0.34, D -1.15 ± 0.47, W -0.24 ± 0.48 | | 0.13,  0.55 ± 0.37 | | 0.01\*,  0.62 ± 0.25 | | 0.14 | | 824.7 | |
| Urban green-space over last two weeks | 0.66,  -0.12 ± 0.27 | 0.36,  0.25 ± 0.28 | | 0.53, -0.18 ± 0.29 | | 0.38,  -0.21 ± 0.24 | | 0.15,  0.38 ± 0.27 | | 0.10,  0.47 ± 0.29 | | 0.36,  0.30 ± 0.33 | | 0.08, C 0.44 ± 0.52, S -0.41 ± 0.34. D -1.12 ± 0.47, W -0.41 ± 0.48 | | 0.09,  0.63 ± 0.37 | | 0.02\*,  0.58 ± 0.25 | | 0.12 | | 829.1 | |
| Countryside per annum | 0.01\*,  0.20 ± 0.07 | 0.37,  0.24 ± 0.27 | | 0.61,  -0.14 ± 0.28 | | 0.54,  -0.15 ± 0.24 | | 0.16,  0.36 ± 0.26 | | 0.48,  0.20 ± 0.29 | | 0.18,  0.44 ± 0.32 | | 0.06, C 0.44 ± 0.51, S -0.43 ± 0.34, D -1.16 ± 0.46, W -0.29 ± 0.47 | | 0.17,  0.50 ± 0.37 | | 0.01\*,  0.64 ± 0.24 | | 0.15 | | 821.9 | |
| Urban green-space per annum | 0.23,  0.08 ± 0.07 | 0.57,  0.16 ± 0.28 | | 0.57,  -0.17 ± 0.29 | | 0.39,  -0.21 ± 0.24 | | 0.25,  0.31 ± 0.27 | | 0.29,  0.32 ± 0.30 | | 0.26,  0.37 ± 0.33 | | 0.09, C 0.33 ± 0.52, S -0.40 ± 0.34, D -1.16 ± 0.47, W -0.34 ± 0.48 | | 0.12,  0.58 ± 0.37 | | 0.01\*,  0.62 ± 0.25 | | 0.13 | | 827.8 | |
| ***Happy yesterday*** |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Countryside over last two weeks | 0.43,  0.31 ± 0.40 | 0.62,  0.18 ± 0.36 | | 0.51,  -0.25 ± 0.38 | | 0.40,  0.25 ± 0.30 | | 0.66,  0.14 ± 0.32 | | 0.81,  0.08 ± 0.35 | | 0.74,  0.14 ± 0.42 | | 0.12, C 0.17± 0.62, S -0.82 ± 0.42, D 0.41 ± 0.57, W -0.68 ± 0.60 | | 0.96,  -0.03 ± 0.46 | | 0.41,  0.25 ± 0.31 | | 0.18 | | 926.1 | |
| Urban green-space over last two weeks | 0.70,  0.13 ± 0.33 | 0.67,  0.15 ± 0.37 | | 0.47,  -0.27 ± 0.38 | | 0.43,  0.23 ± 0.30 | | 0.65,  0.15 ± 0.32 | | 0.85,  0.07 ± 0.36 | | 0.78,  0.12 ± 0.42 | | 0.13, C 0.14 ± 0.62, S -0.80 ± 0.42, D 0.40 ± 0.57, W -0.74 ± 0.59 | | 0.98,  -0.01 ± 0.46 | | 0.43,  0.24 ± 0.31 | | 0.17 | | 926.5 | |
| Countryside per annum | 0.14,  0.14 ± 0.09 | 0.61,  0.18 ± 0.36 | | 0.51,  -0.25 ± 0.38 | | 0.35,  0.28 ± 0.30 | | 0.64,  0.15 ± 0.32 | | 0.88,  -0.05 ± 0.36 | | 0.66,  0.18 ± 0.42 | | 0.12, C 0.18 ± 0.62, S -0.81 ± 0.42, D 0.40 ± 0.57, W -0.67 ± 0.59 | | 0.85,  -0.09 ± 0.46 | | 0.37,  0.27 ± 0.31 | | 0.18 | | 924.6 | |
| Urban green-space per annum | 0.24,  0.10 ± 0.08 | 0.79 ,  0.10 ± 0.37 | | 0.50,  -0.26 ± 0.38 | | 0.42,  0.24 ± 0.30 | | 0.79,  0.09 ± 0.33 | | 0.90,  -0.05 ± 0.37 | | 0.68,  0.17 ± 0.42 | | 0.15, C 0.08 ± 0.62, S -0.80 ± 0.42, D 0.38 ± 0.57, W -0.68 ± 0.59 | | 0.92,  -0.04 ± 0.46 | | 0.38,  0.27 ± 0.31 | | 0.18 | | 925.3 | |

**Table** **3.4.** Continued.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | | | | | | | | | | | | |
|  | *Visits* | | *City size* | | *Actual local urbanisation* | | *Perceived built-up land* | | *Garden use* | | *Socio-economic status* | | *Ethnicity deprivation index* | | *Marital status (reference = married,*  *C = co-habiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | | *Age* | | *Gender*  *(reference = male)* | | *Conditional R2* | | *AICc* | |
| ***Anxious yesterday*** |  |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Countryside over last two weeks | 0.92,  -0.05 ± 0.53 | 0.75,  0.15 ± 0.46 | | 0.69,  -0.19 ± 0.49 | | 0.52,  -0.26 ± 0.40 | | 0.75,  -0.14 ± 0.43 | | 0.40,  -0.39 ± 0.46 | | 0.84,  0.11 ± 0.55 | | 0.58, C 0.11 ± 0.85, S 0.44 ± 0.56, D -0.34 ± 0.76, W -1.10 ± 0.80 | | 0.91,  -0.07 ± 0.61 | | 0.92,  0.04 ± 0.41 | | 0.08 | | 1038.5 | |
| Urban green-space over last two weeks | 0.27,  -0.48 ± 0.44 | 0.59,  0.25 ± 0.46 | | 0.66,  -0.21 ± 0.48 | | 0.54,  -0.25 ± 0.40 | | 0.81,  -0.10 ± 0.43 | | 0.56,  -0.27 ± 0.46 | | 0.87,  0.09 ± 0.54 | | 0.60, C 0.20 ± 0.86, S 0.38 ± 0.56, D -0.31 ± 0.76, W -1.10 ± 0.78 | | 0.97,  -0.02 ± 0.61 | | 0.98,  0.01 ± 0.41 | | 0.05 | | 1037.3 | |
| Countryside per annum | 0.50,  -0.08 ± 0.12 | 0.76,  0.14 ± 0.46 | | 0.67,  -0.21 ± 0.49 | | 0.49,  -0.28 ± 0.40 | | 0.75,  -0.14 ± 0.43 | | 0.53,  -0.30 ± 0.48 | | 0.90,  0.07 ± 0.55 | | 0.56, C 0.11 ± 0.85, S 0.44 ± 0.56, D -0.33 ± 0.76, W -1.13 ± 0.79 | | 0.97,  -0.02 ± 0.61 | | 0.96,  0.02 ± 0.61 | | 0.08 | | 1038.0 | |
| Urban green-space per annum | 0.02\*,  -0.25 ± 0.11 | 0.46,  0.35 ± 0.48 | | 0.63,  -0.23 ± 0.49 | | 0.49,  -0.27 ± 0.39 | | 0.91,  0.05 ± 0.43 | | 1.00,  0.00 ± 0.48 | | 0.93,  -0.05 ± 0.55 | | 0.44, C 0.41 ± 0.84, S 0.45 ± 0.55, D -0.26 ± 0.75, W -1.28 ± 0.78 | | 0.91,  0.07 ± 0.61 | | 0.90,  -0.05 ± 0.40 | | 0.14 | | 1033.3 | |

### Mental well-being models - countryside and urban green-space visit rates and short-term versus long-term visitation measures

Visits to green-spaces were associated with an improvement in all mental well-being indices except for happy yesterday (Table 3.4). Visits to the countryside improved mental well-being as measured by SWEMWBS, satisfied and worthwhile scores. Visits to urban green-space improved mental well-being as measured by SWEMWBS, satisfied and anxious yesterday scores. When both countryside and urban green-space visits were associated with the same mental well-being metric there was no consistent difference in their relative effects (assessed by comparing the magnitude of parameter estimates; Table 3.4). In all these models associations between well-being metrics and green-space visitation rates either only occurred for annual visitation rates, or (for the satisfied and worthwhile metrics) the parameter estimates for annual visitation rates were larger than their equivalent measures for visitation rates over a two week period.

### Interaction between biodiversity knowledge and green-space visitation rates and additional predictors of mental well-being

The interaction between visitation rates to green-spaces and biodiversity knowledge was not associated with any of our mental well-being measures, except for the relationship between worthwhile and visitation rate to urban green-spaces during the last two weeks when the increase in well-being associated with a given visitation rate was greater in people with more biodiversity knowledge (Table 3.5).

**Table 3.5.** Parameter estimates and *P* values for interaction terms between biodiversity knowledge and green-space visitation rate when modelling well-being indicators as a function of visitation rates, perceived and actual urbanisation intensity around the home, city size, garden use, socio-economic and demographic variables (all fixed factors) and postcode (random factor) in linear mixed models. Only the interaction is shown as this is the main interest. \**P* < 0.05.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Biodiversity knowledge & green-space interaction* | | |
| *Response variable* | *Green-space visitation rate type* | *Parameter estimate* ± *SE* | *P value* |
| SWEMWBS | Country visits 2 weeks | 1.34 ± 1.86 | 0.47 |
|  | Urban visits 2 weeks | 0.57 ± 1.13 | 0.61 |
|  | Country visits per year | 0.21 ± 0.31 | 0.49 |
|  | Urban visits per year | -0.02 ± 0.24 | 0.93 |
| Satisfied | Country visits 2 weeks | 0.62 ± 1.07 | 0.56 |
|  | Urban visits 2 weeks | 0.47 ± 0.64 | 0.46 |
|  | Country visits per year | 0.27 ± 0.17 | 0.12 |
|  | Urban visits per year | 0.20 ± 0.14 | 0.15 |
| Worthwhile | Country visits 2 weeks | 0.34 ± 0.96 | 0.72 |
|  | Urban visits 2 weeks | 1.34 ± 0.57 | 0.02\* |
|  | Country visits per year | 0.19 ± 0.16 | 0.23 |
|  | Urban visits per year | 0.23 ± 0.12 | 0.07 |
| Happy yesterday | Country visits 2 weeks | 1.02 ± 1.20 | 0.39 |
|  | Urban visits 2 weeks | 0.04 ± 0.70 | 0.95 |
|  | Country visits per year | 0.22 ± 0.19 | 0.27 |
|  | Urban visits per year | 0.05 ± 0.15 | 0.76 |
| Anxious yesterday | Country visits 2 weeks | -1.10 ± 1.59 | 0.49 |
|  | Urban visits 2 weeks | 0.78 ± 0.94 | 0.40 |
|  | Country visits per year | 0.20 ± 0.26 | 0.35 |
|  | Urban visits per year | 0.19 ± 0.20 | 0.45 |

Neither garden use nor city size was associated with any of our mental well-being metrics. There was some evidence for socio-economic status being positively associated with SWEMWBS, but it had no significant influence on any other well-being metrics. Older people had significantly higher SWEMWBS scores, but other well-being indices were not significantly associated with age. Women were significantly more satisfied with their lives and found them more worthwhile than men, but gender did not significantly alter other mental well-being metrics.

## Discussion

### Perceptions of local surroundings

Areas that respondents perceived to be more built-up were typically also perceived to contain less greenery, and areas that had higher empirical urbanisation scores were perceived to be more built-up and less green. Broadly speaking people thus perceived the composition of their local surroundings accurately (as reported by Hur et al. 2010). We find, however, that local residents do not perceive greenery and built-up land as exact opposites of each other, as evidenced by the similar amounts of greenery perceived in environments that are regarded as containing ‘very little’ and a ‘fair amount’ of built-up land. Moreover, a given increase in actual urbanisation scores was associated with a greater decrease in perceived greenery than increase in the perceived amount of built-up land.

Although the amount of built-up land and greenery in a given area does not always equate to a perfect inverse relationship, for example due to hard surfaces occurring below tree canopies, we would expect a tighter association between perceived built-up land and perceived greenery, and between perceived surroundings and actual levels of urbanisation. It is thus tempting to interpret these patterns as evidence that urban residents do not perceive their environments entirely accurately due to insufficient attention to detail (Leslie et al. 2010). This is certainly likely to contribute to our findings but other factors are probably also contributing. There may be slight differences in the area that respondents are considering when reporting perceived urbanisation and greenery scores, and the 1km grid cell in which actual urbanisation scores are obtained – but we do not expect this to introduce systematic bias and this would thus not influence the lack of a tighter concordance between perceived urbanisation and greenery measures. Rather, we consider it likely that perceived levels of greenery take into consideration the type of vegetation that is present, with trees potentially contributing disproportionately to perceived levels of greenness than other forms of green-space such as mown amenity grassland – yet, these vegetation types contribute equally when calculating how much of the environment is not urbanised. Greater contributions of trees to perceived levels of greenness may arise from the greater volume of vegetation present in trees and other taller vegetation, but also the strong attachment that many people feel towards trees (Henwood and Pidgeon, 2001). In a similar way to the height effect of trees, people may perceive areas to be more built-up when surrounded by taller buildings even though simple two dimension measures of urbanisation do not distinguish between relatively short two storey houses and tall multi-story blocks of flats. Consequently it seems likely that a combination of observer inaccuracies and real differences between standard urbanisation scores and the way that people perceive and respond to built-up land and greenery probably drive the lack of perfect accordance between perceived and actual levels of urbanisation.

### Mental well-being, local surroundings and green-space visits

Models of mental well-being as a function of local surroundings and green-space visit rates which controlled for garden use, socio-demographic factors and city size explained on average 13% of the variation, which whilst somewhat modest is similar to that typically found in such studies (Mathew P. White *et al.*, 2013; Bertram and Rehdanz, 2015). The precise form of the relationships varied between mental well-being metrics, demonstrating the benefit of using a broad suite of well-being indicators, but across our mental health indicators we uncover fairly consistent evidence regarding the relationships between green-space and mental well-being.

There was marginal evidence that SWEMWBS scores decreased in areas that were perceived to be more built-up (*P* values were close to the significance threshold for urban green-space visit models). Consideration of all well-being metrics, however, revealed that there was generally negligible evidence that mental well-being was associated with perceived built-up land, perceived greenery, or actual urbanisation intensity. One possible reason for this is that mental well-being was determined by the amount of contact with green-space at even smaller spatial scales, i.e. in people’s gardens. There is an abundance of research showing the beneficial nature of gardens and gardening on health and mental well-being, however, these largely focus on community gardens and allotments, therapeutic gardens in care homes and hospitals or specific gardening interventions as opposed to time spent (both actively gardening and not) in domestic gardens (van den Berg, van Winsum-Westra, *et al.*, 2010; Cameron *et al.*, 2012; Clatworthy, Hinds and Camic, 2013). In contrast, we found no association between the amount of time spent in a garden and mental health measures. This could be because gardens have a greater impact when used to engage actively with nature (e.g. through gardening), or because only gardens with more natural vegetation types deliver notable well-being benefits. It is also plausible that gardens contribute to mental well-being through passive exposure to green-space, especially for those people who are unable to visit other forms of green-space.

Indeed we find that, when controlling for socio-demographics and city size, visitation rates to green-space are much stronger predictors of mental well-being than measures of the composition of the landscape surrounding residents’ homes. This is intriguing given the focus of much research into urbanisation impacts on well-being which have highlighted the importance of the amount of greenery in local surroundings (e.g. van den Berg et al. 2015; Sandifer et al. 2015). Fan et al. (2011), however, found that the size and accessibility of urban parks further away from the home had a larger influence on well-being than the amount of green-space close to residents’ homes. Notably our results indicate that regularly visiting green-space away from the immediate vicinity of the home may help compensate for these previously documented negative impacts on well-being of living in areas with little green-space.

### Importance of the ‘duration of the dose’ of green-space visit rates and type

Experimental studies that expose participants to either urban or rural green-spaces most commonly compare these environments to indoor areas or those lacking green-space (e.g. Laumann et al. 2003; Berman et al. 2008; Park et al. 2010) but do not directly compare the effects of different green-space types on well-being. We find that visits to both the countryside and urban green-spaces were positively associated with improved mental well-being, except when using responses to the question of whether respondents were happy yesterday. When assessing relationships between mental well-being metrics and visitation rates over short time periods, i.e. two weeks, we exclusively find positive associations with visits to the countryside. Indeed, there is some previous evidence that visits to rural areas contribute disproportionately to short-term restoration and reflection compared to visits to urban green-space (Mathew P. White *et al.*, 2013). When assessing relationships between mental health and green-space visitation rates measured over longer durations, i.e. a year, we found that increased visits to both urban and rural green-space were associated with higher mental well-being measures. This suggests that longer durations of the ‘dose’ of visits to green-space in urban areas may compensate for any shorter-term advantages of visiting the countryside rather than urban green-space. Notably, however, when well-being scores were associated with visitation rates measured over two weeks and annually the latter consistently had a larger influence. There is increasing interest in prescribing visits to green-space to enhance well-being as part of formal health interventions, and these results provide some evidence that such treatments would be more beneficial if they occurred over longer time periods.

Interestingly, we found some differences in the type of well-being benefits delivered by the two types of green-space. While SWEMWBS scores and life satisfaction were associated with both urban and country visits, the degree to which participants felt the things they do in their lives to be worthwhile was only associated with visits to the countryside and reductions in levels of anxiety were only associated with more frequent visits to urban green-space. We suspect these differences may results from visits to the countryside generally being longer in duration and allowing greater escapism and opportunity for reflection while urban parks readily allow for quick relief from the everyday anxieties associated with urban environments (Kaplan, 1995; van den Berg, Hartig and Staats, 2007; Natural England, 2009) but further research is needed to understand these relationships better.

Although we are unable to assume causality, our findings suggest that urban green-space can deliver multiple mental well-being benefits, which is important given concerns that some urban residents’ have limited access to the countryside. Despite this it seems that green-space in urban areas and the countryside differ somewhat in their capacity to deliver certain types of well-being benefits. The greatest benefits to overall well-being of urban residents appear to arise from visiting both urban green-space and the countryside.

### Biodiversity knowledge and green-space visit interaction

We found very little evidence to suggest that people’s biodiversity knowledge (a composite measure of identification skills and conservation knowledge, including ability to recognise high quality wildlife habitat) influenced the mental well-being benefits received from visiting urban green-space and the countryside. Our hypothesis was that in areas of high biodiversity, greater knowledge may enhance perception of environmental quality leading to greater well-being benefits from visiting green-space, but that in environments with relatively little biodiversity having greater biodiversity knowledge will limit appreciation of the environment (as its poor quality is recognised) reducing beneficial impacts of green-space on well-being. In contrast the only evidence that we found was for greater well-being benefits (as measured by ‘worthwhile’ scores) arising from visiting urban green-space when people had higher biodiversity knowledge. It is plausible that the failure to detect such patterns arises because although urban green-spaces tend on average to have lower levels of biodiversity than rural areas there is considerable variation in the biodiversity value of both green-space types (Fernandez-Juricic, 2000; Alvey, 2006; Clergeau *et al.*, 2006) which might mask any underlying associations between biodiversity knowledge and the type of green-space visited. In addition, it is plausible that for most urban residents any connection with nature in green-space enhances well-being regardless of whether these interactions arise with common urban-adapted species that inhabit relatively poor quality habitats – in which case the ability to identify biodiversity and habitats that promote high biodiversity would not influence well-being.

### Limitations

Limitations of the study design and sampling approach used in this research are addressed in Chapter 2 (section 2.5.8). Additional limitations specific to this study are addressed below.

*Actual and perceived local urbanisation*

We unfortunately did not capture data on perceptions of the amount of greenery within a five minute walk of 76 participants’ houses. Where data was collected on both perceived greenery and built up land around the home, our results showed perceptions of the amount of built up area and greenery though correlated, did not perfectly match. Thus, although we found no association between perceived levels of built up land around the home and mental well-being for our full sample of respondents, nor between perceived greenery and mental well-being benefits for the reduced sample of respondents, it is possible that a larger sample size of perceived greenery data may have provided a different result.

Participants were asked to estimate how much built up land and greenery there was within a five minute walk of their homes. This distance, however, was not measured in any way and so the area considered as five minutes from the home is likely to vary by participant according to multiple factors including how mobile they are or how walkable their neighbourhood is (Kirtland *et al.*, 2003; Mccormack *et al.*, 2008). Our key interest was in determining the influence of perceptions of local surroundings and actual composition of surroundings on well-being benefits which we were able to achieve. However, we cannot say with any certainty whether differences in perceptions of the area included within a five minute walk influenced our results.

We were also interested in how well participants’ perceptions of the area within a five minute walk of their homes reflected reality which we assessed by comparing perception measurements with satellite data of a distance calculated as a five minute walk using an average walking speed. Taking the average distance covered in a five minute walk to capture actual composition of local surroundings, however, will not necessarily map on to the same area of a participant’s perceptions of a five minute walk again due to differences in walking speed, walking route availability and potentially differing perceptions of the distance by participants. Thus the mismatch observed between perceptions of areas surrounding the home and reality in this study could simply reflect a genuine mismatch as opposed to people inaccurately perceiving their local environment.

*Definitions of urban green-space and the countryside*

Definitions of urban green-space and the countryside were only provided if participants asked for clarification. Asking how often respondents visited urban green-spaces and the countryside consecutively helped trigger participants to ask if they were unsure what the difference was. However, it is possible that some confusion may still have occurred with what might be classed as urban green-space by some being considered as countryside by others and vice versa which may have influenced our results.

*Other influences on well-being*

In an ideal scenario we would have incorporated all factors known to influence mental well-being into our survey in order to control for their effects, thereby improving our ability to determine associations between mental well-being and both green-space visitation rates and urbanisation. Although we controlled for key drivers such as income and relationship status, other factors shown to influence mental well-being including physical health and social circumstances (Michaelson, Mahoney and Schifferes, 2012; Thomas, Randall and Statistics, 2012) were not incorporated into our analyses.

### Conclusion

We find that neither perceived nor actual composition of environments surrounding the home are associated with mental well-being. Visits to green-space, however, were positively associated with mental well-being and thus seem to be the more important factor. We have therefore provided novel insight suggesting that, with regards to delivery of mental well-being benefits, visits to urban green-space and the countryside can compensate for increased local urbanisation in close proximity to the home. Whilst regular visits to urban green-space is associated with improved mental well-being, especially reduced anxiety, a combination of visits to both urban and country green-space appears important for delivery of a wider range of mental well-being benefits. We found greater well-being benefits (as measured by ‘worthwhile’ scores) arising from visiting urban green-space when people had higher biodiversity knowledge, but such interactions between biodiversity knowledge and well-being were rare. Importantly, visitation rates measured over an annual cycle typically had a larger association with well-being metrics than visitation rates measured over a two week period. Our results suggest that maximising urban residents’ well-being requires prolonged doses of nature obtained by regularly visiting urban green-space and the countryside. Action should thus focus on improving access and engagement with both urban and country green-spaces on a regular basis over long time scales.

## Appendix 3.1

Models of five different mental well-being indices constructed using linear mixed models and treating response variables as continuous data. These models differ from those reported in the main body of the manuscript by incorporating perceived greenery in addition to perceived urbanisation intensity around respondents’ homes (at the expense of a reduced sample size). Each well-being indicator is modelled as a function of four different visitation rates, perceived and actual urbanisation intensity around the home, city size, garden use, postcode (random factor) and socio-economic and demographic variables (fixed factors). The model with the lowest AICc value of the four visitation types for each well-being metric is highlighted in grey. *\* P* < 0.05, *\*\* P* < 0.01.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | |
|  | *Visits* | *City size* | *Local urbanisation* | *Perceived built-up land* | *Perceived greenery* | *Garden use* | *Socio-economic status* | *Ethnicity deprivation index* | *Marital status (reference = married, C = cohabiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | *Age* | *Gender (reference = male)* | *Conditional R2* | *AICc* |
| ***SWEMWBS*** |  | | | | | | | | | | | | |
| Countryside over last two weeks | 0.27,  0.81±0.73 | 0.18,  0.83±0.62 | 0.70,  0.26±0.69 | 0.58,  -0.35±0.63 | 0.88,  0.10±0.68 | 0.75,  0.20±0.62 | 0.42,  0.52±0.64 | 0.87,  0.12±0.77 | 0.96, C 0.64±1.03, S 0.22±0.77,  D -0.34±1.07, W -0.03±1.21 | 0.05\*,  1.69±0.84 | 0.61,  -0.30±0.60 | 0.07 | 787.1 |
| Urban green-space over last two weeks | 0.69,  -0.23±0.58 | 0.17,  0.86±0.64 | 0.75,  0.22±0.69 | 0.55,  -0.38±0.63 | 0.78,  0.19±0.68 | 0.64,  0.29±0.63 | 0.32,  0.65±0.66 | 0.95,  0.05±0.78 | 0.97, C 0.62±1.04, S 0.21±0.77,  D -0.31±1.07, W -0.18±1.21 | 0.04\*,  1.76±0.85 | 0.49,  -0.41±0.60 | 0.07 | 788.1 |
| Countryside per annum | 0.13,  0.26±0.17 | 0.17,  0.85±0.62 | 0.68,  0.28±0.69 | 0.61,  0.26±0.17 | 0.91,  0.07±0.68 | 0.73,  0.21±0.62 | 0.71,  0.25±0.68 | 0.79,  0.20±0.77 | 0.96, C 0.63±1.03, S 0.21±0.76,  D -0.41±1.07, W -0.13±1.20 | 0.06,  1.62±0.85 | 0.68,  -0.25±0.60 | 0.08 | 786.1 |
| Urban green-space per annum | 0.12,  0.24±0.15 | 0.36,  0.58±0.64 | 0.73,  0.24±0.69 | 0.54,  -0.39±0.63 | 0.99,  0.01±0.68 | 0.93,  0.06±0.63 | 0.68,  0.27±0.67 | 0.81,  0.18±0.77 | 0.99, C 0.36±1.04, S 0.21±0.76,  D -0.36±1.06, W 0.07±1.21 | 0.05,  1.66±0.84 | 0.61,  -0.30±0.59 | 0.09 | 785.9 |

**Appendix 3.1** Continued

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | |
|  | *Visits* | *City size* | *Local urbanisation* | *Perceived built-up land* | *Perceived greenery* | *Garden use* | *Socio-economic status* | *Ethnicity deprivation index* | *Marital status (reference = married, C = cohabiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | *Age* | *Gender (reference = male)* | *Conditional R2* | *AICc* |
| ***Satisfied*** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Countryside over last two weeks | 0.06,  0.78±0.42 | 0.87,  0.06±0.35 | 0.23,  -0.46±0.38 | 0.75,  0.11±0.35 | 0.63,  0.18±0.38 | 0.88,  0.06±0.37 | 0.54,  -0.23±0.38 | 0.26,  0.50±0.44 | 0.42, C 0.30±0.61, S -0.68±0.43,  D -0.47±0.59, W -0.41±0.67 | 0.83,  0.10±0.48 | 0.08,  0.60±0.33 | 0.08 | 645.1 |
| Urban green-space over last two weeks | 0.55,  0.20±0.33 | 0.99,  -0.00±0.37 | 0.17,  -0.53±0.39 | 0.82,  0.08±0.36 | 0.62,  0.19±0.38 | 0.79,  0.10±0.37 | 0.58,  -0.22±0.39 | 0.30,  0.46±0.45 | 0.50, C 0.20±0.62, S -0.64±0.44,  D -0.47±0.60, W -0.50±0.68 | 0.77,  0.14±0.49 | 0.11,  0.54±0.34 | 0.07 | 648.2 |
| Countryside per annum | 0.00\*\*,  0.29±0.09 | 0.86,  0.06±0.35 | 0.25,  -0.43±0.38 | 0.63,  0.16±0.35 | 0.66,  0.16±0.35 | 0.84,  0.07±0.36 | 0.15,  -0.55±0.39 | 0.19,  0.57±0.44 | 0.40, C 0.28±0.60, S -0.65±0.43,  D -0.49±0.58, W -0.56±0.66 | 0.98,  0.01±0.47 | 0.05\*,  0.66±0.33 | 0.12 | 639.6 |
| Urban green-space per annum | 0.00\*\*,  0.25±0.09 | 0.58,  -0.20±0.36 | 0.20,  -0.48±0.38 | 0.80,  0.09±0.35 | 0.83,  0.08±0.37 | 0.72,  -0.13±0.37 | 0.15,  -0.56±0.39 | 0.21,  0.55±0.44 | 0.49, C -0.09±0.61, S -0.72±0.43,  D -0.58±0.58, W -0.36±0.66 | 0.99,  0.00±0.48 | 0.05\*,  0.65±0.33 | 0.12 | 640.1 |
| ***Worthwhile*** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Countryside over last two weeks | 0.02\*,  0.91±0.38 | 0.34,  0.31±0.32 | 0.45,  -0.26±0.35 | 0.67,  0.14±0.32 | 0.79,  0.09±0.34 | 0.21,  0.42±0.34 | 0.85,  0.06±0.35 | 0.32,  0.40±0.40 | 0.07, C 0.48±0.56, S -0.68±0.39,  D -1.18±0.55, W -0.37±0.59 | 0.35,  0.41±0.44 | 0.04,  0.64±0.30 | 0.15 | 615.7 |
| Urban green-space over last two weeks | 0.74,  -0.10±0.30 | 0.35,  0.31±0.34 | 0.35,  -0.33±0.35 | 0.74,  0.11±0.33 | 0.69,  0.14±0.35 | 0.12,  0.53±0.34 | 0.64,  0.17±0.36 | 0.44,  0.32±0.41 | 0.09, C 0.45±0.57, S -0.66±0.40,  D -1.16±0.57, W -0.50±0.60 | 0.28,  0.48±0.45 | 0.08,  0.53±0.31 | 0.12 | 621.1 |
| Countryside per annum | 0.00\*\*\*,  0.29±0.09 | 0.35,  0.30±0.32 | 0.46,  -0.25±0.34 | 0.54,  0.19±0.32 | 0.82,  0.08±0.34 | 0.16,  0.46±0.33 | 0.47,  -0.26±0.36 | 0.24,  0.46±0.40 | 0.07, C 0.46±0.55, S -0.65±0.39,  D -1.17±0.54, W -0.50±0.58 | 0.46,  0.32±0.43 | 0.02\*,  0.69±0.30 | 0.19 | 610.2 |
| Urban green-space per annum | 0.07,  0.14±0.08 | 0.65,  0.15±0.34 | 0.37,  -0.31±0.35 | 0.74,  0.11±0.32 | 0.87,  0.06±0.35 | 0.30,  0.36±0.35 | 0.83,  -0.08±0.37 | 0.33,  0.39±0.41 | 0.10, C 0.24±0.57, S -0.69±0.40,  D -1.24±0.56, W -0.39±0.60 | 0.38,  0.39±0.44 | 0.04,  0.63±0.31 | 0.14 | 618.0 |

**Appendix 3.1** Continued

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | |
|  | *Visits* | *City size* | *Local urbanisation* | *Perceived built-up land* | *Perceived greenery* | *Garden use* | *Socio-economic status* | *Ethnicity deprivation index* | *Marital status (reference = married, C = cohabiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | *Age* | *Gender (reference = male)* | *Conditional R2* | *AICc* |
| ***Happy yesterday*** | |  |  |  |  |  |  |  |  |  |  |  |  |
| Countryside over last two weeks | 0.43,  0.37±0.47 | 0.17,  0.59±0.43 | 0.76,  -0.14±0.46 | 0.33,  0.38±0.39 | 0.79,  0.11±0.42 | 0.61,  0.21±0.40 | 0.67,  -0.18±0.43 | 0.41,  0.42±0.51 | 0.03\*, C 0.62±0.65, S -1.07±0.48, D 0.05±0.66, W -1.35±0.74 | 0.82,  0.13±0.54 | 0.59,  0.20±0.37 | 0.31 | 686.2 |
| Urban green-space over last two weeks | 0.92,  -0.04±0.35 | 0.18,  0.59±0.44 | 0.69,  -0.18±0.46 | 0.33,  0.38±0.39 | 0.74,  0.14±0.43 | 0.53,  0.25±0.40 | 0.75,  -0.14±0.44 | 0.43,  0.40±0.51 | 0.03\*, C 0.61±0.65, S -1.06±0.48,  D 004±0.66, W -1.37±0.74 | 0.79,  0.15±0.52 | 0.69,  0.15±0.37 | 0.29 | 686.8 |
| Countryside per annum | 0.03\*,  0.22±0.10 | 0.17,  0.59±0.43 | 0.86,  -0.08±0.46 | 0.28,  0.42±0.38 | 0.82,  0.10±0.42 | 0.66,  0.18±0.40 | 0.33,  -0.44±0.45 | 0.34,  0.48±0.50 | 0.02\*, C 0.61±0.64, S -1.07±0.47,  D 0.08±0.65, W -1.43±0.73 | 0.95,  0.03±0.54 | 0.43,  0.29±0.37 | 0.36 | 682.4 |
| Urban green-space per annum | 0.28,  0.10±0.09 | 0.27,  0.49±0.44 | 0.73,  -0.16±0.46 | 0.34,  0.37±0.39 | 0.84,  0.08±0.42 | 0.72,  0.15±0.41 | 0.50,  -0.30±0.45 | 0.38,  0.45±0.51 | 0.04\*, C 0.49±0.65, S -1.09±0.47,  D 0.00±0.66, W -1.33±0.74 | 0.88,  0.08±0.54 | 0.59,  0.20±0.37 | 0.31 | 685.6 |
| ***Anxious yesterday*** | |  |  |  |  |  |  |  |  |  |  |  |  |
| Countryside over last two weeks | 0.69,  -0.25±0.64 | 0.82,  0.13±0.54 | 0.46,  0.43±0.58 | 0.45,  -0.40±0.53 | 0.20,  0.73±0.58 | 0.60,  -0.29±0.55 | 0.94,  0.04±0.57 | 0.97,  -0.03±0.67 | 0.71, C -0.48±0.93, S -0.22±0.66,  D 0.14±0.90, W -1.33±1.00 | 0.61,  -0.38±0.73 | 0.53,  0.32±0.51 | 0.04 | 775.6 |
| Urban green-space over last two weeks | 0.08,  -0.86±0.49 | 0.55,  0.33±0.54 | 0.41,  0.47±0.57 | 0.51,  -0.35±0.53 | 0.15,  0.83±0.57 | 0.71,  -0.20±0.55 | 0.66,  0.25±0.57 | 0.92,  -0.07±0.66 | 0.71, C -0.27±0.93, S -0.28±0.65,  D 0.14±0.89, W -1.34±0.99 | 0.67,  -0.31±0.73 | 0.62,  0.25±0.50 | 0.06 | 772.8 |
| Countryside per annum | 0.34,  -0.14±0.15 | 0.82,  0.12±0.54 | 0.48,  0.41±0.58 | 0.42,  -0.43±0.53 | 0.19,  0.75±0.57 | 0.60,  -0.29±0.55 | 0.74,  0.20±0.59 | 0.92,  -0.06±0.67 | 0.72, C -0.48±0.93, S -0.24±0.66,  D 0.14±0.90, W -1.29±0.99 | 0.66,  -0.33±0.73 | 0.59,  0.28±0.51 | 0.05 | 774.9 |
| Urban green-space per annum | 0.02,  -0.31±0.13 | 0.45,  0.41±0.54 | 0.46,  0.42±0.57 | 0.45,  -0.39±0.52 | 0.12,  0.89±0.57 | 0.95,  -0.03±0.55 | 0.41,  0.49±0.59 | 0.84,  -0.14±0.66 | 0.60, C -0.07±0.93, S -0.15±0.65,  D 0.26±0.89, W -1.52±0.98 | 0.77,  -0.21±0.72 | 0.71,  0.18±0.50 | 0.08 | 770.3 |

## Appendix 3.2

Models of five different mental well-being indices constructed using ordered mixed probit regression models that treat response variables as ordinal data. Each well-being indicator is modelled as a function of four different visitation rates, perceived and actual urbanisation intensity around the home, city size, garden use, postcode (random factor) and socio-economic and demographic variables (fixed factors). The model with the lowest AICc value of the four visitation types for each well-being metric is highlighted in grey. Models using worthwhile and anxious yesterday did not converge. *\* P* < 0.05, *\*\* P* < 0.01.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | |  |
|  | *Visits* | *City size* | *Local urbanisation* | *Perceived built-up land* | *Garden use* | *Socio-economic status* | *Ethnicity deprivation index* | *Marital status (reference = married, C = co-habiting,*  *S = single,*  *D = divorced,*  *W = widowed)* | *Age* | *Gender* | *AIC* |
| ***Satisfied*** |  |  |  |  |  |  |  |  |  |  |  |
| Countryside over last two weeks | 0.06,  0.27 ± 0.14 | 0.61,  -0.08 ±0.15 | 0.23,  -0.20 ±0.16 | 0.61,  -0.07 ± 0.14 | 0.37,  -0.12 ±0.14 | 0.27,  0.17 ± 0.16 | 0.21,  0.23 ± 0.18 | 0.52, C: -0.16 ± 0.27, S: -0.26 ± 0.19, D: -0.26 ± 0.25, W: -0.32 ± 0.30 | 0.10,  0.38 ± 0.23 | 0.08,  0.24 ± 0.14 | 1015.9 |
| Urban green-space over last two weeks | 0.91,  0.02 ± 0.14 | 0.61,  -0.08 ±0.16 | 0.19,  -0.22 ±0.17 | 0.44,  -0.11 ± 0.14 | 0.37,  -0.13 ±0.14 | 0.23,  0.20 ± 0.16 | 0.30,  0.19 ± 0.18 | 0.43, C: -0.15 ± 0.27, S: -0.27 ± 0.19, D: -0.24 ± 0.26, W: -0.40 ± 0.29 | 0.08,  0.39 ± 0.23 | 0.11,  0.22 ± 0.14 | 1019.5 |
| Countryside per annum | 0.02\*,  0.09 ± 0.04 | 0.57,  -0.08 ±0.15 | 0.26,  -0.19 ±0.16 | 0.63,  -0.07 ± 0.14 | 0.37,  -0.12 ±0.14 | 0.56,  0.09 ± 0.16 | 0.17,  0.25 ± 0.18 | 0.46, C: -0.17 ± 0.27, S: -0.28 ± 0.19, D: -0.27 ± 0.25, W: -034 ± 0.29 | 0.13,  0.34 ± 0.22 | 0.07,  0.25 ± 0.14 | 1014.4 |
| Urban green-space per annum | 0.02\*,  0.09 ±0.04 | 0.40,  -0.13 ±0.16 | 0.21,  -0.22 ±0.17 | 0.50,  -0.09 ± 0.04 | 0.19,  -0.19 ±0.14 | 0.63,  0.08 ± 0.17 | 0.15,  0.27 ± 0.19 | 0.41, C: -0.22 ± 0.27, S: -0.28 ± 0.19, D: -0.28 ± 0.26, W: -0.39 ± 0.30 | 0.09,  0.38 ± 0.23 | 0.07,  0.25 ± 0.14 | 1013.3 |
| ***Happy yesterday*** |  |  |  |  |  |  |  |  |  |  |  |
| Countryside over last two weeks | 0.45,  0.11 ± 0.15 | 0.67,  0.07 ± 0.18 | 0.35,  -0.18 ±0.19 | 0.49,  0.10 ± 0.15 | 0.58,  -0.08 ±0.15 | 0.86,  0.03 ± 0.17 | 0.62,  0.10 ± 0.20 | 0.07, C: 0.01 ± 0.27, S: -0.41 ± 0.20, D: 0.24 ± 0.27, W: -0.42 ± 0.30 | 0.81,  0.05 ± 0.22 | 0.41,  0.12 ± 0.14 | 1069.4 |
| Urban green-space over last two weeks | 0.69,  -0.06 ±0.15 | 0.64,  0.08 ± 0.18 | 0.31,  -0.19 ±0.19 | 0.55,  0.09 ± 0.15 | 0.59,  -0.08 ±0.15 | 0.76,  0.05 ± 0.17 | 0.70,  0.08 ± 0.20 | 0.05\*, C: 0.03 ± 0.27, S: -0.41 ± 0.20, D: 0.25 ± 0.27, W: -0.44 ± 0.30 | 0.80,  0.05 ± 0.22 | 0.47,  0.10 ± 0.14 | 1069.8 |
| Countryside per annum | 0.39,  0.04 ±0.04 | 0.70,  0.07 ± 0.18 | 0.36,  -0.17 ±0.19 | 0.49,  0.10 ± 0.15 | 0.57,  -0.09 ±0.15 | 1.00,  0.00 ± 0.18 | 0.59,  0.10 ± 0.20 | 0.06, C: 0.01 ± 0.27, S:-0.41 ± 0.20, D: 0.24 ± 0.27, W: -0.42 ± 0.30 | 0.89,  0.03 ± 0.22 | 0.39,  0.12 ± 0.14 | 1069.2 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Urban green-space per annum | 0.53,  0.02 ±0.04 | 0.74,  0.06 ± 0.18 | 0.32,  -0.19 ±0.19 | 0.53,  0.09 ± 0.15 | 0.51,  -0.10 ±0.15 | 0.97,  0.01 ± 0.18 | 0.61,  0.10 ± 0.20 | 0.06, C: 0.00 ± 0.27, S:-0.41 ± 0.20, D: 0.24 ± 0.27, W: -0.44 ± 0.30 | 0.84,  0.05 ± 0.22 | 0.42,  0.12 ± 0.14 | 1069.6 |

# Landscape-scale restoration and the visitor experience

## Abstract

Landscape scale conservation initiatives often aim to improve biodiversity and ecosystem service and benefit provision, including cultural benefits to visitors. Knowledge of how these initiatives influence the visitor experience, their support for conservation and well-being is, however, very limited. We use a major landscape-scale restoration programme, the Dark Peak Nature Improvement Area (NIA) to assess impacts of restoration management activities on visitors. We conducted face-to-face surveys at treatment and control sites using a before and after experimental design to assess responses to conservation management activities. We focus on responses to management rather than biodiversity per se due to time lags in ecological responses to restoration, and this phase of active management is when the largest disruption and most visually dramatic landscape changes occur. We find that visitors have limited awareness of the Dark Peak NIA, yet express strong support for its conservation objectives. There was no evidence that conservation restoration activities altered visitor numbers, visit rates, the socio-demographic mix of visitors, awareness of the NIA, perceived species richness, psychological well-being, or support for its conservation objectives. Exposure to restoration activities did, however, significantly increased visitors’ willingness to participate in voluntary conservation work and were positively associated with perceived species richness demonstrating the potential for further improvements in the long-term as biodiversity increases following restoration. There were, however, no associations between perceived species richness and mental well-being despite evidence to the contrary from previous studies. Both conservation support and psychological well-being were positively associated with visit frequency emphasizing the importance of improving levels of engagement for cultural ecosystem service provision. Only 6% of respondents stated that NIA restoration activities altered site quality, with the majority of these reporting positive changes. At the site with the most visually dramatic landscape change (removal of a non-native conifer plantation) there was a higher level of adverse response to restoration though provision of additional information on the rationale and longer-term management goals (establishing native broad-leaved woodland) significantly increased acceptance of restoration. Cultural benefit delivery, however, was not influenced by this greater adverse reaction. Thus, even in frequently visited iconic landscapes, large scale ecological restoration work can be conducted without adversely impacting the visitor experience, especially when visitors are provided with information on the rationale and future long-term management of the site.

## Introduction

Biodiversity conservation initiatives are increasingly being undertaken at the landscape-scale (Lindenmayer et al. 2008, England Biodiversity Group 2011, Hodder et al. 2014). As well as enhancing biodiversity such initiatives frequently aim to restore and improve the delivery of ecosystem services and benefits, including non-material cultural benefits such as aesthetic value and improved well-being that can be associated with visiting green-spaces (Millennium Ecosystem Assessment 2005). Quite a lot of attention has been given to how visitors respond aesthetically to ecological restoration projects, although these generally rely on hypothetical and counterfactual scenarios using photo elicitation (e.g. Junker & Buchecker 2008; Van Marwijk et al. 2012; Petursdottir et al. 2013). These studies are thus unlikely to fully capture the change in visitor experiences that occur when directly experiencing landscapes. They also do not usually capture the impacts of experiencing active restoration which may generate negative reactions, for example changes to existing site features to which they are attached or the presence of large or noisy machinery.

Many conservation orientated landscape restoration initiatives state in their objectives that they aim to improve visitor experiences, or other aspects of cultural ecosystem services, but only a minority of restoration programmes actually assess these beyond considering aesthetic value. A meta-analysis on restoration impacts on ecosystem service provision, for example, excluded cultural services as these were not explicitly measured in any of the 89 studies considered (Rey Benayas *et al.*, 2009). This has, in part, been due to the difficulty in capturing and quantifying some aspects of these non-material benefits and insufficient resourcing to do so effectively. It is vital that this knowledge gap is addressed as visitors are important stakeholders who may be affected by restoration activities. Public support for the overarching aims and objectives of conservation and restoration programmes is often high, with people reporting these as important to them (Vining, Tyler and Kweon, 2000; Ostergren, Abrams and Lowe, 2008; Buijs, 2009) and preferring images of restored environments compared to their pre-restoration state (e.g. Junker & Buchecker 2008; Van Marwijk et al. 2012; Petursdottir et al. 2013). Once restoration management begins, however, there is often substantial public opposition and outcry - which can impede the spatial extent and timing of planned restoration works and potentially reduce land managers’ willingness to propose large-scale or dramatic restoration activities (e.g. Gobster 1997; Ostergren et al. 2008; Buijs et al. 2011). A greater understanding of reactions to the initial phase of restoration programmes is thus critical.

Landscape-scale restoration could potentially influence cultural benefits through a number of mechanisms. Several theoretical frameworks describe how exposure to natural environments allows opportunities for cognitive restoration and reflection (Kaplan and Kaplan, 1989), emotional attachments (Altman and Low, 1992) and a sense of identity (Proshansky, Fabian and Kaminoff, 1983), and these theories receive substantial support (Hartig et al. 2014; Sandifer et al. 2015; van den Berg et al. 2015). Delivery of these benefits could be greater from ecologically restored landscapes as the biodiversity value of sites is positively associated with the psychological benefits obtained from green-spaces (Fuller *et al.*, 2007). Recent reviews though suggest that the evidence base for such relationships is limited and conflicting (Cardinale *et al.*, 2012; Sandifer, Sutton-Grier and Ward, 2015), perhaps because well-being may be driven by perceived rather than actual biodiversity, and the two can be poorly or even negatively correlated (Dallimer *et al.*, 2012).

There is also empirical evidence for theories linking greater aesthetic values and enhanced delivery of mental restoration to locations with which people have a strong sense of attachment, for example through forming a sense of identity with a site, i.e. sense of place (Millennium Ecosystem Assessment, 2005; Pazhouhanfar & Mustafa Kamal, 2014; van den Berg, Koole, & van der Wulp, 2003). Ecological restoration activities, especially those that result in widespread and marked changes to landscapes that alter features that provide a sense of place, could thus have negative impacts on cultural benefit delivery – at least until novel attachments and a sense of place is formed with the newly altered landscape.

Another cultural benefit that could be influenced by restoration is conservation support. It is widely assumed that engaging with natural environments improves biodiversity knowledge and conservation support (Schultz 2000, Miller 2005). Empirical demonstration of these linkages is difficult, although some evidence is provided in Chapter 2. Thus restoration work that increases environmental quality may develop greater awareness of biodiversity and support for conservation. Visitors that are exposed to landscapes undergoing active conservation management may also be more willing to support conservation when they directly witness conservation activities.

Improving understanding of people’s responses to conservation management could thus facilitate the design and implementation of landscape restoration to benefit people and wildlife, and provide insight into the underlying mechanisms of cultural benefit delivery. Here, we explore these issues using the Dark Peak Nature Improvement Area (NIA) as a case study. This is one of 12 NIA sites that combine to form a major landscape restoration initiative designed to create a more inter-connected and resilient ecological network across England’s key wildlife sites to aid adaptation to climate change (Natural England, 2012). The Dark Peak NIA is situated within the Peak District National Park, an ideal location for assessing the impacts of restoration activities on people as it receives over 22 million visitors per annum (Peak District National Park Authority, 2004). We focus on six sites, four experimental sites undergoing landscape scale restoration and two control sites lacking conservation interventions. We use a before and after experimental design and conduct visitor surveys prior to the commencement of restoration activities and two to three years later once restoration had been completed. We thus assess how restoration management alters visitor numbers, their experiences and the delivery of cultural benefits rather than the indirect effects of biodiversity responses to restoration as these typically occur over much longer time scales. Specifically, we address i) awareness of the NIA and support for its key objectives, ii) perceived changes in site quality, and the reasons for this, and iii) indicators of provision of cultural benefits, i.e. visitor numbers and type, site visitation rates, changes in perceived species richness, and visitors’ psychological well-being and support for conservation.

## Methods

### Survey sites, participant recruitment and sample size

Visitor surveys took place at six different sites within the Peak District National Park, Derbyshire, England. We selected four treatment sites located inside the Dark Peak NIA (Blacka Moor, Burbage, Curbar and Stanage) from a limited number of sites that would be undergoing NIA conservation and access management (Table 4.1) in areas with a high visitor presence. Two additional sites were selected as controls, one of which was located just outside the NIA (Redmires); the other was inside the NIA (Longshaw), but our survey area was not subject to NIA management activities (which were restricted to a more remote part of the site which receives few visitors). Control sites were selected to reflect the variation in habitat types found at the treatment sites (primarily woodland, moorland and grassland). In addition, all six sites were selected on account of them being within relatively close proximity of each other allowing for coordination of a team of volunteers for simultaneous surveying across all sites. All sites also had major entry/exit points (a car park) in order to be able to maximise sample size.

**Table** **4.1.** Sample site habitat type and NIA management activities, and number of questionnaires completed in each phase of the survey.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Site* | *Site type* | *Dominant habitat type* | *NIA management activity* | *No. early phase questionnaires* | *No. late phase questionnaires* |
| Blacka Moor | Treatment | Woodland (conifer & deciduous), moorland, blanket bog, grassland | Restoration of semi-natural woodland through rhododendron clearance and tree thinning; heathland diversification and restoration of species rich grassland through bracken control; access improvements. | 77 | 87 |
| Burbage | Treatment | Moorland, conifer plantation | Replacing upland conifer plantation with native broadleaved woodland; heathland creation and enhancement, partially through introducing cattle grazing; access improvements. | 119 | 111 |
| Curbar | Treatment | Grassland, moorland | Restoration and enhancement of heathland through cattle grazing and *Molinia* management; restoration of species rich hay meadows; access improvements. | 122 | 113 |
| Stanage | Treatment | Moorland, grassland | Upland native woodland and successional scrub creation; restoration and enhancement of heathland through scrub and bracken control. | 90 | 104 |
| Longshaw | Control | Grassland, moorland, deciduous woodland | N/A | 135 | 124 |
| Redmires | Control | Moorland, conifer plantations | N/A | 105 | 103 |

Visitor surveys were conducted at these major entrance/exit points to sites from mid-morning (c. 10am) until mid-afternoon (c. 3.30pm) to maximise the number of respondents. Unbiased sampling was achieved by approaching the next available person on completion of the previous survey. All surveys took place simultaneously across the six sites on four days (two week days and two weekend days) in late summer, winter and spring during 2012/13 and again in 2014/15. The 2012/13 surveys represent the early phase of the programme where NIA management activities had not yet begun or were just getting underway. The 2014/15 surveys represent the late phase of the programme where all NIA management works were being finalised or had recently been completed. Additional visitor surveys were conducted at sites where questionnaire numbers were low (< 30) after the initial four day period.

The overall response rate was high (71%) and similar across both the early and late phase of the study (69% in 2012/13, 73% in 2014/15) and control (72%) and experimental sites (71%). The total number of questionnaires (Table 4.1) used for analyses ranged from 1050 – 1083 (depending on the number of missing values for different questions).

### Awareness of the NIA and support for the key NIA management objectives

To gauge respondents’ awareness of the Dark Peak NIA we asked whether they were “aware of the Dark Peak Nature Improvement Area before today” with a yes/no response where aware was defined as knowing anything about it. The core objectives of the Dark Peak NIA included increasing the quality of moorland, the amount and quality of native woodland, the amount and quality of hay meadow and the amount and quality of access to the countryside. To assess whether perceptions of changes in site quality in response to management work were influenced by participants attitudes towards these broad objectives, respondents were asked to state how much they agreed with statements that it was important to conduct each of these management objectives along a standard five point Likert scale of agreement from “strongly disagree” to “strongly agree”. Answers also provide an additional measure of support for conservation in conjunction with section 4.3.4.

### Perceptions of changes in site quality, reasons for this and perceived changes in species richness

#### Perceptions of change in site quality and reasons for this

Participants who had visited the sites in the previous two years (82%) were asked whether they felt the site had changed in quality over that time on a five point scale (large decline, slight decline, no change, slight improvement, large improvement). Quality was not defined as we were interested in capturing any changes that were perceived as important to the participants. Those who felt the site had changed in quality were asked (in an open-ended question) what the causes of this change were to allow a more complete exploration of the underlying causes and whether these were associated with specific NIA management activities. The vast majority of respondents (97.5%) gave one or two causal factors, and subsequent analyses were thus restricted to the first two reasons provided for changes in site quality. Each reason was assigned to a category (Table 4.2). **Table 4.2.** Categories and examples of visitor statements for changes in site quality at NIA restoration sites in the previous two years with example answers.

|  |  |  |
| --- | --- | --- |
| *Category* | *Improved site quality* | *Decline in site quality* |
| Access | “Pathways more established” | “Footpaths eroded” |
| NIA conservation management | “Maintenance & clearing of rhododendron” | “Over-management of vegetation, cut to shreds”, |
| Wildlife | “More wildlife” | “Less wildlife” |
| People | “More people visiting” | “Too many people” |
| Facilities | “More benches” | “Toilets need improving” |
| Dry stone walls | “Maintaining dry stone walls” | “Walls crumbling” |
| Car parks | “Better car parking” | “Potholes in car park” |
| Bins / litter | “More bins” | “Litter” |
| Conflict with other users | NA | “Cyclist on footpath” |
| Non-site related | “Better roads” | “Traffic” |

To further gauge visitor reactions to the management work, respondents were asked in open-ended questions what was a) the best, and b) the most disappointing aspect of their visit excluding the weather. Only 1% of respondents gave more than two answers for each of these questions and so these additional answers were excluded from the analysis. All remaining answers were assigned to categories. Categories of relevance to the management work are summarised in (Table 4.3).

**Table 4.3.** The most popular categories of best and most disappointing aspect of visits with example answers.

|  |  |  |
| --- | --- | --- |
| *Category* | *Best aspect* | *Most disappointing aspect* |
| NIA conservation management | “Interested in the reforestation”, “Rhododendron removal” | “Disturbance from tree felling”, “Over-managed” |
| Views & scenery | “Scenery”, “Beautiful landscape” | NA |
| Biodiversity & nature | “Seeing wildlife”, “Natural sounds” | “Poor biodiversity”, “Lack of wildlife” |
| Access | “Improving the bridleway network”, “Firm pathways” | “Boggy paths”, “Not enough bike access” |

One site, Burbage, experienced a particularly visually dramatic change as part of the NIA restoration programme, i.e. felling the vast majority of a commercially unviable conifer plantation at the centre of the site. This work began during the second to last set of surveys of the programme (Summer 2014) though primarily consisted of site preparation for the felling (i.e. enhancing and improving an access road for machinery). Felling works were completed by the final round of surveys (Winter 2014/15) though replanting, fencing and access road repair took place after our core visitor surveys had been completed. Given the dramatic nature of this work and the opposition regularly encountered by restoration programmes that fell trees (e.g. Ostergren et al. 2008; Van Marwijk et al. 2012) we collected some additional data on visitor reactions to removal of most of the plantation at this site (see Table 4.4 for questions that were asked in addition to those from the core surveys) during September 2015 using the same set up as the core visitor surveys (N = 44, 37 of which had visited the site prior to the removal of the trees). These additional results are used to explore some of the issues surrounding visitor responses to restoration activities at this site.

**Table 4.4.** Additional questions asked at Burbage during September 2015.

|  |  |
| --- | --- |
| *Question* | *Answer scale* |
| Has the removal of most of the plantation changed the quality of the site in your opinion? | Large decline / slight decline / no change / slight improvement / large improvement |
| Has this influenced how often you visit the site? | Visit a lot less / a little less / no change / a little more / a lot more |
| Are you aware that the plan is for it to become native, broadleaf woodland? | Yes / no |
| Does this change how you feel about the site and why? | Open |

#### Motivations for site visits

Participants were asked what the two main reasons were for visiting the sites in order to help contextualise responses to changes in site quality as a result of the NIA conservation restoration. The six options from which they could choose were i) exercise, ii) see good scenery, iii) get away from it all/tranquillity, iv) walk the dog, v) socialise, vi) experience nature and education. These categories were derived from previous findings of visitor motivations for visiting sites in the Peak District National Park by one of our project partners, The Moors for the Future Partnership (Davies, 2006) as well as to provide necessary data for the Dark Peak NIA’s monitoring requirements.

#### Perceived species richness

In order to assess whether the NIA conservation management works led to perceived increases in species richness at the sites, participants were asked how many species of a) plants, b) birds and c) butterflies they thought regularly occurred at or used the site in spring and summer on a six point scale of 1-10, 11-20, 21-50, 51-100, 101-150 and over 150. These three taxa were selected as they had to be taxa that were relatively easy to notice by members of the public and as doing so follows the approach taken by previous studies (Fuller *et al.*, 2007; Dallimer *et al.*, 2012). We used the same categories for all three taxonomic groups to avoid providing respondents with information on differences in the species richness of these groups. Incorporating perceived species richness into analyses of cultural benefits also enables us to determine any role this might have in their delivery.

### Cultural benefit delivery

In order to determine any impacts of the restoration management on cultural benefit delivery, we assessed changes in visitor behaviour (differences in the number and type of people visiting and how frequently they visited) as well as respondents’ psychological well-being and their willingness to support conservation.

#### Visitor numbers, type and site visitation rate

As it is virtually impossible to capture total visitor numbers across open sites, we instead opted for a “snapshot” approach. On each survey day of the four day core survey period (144 days in total) five minute counts of the total number of visitors visible at two locations within each site were conducted simultaneously across all sites at three time points (10:30, 13:00 and 15:30, or within 45 minutes of these times when other activities prevented counts being conducted at these precise times). The main car park for the site was one location, the business of which gives a good indicator of how busy the site is. We recognised that a single point count was not ideal and chose a section of path as a second replicate. Two sites was the maximum possible to allow simultaneous counts (necessary to avoid double counting of visitors) as there were two surveyors per site. Sections of path were selected that represented a main, well used path that was 30-50m in length with a clear view of the full stretch to allow accurate counting. Daily snap shot totals, calculated as the summed totals of all three counts from both locations within a site, were used for analyses to determine whether visitor numbers changed between the early and late phases of the conservation management work.

In order to assess whether the NIA conservation management activities influenced how regularly people were visiting the sites we asked participants how often they visited the site on a seven point scale (first visit, less than monthly, monthly, fortnightly, weekly, two to three times a week and daily).

In order to assess any changes in visitor type as a result of the conservation management work, and to control for the influence of socio-demographic factors on our response variables, we recorded participants tax band, highest level education qualification, age, gender and ethnicity (Table 4.5).

**Table 4.5.** The categories available to respondents when answering questions concerning socio-economic and demographic indicators.

|  |  |
| --- | --- |
| *Socio-economic / demographic indicator* | *Answer categories* |
| Education | None, O level/GCSE or equivalent, A level or equivalent, Undergraduate degree, Higher degree |
| Tax band | No tax (<£8,105 taxable income), Basic rate (£8,105-£34,370), Higher rate (£34,371-£150,000), Top rate (£>150,000) |
| Ethnicity | Office for National Statistics guidelines were used for ethnic group selection (http://ons.gov.uk/ons/guide-method/measuring-equality/equality/ethnic-nat-identity-religion/ethnic-group/index.html) but for analysis purposes these were categorised as white British, white non-British and non-white |
| Age | 19-25, 26-35, 36-45, 46-55, 56-65, over 66 (midpoints taken for analyses: 20, 30, 40, 50, 60, 70) |
| Gender | Male, Female |

#### Psychological well-being

There is currently no consensus on how best to measure the well-being benefits derived from green-spaces. At the time of devising the survey, studies by Fuller et al. (2007) and Dallimer et al. (2012) were amongst the very few to have considered the relationship between the biodiversity of green-spaces (as opposed to green-spaces in their entirety) and delivery of well-being benefits. Given that conservation management ultimately influences the biodiversity of an area, we felt using the same well-being metric as the Fuller et al. (2007) and Dallimer et al. (2012) studies was appropriate. Using the same approach as these two existing studies also helps to build consensus of relationships between well-being benefits and what influences their delivery from natural environments. Thus we used factor analysis as described by Tabachnick & Fidell (2001) to condense a series of statements grounded in the theoretical frameworks representative of cognitive restoration/reflection and sense of place well-being benefits delivered from green-spaces. Participants responded to statements on a standard five point Likert scale of agreement. Scores for negatively phrased statements were reversed and then separate analyses were conducted on the statements representative of (a) cognitive restoration and reflection (N = 6) and (b) sense of place (N = 10) using Principal Axis Factoring (Appendix 4.1) which identified three dimensions: i) cognitive restoration and reflection (termed reflection), ii) attachment, and iii) continuity with the past (how sense of identity is formed in connection with the site through continuity with the past). Participant scores from the statements representing each of the three factors were averaged to produce a new, single, continuous score per individual for each of these three well-being dimensions.

#### Support for conservation

We wanted to be able to gauge any changes in visitors personal support for the type of conservation management being undertaken across the Dark Peak NIA as a result of restoration activities and so asked participants, in principle, a) how much money (none, £1-5, £6-10, £11-15, over £15 a month) and b) how much time (none, half a day a month, one day a month, two days a month and over two days a month), they would be willing to volunteer to help improve the Dark Peak NIA for plants and wildlife. We selected financial donations and volunteering as our indicators of support given the prominence of these two types of activity as forms for members of the public to participate in and support restoration projects. Our primary aim was to assess how this support might change as a result of experiencing conservation management while visiting the sites and so although the willingness to pay approach can be subject to biases (see 4.5.4), it still anables us to detect temporal changes in levels of support.

#### Membership of conservation organisations

Respondents were asked whether they were a member of a wildlife or conservation organisation in order to be able to control for the influence this might have on some of our key variables of interest. A list of some of the more popular organisations were given for participants to choose from to which they could add any additional organisations allowing us to determine whether these were indeed wildlife or conservation organisations. Because of the dual aims of the National Trust to conserve both landscapes and historic buildings, analyses which controlled for wildlife or conservation organisation membership were repeated both including and excluding National Trust members. This made no difference to the results except for conservation support thus we only report both sets of analyses for this response variable. For all other analyses we report the results including National Trust membership only.

### Statistical analysis

We follow Whittingham et al. (2006) and use a full model approach, implemented in R, to test our core research questions (Table 4.6). All ordinal response variables were modelled using ordered mixed logit regressions in the ordinal package (Christensen, 2015). Continuous response variables were modelled using a linear mixed model in the lme4 package (Bates *et al.*, 2014) and our binary response variable (awareness of the NIA) was modelled using a logistic mixed effects regression. Conditional R2 values were calculated to assess model fit of linear models using R package piecewiseSEM (Nakagawa & Schielzeth 2013) while McFadden’s R2 were calculated for logistic and ordinal models. The diagnostic procedure advocated by Pasta (2009) which assesses whether ordinal predictor variables best fit the data when treated as categorical or continuous was employed to determine whether our ordinal variables (i.e. site visit rate, perceived species richness, education and tax) could be treated as continuous when used as predictors. In all cases, the Pasta test advocated treating these predictors as continuous except for tax band and education in the model of perceived butterfly species richness which were treated as ordinal. All continuous predictors were standardized using z-scores thus enabling direct comparison of predictors’ parameter estimates. All predictor variables were modelled as fixed factors except for site which was modelled as a random factor.

**Table 4.6.** Summary of models. Predictor type B = binary, C = categorical, L = linear. Site was incorporated into all models as a random factor. Ticks represent predictor inclusion within the model. Education and tax were both treated as categorical for the model of perceived butterfly species richness in accordance with the Pasta test outcome.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | *Predictors* | | | | | | | | | | | |  |
| *Response variables* | *Model type* | *Phase B* | *Treatment B* | *Phase \**  *treatment*  *interaction* | *Site visit*  *L* | *Perceived species richness L* | *Conservation organisation member*  *B* | *Season*  *C* | *Education*  *L* | *Tax*  *L* | *Ethnicity*  *C* | *Age*  *L* | *Gender*  *B* | *Site*  *C* |
| Visitor numbers | Linear | ✓ | ✓ | ✓ |  |  |  | ✓ |  |  |  |  |  | ✓ |
| Site visit rate | Ordinal | ✓ | ✓ | ✓ |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| NIA aware | Logistic | ✓ | ✓ | ✓ | ✓ |  |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| NIA objectives | Ordinal | ✓ | ✓ | ✓ | ✓ |  |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Perceived change in site quality | Ordinal | ✓ | ✓ | ✓ | ✓ |  |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Psychological well-being | Linear | ✓ | ✓ | ✓ | ✓ | ✓ |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Conservation support | Ordinal | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Perceived species richness | Ordinal | ✓ | ✓ | ✓ | ✓ |  | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Sheffield is located on the eastern fringe of the Dark Peak NIA area and is the closest urban centre, and as expected the majority of visitors (2012/13: 64.5%, 2014/15: 65.1%) to the Dark Peak NIA sites were from Sheffield (as assessed by postcodes). We conducted chi-squared analyses to determine whether the socio-demographic composition of the visitors to the Dark Peak NIA sites differed from that of the Sheffield resident population where this data was available (Office of National Statistics, 2012).

In order to assess whether there was any difference between the type of visitors taking part in the surveys between the two phases of the programme we conducted Mann-Whitney-U tests on tax band, level of education and ethnicity. A T-test was used to determine differences between early and late restoration phases in visitors’ ages and a chi-squared test for visitors’ gender. In order to determine any differences in visitor numbers between the phases, these were square root transformed to meet model assumptions and modelled, using a linear mixed model, as a function of phase, treatment, the interaction between phase and treatment, season, and weather. In order to determine any differences in visitation rate between phases and to address what other factors may be influencing this, visitation rate was modelled, in a linear mixed model, as a function of phase, treatment and their interaction, perceived plant species richness, bird species richness, butterfly species richness, season, being a member of a conservation charity as well as all socio-demographic variables (education, tax, ethnicity, age, gender). In these models species richness was treated as a continuous variable by taking the mid-points of each category (i.e. 5, 15, 35, 75, 125) and a value of 200 for the over 150 category.

In order to assess differences in visitors’ awareness of the NIA between programme phases, and support for four of its core objectives (increasing the quality of moorland, increasing the amount and quality of native woodland, hay meadow and access to the countryside), these were modelled in ordered logistic and ordered mixed logit regressions respectively as a function of phase, treatment and their interaction, site visit rate, season and all socio-demographic factors. Differences between levels of support for the four NIA objectives were assessed using a Kruskal-Wallis with Dunn’s post-hoc test. Both phases of the programme were combined for this analyses as the model revealed no difference in support for the objectives between the early and late phase.

Perceived change in site quality was also modelled in an ordered mixed logit regression as a function of phase, treatment and their interaction, site visit rate, season, all socio-demographic factors and site (as a random factor).

In order to assess any changes in perceived species richness as a result of conservation management, we modelled our three perceived species richness metrics (plants, birds and butterflies) in linear mixed models as a function of phase, treatment and their interaction, site visit rate, being a member of a conservation organisation, season while controlling for all socio-demographic variables and site (as a random factor). Perceived species richness was also incorporated into our cultural benefit models to determine any role it might play in their delivery.

To test our hypothesis that landscape scale restoration influences cultural benefit delivery we considered psychological well-being using each of our three well-being metrics (reflection, attachment and continuity with the past) and conservation support using our two metrics (willingness to volunteer and willingness to donate money to help improve the Dark Peak NIA for plants and wildlife). Psychological well-being indicators were modelled in linear mixed models as a function of survey phase, treatment and their interaction, site visit rate and perceived species richness whilst taking socio-demographic factors and site (as a random factor) into account. Conservation support metrics were modelled in ordered mixed logit regressions as a function of the same predictors as psychological well-being with the addition of membership of a conservation organisation. Both conservation support metrics were modelled twice, once with and once without including members of the National Trust as part of the member of a conservation organisation predictor due to the organisations duel focus of conserving both landscapes and historic buildings.

To assess the impact of the particularly dramatic management work of the plantation felling at Burbage on cultural benefit delivery, we modelled psychological well-being and conservations support as a function of phase, site visit rate, season and socio-demographic factors. The additional surveys that took place during September 2015 were added to the other late phase surveys from the core survey period. Perceived species richness and being a member of a conservation organisation were not included in these models as they were more adequately addressed in the models assessing cultural benefit delivery across all sites.

## Results

### Awareness of the NIA and support for the key NIA objectives

Awareness of the NIA was low across the five NIA sites, and did not vary between the early and late phases of the programme (Table 4.7). When pooling data across both survey phases, 22% of participants were aware of the NIA. Support for the NIA objectives, however, was high with the majority of respondents either agreeing or strongly agreeing it was important to increase the quality of moorland (85%) and the amount and quality of native woodland (89%), hay meadow (63%) and access to the countryside (73%). This variation in support for the divergent objectives was statistically significant (Kruskal-Wallis test, *χ2* = 205.49, d.f. = 3, *P* < 0.0001, Dunn’s post hoc tests, all *P* < 0.001). Comments such as “I’m not really sure what hay meadows are” and “I don’t know if hay meadows were traditionally found in these areas” were commonly made while responding to the hay meadow objective. Frequently made comments, for example, “I think the access is already pretty good” and “I’m not sure, I don’t want too many people” were also made in response to the access objective. There was no difference in the amount of support between the early and late phases (Table 4.7). People who visited sites more frequently were more likely to be aware of the NIA, and older people were consistently more supportive of all the NIA objectives (except increasing access). Women were more likely to support increasing the amount of moorland than men.

**Table 4.7.** Logistic mixed effect regression analysis of respondents’ awareness of the NIA (N = 1069) and ordered mixed logit regressions support for support for the NIAs four primary objectives, increasing the amount and quality of moorland (N = 1081), woodland (N = 1083), hay meadow (N = 1082), and access (1082). Reference categories for phase = early, treatment = control, and gender = male. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Site was included as a random factor in all models. R2 values are McFadden’s. \* P < 0.05, \*\* P < 0.01, \*\*\* P < 0.001.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | |  |
| *Response variable* | *Phase* | *Treatment* | *Phase treatment interaction* | *Site visit rate* | *Season* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Awareness | 0.10,  -0.43 ± 0.27 | 0.59,  0.17 ± 0.31 | 0.31,  0.32 ± 0.32 | 0.01\*\*,  0.43 ± 0.15 | 0.71, S -0.00 ± 0.18, W 0.14 ± 0.19 | 0.13,  0.25 ± 0.16 | 0.61,  -0.08 ±0.16 | 0.75, W 0.27 ± 0.50, NW 0.28 ± 0.50 | 0.00\*\*,  0.53 ± 0.17 | 0.54,  -0.10 ± 0.16 | 0.165 |
| Objectives - moorland | 0.34,  -0.19 ± 0.20 | 0.02\*,  -0.43 ± 0.19 | 0.90,  0.03 ± 0.25 | 0.24,  -0.15 ± 0.13 | 0.59, S 0.14 ± 0.14, W 0.18 ± 0.39 | 0.92,  -0.01 ± 0.13 | 0.69,  0.05 ± 0.12 | 0.51, W 0.46 ± 0.43, NW 0.18 ± 0.39 | 0.01\*\*,  0.35 ± 0.13 | 0.04\*,  0.25 ± 0.12 | 0.158 |
| Objectives - woodland | 0.45,  0.16 ± 0.21 | 0.16,  -0.28 ± 0.20 | 0.38,  -0.22 ± 0.25 | 0.62,  0.06 ± 0.13 | 0.51, S 0.17 ± 0.14, W 0.07 ± 0.15 | 0.41,  0.11 ± 0.13 | 0.31,  -0.13 ± 0.13 | 0.48, W 0.11 ± 0.42, NW 0.47 ± 0.41 | 0.02\*,  0.30 ± 0.13 | 0.22,  0.15 ± 0.12 | 0.165 |
| Objectives - hay meadow | 0.47,  0.14 ± 0.19 | 0.42,  -0.16 ± 0.20 | 0.39,  -0.20 ± 0.23 | 0.54,  0.07 ± 0.12 | 0.81, S -0.02 ± 0.13, W -0.09 ± 0.14 | 0.41,  -0.10 ± 0.12 | 0.02\*,  -0.27 ±0.12 | 0.69, W 0.21 ± 0.37, NW -0.22 ± 0.34 | 0.00\*\*\*,  0.51 ± 0.12 | 0.67,  0.05 ± 0.12 | 0.165 |
| Objectives -access | 0.11,  0.31 ± 0.19 | 0.85,  -0.04 ± 0.20 | 0.08.  -0.42 ± 0.24 | 0.07,  -0.21 ± 0.12 | 0.81, S -0.06 ± 0.14, W -0.09 ± 0.14 | 0.15,  -0.18 ± 0.12 | 0.66,  0.05 ± 0.12 | 0.15, W -0.50 ± 0.40, NW 0.58 ± 0.40 | 0.52,  -0.08 ± 0.12 | 0.06,  0.22 ± 0.12 | 0.161 |

### Perceptions of changes in site quality, reasons for this and perceived changes in species richness

#### Perceived changes in site quality and reasons for this

A large proportion of respondents reported no change in site quality across both phases of the programme (Fig. 4.1). There were, however, significant increases in those reporting improvements in site quality in the later phase of the programme (Table 4.8; Fig. 4.1). These increases, however, were not confined to the treatment sites (Fig. 4.1), and there was no significant interaction between phase and treatment (Table 4.8). The changes in site quality that were reported were largely a result of perceived access improvements (54%), primarily path quality, quantity and condition (37% of all reported improvements). Interestingly, access was also the most cited reason for perceived declines in site quality (37% of all reported declines) with deteriorating path conditions and erosion being the main cause (27% of all reported declines). Less than 1% stated path improvement and expansion as the reason for declines in site quality though complaints about too many people accounted for 4% of reported declines. In some cases it was clear that specific access works were identified as the reasons for improved site quality. However, there were also responses which clearly referred to areas where no works were taking place thus perceived changes in access quality were not always due to management activities.

|  |  |
| --- | --- |
| a) |  |
| b) |  |

**Figure 4.1.** The mean percentages of Dark Peak NIA visitor survey respondents reporting perceived changes in site quality across a) treatment sites, and b) control sites in both early and late phases of the programme. Error bars represent standard errors.

**Table 4.8**. Ordered mixed logit regression models of perceived changes in site quality (from large decline to large improvement) over the previous two years (N = 885). Reference categories for phase = early, treatment = control, and gender = female. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Site was included as a random factor. McFadden’s R2 is given. \*\* P < 0.01.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | |  |
| *Response variable* | *Phase* | *Treatment* | *Phase treatment interaction* | *Site visit rate* | *Season* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Perceived changes in site quality | 0.01\*\*,  0.55 ± 0.21 | 0.36,  -0.32 ± 0.35 | 0.14,  -0.40 ± 0.27 | 0.84,  -0.03 ± 0.15 | 0.76, S -0.11 ± 0.15, W -0.03 ± 0.16 | 0.85,  0.03 ±0.14 | 0.91,  0.02 ± 0.14 | 0.22, W 0.86 ± 0.50, NW 0.18 ± 0.48 | 0.09,  0.23 ± 0.14 | 0.53,  -0.40 ± 0.27 | 0.16 |

Only 6% of all reported changes in site quality were due to NIA management activities (Table 4.9). NIA conservation management activities were the next most reported cause of improvements at treatment sites in the late phase of the programme albeit to a much lesser extent than access (14% of all reported improvements). The vast majority (84%) of those who did mention NIA management activities felt they had improved site quality (Table 4.9). The majority of NIA management activities explicitly mentioned by visitors referred to Burbage (conifer plantation removal) and Blacka Moor (rhododendron clearance and tree thinning), i.e. the sites with the most obvious visual impact of management activities (Table 4.9). Very few respondents commented on restoration activities at Curbar and Stanage (Table 4.9).

**Table 4.9.** Number of responses from participants on perceived changes in site quality related to NIA conservation restoration activities. See Table 4.1 for additional management activities that took place but were not commented on by respondents.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Site* | *Responses related to NIA restoration* | *NIA restoration activity reported* | *Improvement* | *Decline* |
| Blacka Moor | 20 | Rhododendron clearance/tree thinning  Bracken control  Heather cut | 14  2  1 | 3  0  0 |
| Burbage | 9 | Conifer plantation removal | 7 | 2 |
| Curbar | 1 | Hay meadow creation | 1 | 0 |
| Stanage | 2 | Bracken control | 2 | 0 |

To explore visitor reactions to the dramatic changes of removing most of the Burbage conifer plantation we consider responses at this site in greater detail. Only 14% of visitors who were interviewed once the plantation work had begun during the core survey period (i.e. not including the additional round of surveys that took place at Burbage in September 2015) stated that the tree felling changed the quality of the site with the majority (seven out of nine respondents) reporting it as an improvement and two people perceiving it as a decline in site quality. During the additional surveys conducted at this site roughly nine months later (during which time replanting, fencing and access road repair took place) a much larger proportion of visitors (55% of 37 respondents) commented on the removal of trees when asked whether the site had changed in quality in the previous two years with the majority of these (72%) now perceiving it as a decline. As well as asking about changes in quality to the site as a whole, we also asked, specifically, whether the felling of the plantation had changed the quality of the site thereby incorporating reactions of participants who had not mentioned the plantation when asked about the site as a whole. Eighty-nine percent of participants stated that the felling of the plantation had changed the site quality with the majority (73%) still perceiving this as a decline. Those who felt it had improved site quality generally referred to it being positive in the long-term though the immediate impact was negative e.g. “Getting rid of the forestry and going to plant natives. Looks a bit bare just now but it’s a long term project”. Negative comments were largely because “the trees” or “woods” had gone and “it looked a mess”. Those that felt it had not changed the quality of the site stated reasons such as “it is still very pretty” and/or “it is not affecting where I’m going”. Despite the majority of respondents stating that site quality had declined only 5% of all respondents stated that they visited the site less frequently.

Once participants were informed that the future management plan was to replace the plantation with native, broadleaf woodland, however, opinions reversed with the majority (72%) stating the restoration work was an improvement to site quality (Fig. 4.2). Those that changed their mind from a negative to a positive response mostly stated that they would feel better about it being woodland again e.g. “I like broadleaf woodland so will be better but takes a long time to grow”. Many mentioned that the site looked a mess but that they now understood it was a longer term benefit though some voiced frustrations about how long it would take before it looked better again. The negative comments (N = 2) about the long-term plan of the site were: “wrong, man-made decision, nature should be allowed to do its own thing, looks ugly now was really pretty” and “should have been left as commercial woodland”.

**Figure 4.2.** Perceived changes in site quality at Burbage (one of the Dark Peak NIA treatment sites) in response to the felling of most of a conifer plantation before and after participants were told that the plan was for it to be replaced with native, broadleaf woodland in the future.

#### Best and most disappointing aspects of visits

Views and scenery were by far the most popular aspect of participants’ visits across all sites and both phases of the programme (early 46%, late 42%). Answers relating to biodiversity and nature were the second most popular aspect of visits though to a much lesser extent than views/scenery with marginal increases in those reporting these as their best aspect in the later phase of the project across the treatment sites (early 8%, late 10%). Small proportions (all < 10%) of visitors reported a wide variety of other aspects as the best part of their visit.

The majority of visitors reported there was nothing disappointing about their visit (early 52%, late 53%). Those that did report a disappointing aspect most frequently stated factors relating to poor access (early 11%, late 9%). Small proportions (all < 10%) of visitors reported a wide variety of other aspects as the worst part of their visit.

Very few people (2%) commented on NIA conservation management activities as their best or most disappointing aspect of their visit. All six of the answers relating to NIA restoration activities at Blacka Moor concerned rhododendron removal with two people saying it was their best aspect and four their most disappointing. Eight people at Burbage made reference to NIA restoration activities with one saying that interest in the reforestation of the plantation as native, broadleaf woodland was their best aspect while another felt the plantation being felled was their most disappointing aspect. The remaining six participants commented on aspects related to the plantation removal as their most disappointing aspect though these were only temporary in nature (path closure, noise and mud from the removal process).

#### Motivation for site visits

Exercise (30%) and seeing good scenery (27%) were the most important reasons why participants were visiting all sites across both phases of the programme. These were followed by getting away from it all/tranquillity (14%), walking the dog (10%), experiencing nature (10%), socialising (7%) and education (2%).

#### Perceived species richness

Perceived species richness of plants and birds present at the site during spring and summer did not vary between early and late phases of the programme (Table 4.10). Although perceived butterfly richness increased in the later phase, there was no interaction with treatment type suggesting this was not due to restoration activities. Plant and butterfly species richness were significantly associated with site visit rate with more frequent visitors reporting lower species richness. Perceived plant species richness was also significantly associated with higher levels of education, while older and non-British respondents reported lower plant species richness (Table 4.10). Older participants also perceived lower species richness of birds and butterflies and lower perceived butterfly species richness was also significantly associated with increasing levels of education (Table 4.10).

**Table 4.10.** Ordered mixed logit regression models of perceived plant (N = 1064), bird (N = 1068) and butterfly (N = 1061) species richness. Reference categories for phase = early, treatment = control, and gender = female. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Education and tax were modelled as categorical for butterfly species richness as recommended by Pasta test outcomes with no qualifications as the reference category for education compared to GCSE or equivalent (G), A-Level of equivalent (A), undergraduate degree (U) and higher level degree (H), and no tax as the reference category for tax compared to basic rate (B), higher rate (H) and top rate (T). Site was included as a random factor in all models. R2 values are McFadden’s. \* P < 0.05, \*\* P < 0.01, \*\*\* P < 0.001.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | |  |
| *Response variable* | *Phase* | *Treatment* | *Phase treatment interaction* | *Site visit rate* | *Conservation organisation member* | *Season* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Perceived plant species richness | 0.97, 0.01 ± 0.19 | 0.20, -0.39 ± 0.30 | 0.76, 0.07 ± 0.23 | 0.03\*, -0.25 ± 0.12 | 0.30, 0.12 ± 0.12 | 0.06, S 0.14 ± 0.13, W -0.19 ± 0.14 | 0.02\*, 0.29 ± 0.12 | 0.43, 0.09 ± 0.12 | 0.03\*, W -0.46 ± 0.37, NW -0.88 ± 0.36 | 0.00\*\*\*, -0.46 ± 0.12 | 0.42, -0.09 ± 0.12 | 0.17 |
| Perceived bird species richness | 0.92, 0.02 ± 0.19 | 0.09, -0.40 ± 0.23 | 0.79, 0.06 ± 0.24 | 0.62, -0.06 ± 0.12 | 0.14, -0.18 ± 0.12 | 0.63, S 0.05 ± 0.12, W 0.13 ± 0.14 | 0.56, 0.07 ± 0.13 | 0.26, 0.14 ± 0.12 | 0.23, W -0.30 ± 0.40, NW -0.58 ± 0.37 | 0.00\*\*\*, -0.77 ± 0.13 | 0.95, -0.01 ± 0.12 | 0.16 |
| Perceived butterfly species richness | 0.03\*, 0.40 ± 0.19 | 0.58, -0.11 ± 0.20 | 0.95, 0.02 ± 0.23 | 0.01\*, -0.31 ± 0.12 | 0.50, -0.07 ± 0.10 | 0.16, S 0.06 ± 0.13, W 0.27 ± 0.14 | 0.00\*\*, G -0.00 ± 0.25, A -0.53 ± 0.25, U -0.45 ± 0.23, H -0.01 ± 0.24 | 0.68, B -0.20 ± 0.16, H -0.16 ± 0.19, T -0.09 ± 0.43 | 0.32, W -0.31 ± 0.39, NW -0.53 ± 0.41 | 0.00\*\*\*, -1.02 ± 0.13 | 0.51, 0.08 ± 0.13 | 0.17 |

### Cultural benefit delivery

#### Visitor type

Respondents were selected in an unbiased manner and thus their socio-demographic profiles provide a strong indicator of the composition of visitor types to the Dark Peak NIA sites. Comparisons between the NIA survey participants and the Sheffield resident population (Table 4.11) reveal significant biases with the users of the NIA more likely than expected by chance to be men sites (*χ*² = 12.77, *P* < 0.001), older than 56 (*χ*² = 93.37, *P* < 0.0001), and white (*χ*² = 126.88, *P* < 0.0001). Comparable data on tax band, employment status and education level were not available for the reference Sheffield population. Comparisons with the UK population as a whole, however, reveal that the number of participants with either an undergraduate or higher degree was more than double the equivalent percentage of the UK population (ONS, 2012). There were no significant differences between the type of visitors between the two phases of the programme except for the proportion of females which increased in the late phase (from 39% to 45%; χ2 = 4.13, *P* < 0.05).

**Table 4.11** Socio-economic and demographic summary of NIA respondents (N = 1083) and resident Sheffield reference population. Comparable Sheffield data were not available for level of education, employment status or tax band.

|  |  |  |
| --- | --- | --- |
| *Category* | *NIA visitors (%)* | *Sheffield resident population (%)* |
| Age  19-25  26-35  36-45  46-55  56-65  >65 | *6*  *12*  *15*  *17*  *26*  *22* | *13*  *19*  *18*  *17*  *13*  *20* |
| Education  None  GCSE  A level  Undergraduate degree  Higher degree | 5  17  16  32  28 |  |
| Employment  Retired  Unemployed  Full-time education  Full-time paid employment  Part-time paid employment  Self-employed | 36  3  5  37  12  7 |  |
| Ethnicity  White British  White non-British  Non-white | 95  3  2 | 81  3  16 |
| Gender  Male  Female | 58  42 | 49  51 |
| Tax band  No tax (<£9,440)  Basic rate (£9,440-£32,010)  Higher rate (£32,011-£150,000)  Top rate (£>150,000) | 17  57  24  2 |  |

#### Visitor numbers and site visitation rates

There was no evidence that visitor numbers changed between the early and late phases of NIA restoration activities, although (unsurprisingly) visitor numbers were lower during winter and on days with poorer weather conditions (Table 4.12).

**Table 4.12.** Linear mixed effects model of visitor numbers (N = 144). Visitor numbers were square root transformed to meet model assumptions. The early phase was the reference category for phase. Control sites were the reference for treatment. Summer (S) and winter (W) were compared to the reference category of spring for season. Weather was recorded at three intervals during each survey day. The reference value for weather was no rain, compared to 1 = one count of rain, 2 = two counts of rain, and 3 = three counts of rain. Site was included as a random factor. Conditional R2 values are given. \* P < 0.05, \*\* P < 0.01.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | |  |
| *Response variable* | *Phase* | *Treatment* | *Phase treatment interaction* | *Season* | *Weather* | *R2* |
| Visitor numbers | 0.13,  0.92 ± 0.61 | 0.51,  -1.01 ± 1.52 | 0.30,  -0.70 ± 0.67 | 0.04\*, S 0.14 ± 0.40, W -0.92 ± 0.46 | 0.00\*\*, 1 -0.34 ± 0.54, 2 -2.21 ± 0.62, 3 -1.05 ± 0.60 | 0.595 |

Participants did not differ in how frequently they visited the sites between the early and late phases of the NIA programme (Table 4.13). Notably, however, older people and those who perceived higher plant species richness at the focal site visited the site more frequently; there was no such association for perceived butterfly or bird species richness (Table 4.13).

**Table 4.13.** Ordered mixed logit regression model of site visitation rate (N = 1056). Reference categories for phase = early, treatment = control, and gender = female. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Site was included as a random factor in all models. McFadden’s R2 value is given. \*\* P < 0.01, \*\*\* P < 0.001.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | |  |
| *Response variable* | *Phase* | *Treatment* | *Phase treatment interaction* | *Perceived plant species richness* | *Perceived bird species richness* | *Perceived butterfly species richness* | *Season* | *Conservation charity member* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Site visit rate | 0.47,  -0.14 ± 0.19 | 0.45,  -0.36 ± 0.18 | 0.20,  0.30 ± 0.23 | 0.00\*\*,  -0.41 ± 0.13 | 0.52,  0.10 ± 0.15 | 0.64,  .07 ± 0.15 | 0.20, S -0.20 ± 0.13, W 0.02 ± 0.14 | 0.91,  -0.01 ± 0.012 | 0.44,  0.10 ± 0.12 | 0.14,  0.18 ± 0.12 | 0.06, W 0.07 ± 0.42. NW -0.90 ± 0.38 | 0.00\*\*\*,  0.53 ± 0.12 | 0.84,  0.02 ± 0.12 | 0.173 |

#### Psychological well-being

Scores for all three domains of psychological well-being were consistently high across all six sites with scores for attachment being highest (median = 4.8 out of 5), followed by reflection (median = 4.2 out of 5) and continuity with the past (median = 3.8 out of 5). There were no differences in levels of reflection or continuity with the past between the two phases of the restoration (Table 4.14). Feelings of attachment did increase in the late phase of the programme but there was no association with the treatment-phase interaction. All three dimensions of well-being were positively associated with more regular site visits (Table 4.14). There was no association between psychological well-being and perceived species richness (Table 4.14). Levels of attachment were greater during spring compared to summer and winter, while females scored higher on reflection and continuity with the past (Table 4.14). Continuity with the past was also greater in older respondents (Table 4.14).

**Table 4.14.** Linear mixed effects models of three different measures of psychological well-being; reflection (N = 1053), attachment (N = 1053) and continuity with the past (N = 1051). Reference categories for phase = early, treatment = control, and gender = female. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Site was included as a random factor in all models. Conditional R2 values are given. \* P < 0.05, \*\* P < 0.01, \*\*\* P < 0.001.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | |  | |
| *Response variable* | *Phase* | *Treatment* | *Phase treatment interaction* | *Site visit rate* | *Perceived plant species richness* | *Perceived bird species richness* | *Perceived butterfly species richness* | *Season* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | | *R2* |
| Reflection | 0.20,  0.08 ± 0.06 | 0.22,  0.07 ± 0.06 | 0.24,  -0.09 ± 0.08 | 0.00\*\*\*,  0.22 ± 0.04 | 0.65,  0.02 ± 0.04 | 0.52,  0.03 ± 0.05 | 0.97,  0.00 ± 0.05 | 0.28, S 0.06 ± 0.04, W 0.06 ± 0.05 | 0.10,  -0.07 ± 0.04 | 0.24,  0.05 ± 0.04 | 0.07, W 0.29 ± 0.13, NW -0.07 ± 0.12 | 0.47,  0.03 ± 0.04 | 0.00\*\*\*,  -0.13 ± 0.04 | | 0.05 |
| Attachment | 0.02\*,  0.10 ± 0.04 | 0.25,  0.06 ± 0.05 | 0.36,  -0.05 ± 0.05 | 0.00\*\*\*,  0.10 ± 0.03 | 0.10,  0.05 ± 0.03 | 0.99,  0.00 ± 0.03 | 0.43,  0.03 ± 0.03 | 0.00\*\*\*. S -0.11 ± 0.03, W -0.01 ± 0.03 | 0.26,  -0.03 ± 0.03 | 0.62,  0.01 ± 0.03 | 0.90, W -0.01 ± 0.08, NW -0.04 ± 0.08 | 0.30,  0.03 ± 0.03 | 0.42,  -0.02 ± 0.03 | | 0.06 |
| Continuity with the past | 0.52,  0.05 ± 0.08 | 0.25,  0.09 ± 0.08 | 0.49,  0.07 ± 0.09 | 0.00\*\*\*,  0.60 ± 0.05 | 0.20,  0.06 ± 0.05 | 0.30,  0.06 ± 0.06 | 0.18,  0.08 ± 0.06 | 0.32, S -0.03 ± 0.05, W 0.05 ± 0.06 | 0.09,  -0.08 ± 0.05 | 0.67,  -0.02 ± 0.05 | 0.84, W 0.04 ± 0.15, NW 0.08 ± 0.15 | 0.00\*\*,  0.15 ± 0.05 | 0.00\*\*,  -0.13 ± 0.05 | | 0.18 |

When considering psychological well-being from Burbage alone, there were no significant differences in the levels of reflection or attachment between the two phases of the programme (Table 4.15). There was a trend towards higher levels of continuity with the past in the late phase which was borderline significant (Table 4.15).

**Table 4.15.** Linear models of three different measures of psychological well-being; reflection (N = 245), attachment (N = 245) and continuity with the past (N = 244) for Burbage surveys only. The reference category for phase = early. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Adjusted R2 values are given. \* P < 0.05, \*\*\* P < 0.001.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | |
| *Response variable* | *Phase* | *Site visit rate* | *Season* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Reflection | 0.83,  0.02 ± 0.09 | 0.10,  0.12 ± 0.07 | 0.59, S 0.01 ± 0.10, W -0.10 ± 0.12 | 0.05\*,  0.14 ± 0.07 | 0.86,  -0.00 ± 0.02 | 0.25, W -0.05 ± 0.30, NW -0.38 ± 0.25 | 0.46,  0.05 ± 0.07 | 0.23,  -0.10 ± 0.09 | 0.01 |
| Attachment | 0.90,  -0.01 ± 0.06 | 0.03\*,  0.10 ± 0.05 | 0.01\*, S -0.16 ± 0.06, W 0.01 ± 0.08 | 0.09,  0.08 ± 0.05 | 0.41,  -0.01 ± 0.01 | 0.43, W -0.24 ± 0.20, NW -0.09 ± 0.17 | 0.10,  0.08 ± 0.05 | 0.92,  0.01 ± 0.06 | 0.05 |
| Continuity with the past | 0.05,  0.21 ± 0.11 | 0.00\*\*\*,  0.37 ± 0.09 | 0.38, S -0.09 ± 0.12, W -0.20 ± 0.14 | 0.01\*,  0.23 ± 0.09 | 0.33,  -0.03 ± 0.03 | 0.53, W 0.13 ± 0.37, NW -0.33 ± 031 | 0.22,  0.11 ± 0.09 | 0.35,  -0.10 ± 0.11 | 0.10 |

#### Support for conservation

The majority (71%) of all respondents were, in theory, were willing to contribute time and/or money to help improve the Dark Peak NIA for plants and wildlife across all sites. How much time participants were willing to volunteer was positively associated with the interaction between phase and treatment suggesting a positive impact of the conservation management work (Table 4.16). This, however, was not the case for the amount of money participants were theoretically willing to donate which had no association with the conservation management activities. Willingness to volunteer and donate money was negatively associated with being a member of a conservation organisation when National Trust members were included in this predictor, but there was no association when National Trust members were excluded (Table 4.16). Some participants who were members of conservation organisations did explain they would not be willing to donate to help improve the NIA for plants and wildlife given they already donated to similar causes. Increases in both the amount of time and money respondents were willing to donate were significantly associated with site visit rate, perceived bird species richness and being male (Table 4.16). The amount of time participants were willing to volunteer was negatively associated with tax rate, while the opposite was true for the amount of money they were willing to donate (Table 4.16).

**Table 4.16.** Ordered mixed logit regression models of two different measures of conservation support, i) time willing to volunteer (from no days a month to over two days a month; N = 1051), and ii) amount willing to donate financially (from nothing to over £15 a month; N = 1050) both including and excluding National Trust (NT) members within the member of a conservation organisation predictor. Reference categories for phase = early, treatment = control, and gender = female. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. Site was included as a random factor in all models. McFadden’s R2 values are given. \* P < 0.05, \*\* P < 0.01.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | | | | | | |  |
| *Response variable* | *Phase* | *Treatment* | *Phase Treatment interaction* | *Site visit rate* | *Perceived plant species richness* | *Perceived bird species richness* | *Perceived butterfly species richness* | *Season* | *Conservation organisation member* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Volunteer inc. NT | 0.39,  -0.17 ± 0.19 | 0.21,  -0.24 ± 0.19 | 0.01\*\*,  0.63 ± 0.24 | 0.01\*,  0.31 ± 0.12 | 0.15,  -0.19 ± 0.13 | 0.04\*,  0.32 ± 0.15 | 0.70,  0.05 ± 0.14 | 0.06, S 0.32 ± 0.14, W 0.13 ± 0.14 | 0.01\*,  -0.08 ± 0.12 | 0.32,  0.13 ± 0.13 | 0.00\*\*,  -0.38 ± 0.12 | 0.10, W 0.49 ± 0.36, NW 0.67 ± 0.37 | 0.02\*,  -0.32 ± 0.13 | 0.04\*,  0.25 ± 0.12 | 0.18 |
| Volunteer exc. NT | 0.43,  -0.16 ± 0.19 | 0.23,  -0.23 ± 0.19 | 0.01\*\*,  0.62 ± 0.24 | 0.01\*,  0.31 ± 0.12 | 0.14,  -0.19 ± 0.13 | 0.04\*,  0.31 ± 0.15 | 0.67,  0.06 ± 0.14 | 0.07, S 0.31 ± 0.14, W 0.13 ± 0.14 | 0.15,  -0.19 ± 0.13 | 0.34,  0.12 ±0.13 | 0.00\*\*,  -0.38 ± 0.12 | 0.10, W 0.51 ± 0.36, NW 0.67 ± 0.37 | 0.01\*,  -0.32 ± 0.13 | 0.04\*,  0.25 ± 0.12 | 0.18 |
| Financial donation inc. NT | 0.78,  -0.06 ± 0.20 | 0.49,  -0.14 ± 0.20 | 0.29,  0.26 ± 0.25 | 0.02\*,  0.30 ± 0.13 | 0.27,  -0.15 ± 0.14 | 0.02\*,  0.37 ± 0.16 | 0.59,  -0.09 ± 0.16 | 0.45, S 0.16 ± 0.14, 0.01 ± 0.15 | 0.04\*,  -0.25 ± 0.12 | 0.49,  0.09 ± 0.13 | 0.01\*,  0.31 ± 0.13 | 0.90, W 0.15 ± 0.41, NW 0.18 ± 0.40 | 0.03\*,  -0.29 ± 0.13 | 0.01\*\*,  0.32 ± 0.12 | 0.17 |
| Financial donation exc. NT | 0.86,  -0.04 ± 0.20 | 0.49,  -0.14 ± 0.20 | 0.34,  0.23 ± 0.25 | 0.02\*,  0.30 ± 0.13 | 0.23,  -0.17 ± 0.14 | 0.02\*,  0.38 ± 0.16 | 0.56,  -0.09 ± 0.16 | 0.53, S 0.14 ± 0.14, W 0.00 ± 0.15 | 0.26,  -0.15 ± 0.14 | 0.41,  0.11 ± 0.13 | 0.01\*,  0.32 ± 0.13 | 0.90, W 0.16 ± 0.41, NW 0.14 ± 0.40 | 0.05,  -0.25 ± 0.13 | 0.01\*\*,  0.32 ± 0.12 | 0.17 |

When considering conservation support at Burbage only, there were no associations between how much participants were willing to donate in time or money between the two phases of the programme (Table 4.17).

**Table 4.17.** Ordinal regression models of two different measures of conservation support, i) time willing to volunteer (from no days a month to over two days a month; N = 246), and ii) amount willing to donate financially (from nothing to over £15 a month; N = 246) at Burbage only. Reference categories for phase = early and gender = female. Summer (S) and winter (W) were compared to the reference category of spring for season. Non-white British (NW) and non-white, non-British (NW) were compared to the reference value white British for ethnicity. \*\* P < 0.01.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *P value, Parameter estimate ± SE* | | | | | | | | |
| *Response variable* | *Phase* | *Site visit rate* | *Season* | *Education* | *Tax* | *Ethnicity* | *Age* | *Gender* | *R2* |
| Volunteer | 0.21,  0.19 ± 0.15 | 0.01\*\*,  0.33 ± 0.13 | 0.10, S -0.01 ± 0.17, W -0.01 ± 0.20 | 0.82,  -0.03 ± 0.12 | 0.63,  0.02 ± 0.04 | 0.10, W 0.05 ± 0.52, NW 0.95 ± 0.44 | 0.48,  0.09 ± 0.13 | 0.84,  0.03 ± 0.15 | 0.01 |
| Donate | 0.12,  0.16 ± 0.10 | 0.11,  0.14 ± 0.09 | 0.71, S 0.02 ± 0.12, W -0.09 ± 0.14 | 0.45,  0.06 ± 0.09 | 0.16,  0.04 ± 0.16 | 0.50, W 0.38 ± 0.36, NW -0.14 ± 0.31 | 0.13,  -0.13 ± 0.09 | 0.00\*\*,  0.32 ± 0.11 | 0.06 |

## Discussion

### Awareness of the NIA and support for the key NIA objectives

Awareness of the NIA was low with participants who visited the sites more frequently being more likely to have heard of it. It might have been expected that awareness would increase at the NIA sites throughout the project duration. There was, however, no evidence for this, probably because the NIA partnership primarily invested the limited resources in restoration rather than publicity and the awareness raising activities conducted took place very early on in the project. This lack of increased awareness as the restoration programme proceeded means that our analysis of other indicators of the visitor experience is unlikely to be confounded by changes in awareness levels.

Levels of agreement with all four of the NIA management objectives were consistently high throughout the programme. This is consistent with other studies showing support for conservation aims amongst the general public to be high (Vining, Tyler and Kweon, 2000; Ostergren, Abrams and Lowe, 2008; Buijs, 2009). Increases to the quality of moorland and the amount and quality of native woodland received greatest support, as expected given the cultural importance of moorland across the Peak District and the public’s affinity for woodlands (Henwood and Pidgeon, 2001). Improving the amount and quality of access received the next highest level of support though many respondents stated that access was already good, and some stated that they did not want visitor numbers to increase. Although hay meadow is the habitat type to have suffered greatest losses (Jefferson, 2005), improving its amount and quality received the least amount of support with some participants being unsure of what it was or if it was traditionally found at the sites.

### Perceptions of changes in site quality, reasons for this and perceived changes in species richness

#### Perceived changes in site quality and reasons for this

We found that the majority (52%) of repeat visitors to the treatment sites, reported no change in site quality in the previous two years and very few (6%) commented on changes in site quality as a result of the conservation management work or as their best/most disappointing aspect of their visit (2%). There are a number of possible explanations for this apparent lack of a reaction to restoration activities. First, management may not directly influence the activities that people conduct at the site, or their primary motivations for visiting the site (30% exercise, 27% views and scenery) with participants telling us, for example, it was not influencing what they were doing or where they were going. Second, at these landscape scales, even dramatic changes only impact on a small proportion of the location and so visitors may not consider that it influences the quality of the site as a whole. Burbage provides evidence for this with 34% of participants only commenting on a change in site quality as a result of a plantation felling when asked specifically about the work and not when asked about site quality as a whole in a previous question. Third, some activities, such as hay meadow improvements and bracken spraying do not have a marked visual impact, or only do so at certain times, which may further contribute to the lack of comments regarding NIA management changing site quality. As far as we are aware, this apparent lack of a response has not been captured in previous studies and we suspect it could be due to differences in methodology. Using hypothetical scenarios for which participants state their preference (e.g. Barro & Bright 1998; Solecki 1998) or ranking photographs of landscapes at different states of restoration (e.g. van Marwijk et al. 2012; Petursdottir et al. 2013) is common place in assessments of people’s responses to restoration. These methods draw participant’s attention to the differences in the landscape and encourages a reaction to them making it difficult to capture indifferent responses or whether people would actually notice such changes in situ. By conducting surveys in situ, as management works are underway, we have provided new insight in to how visitors may respond to large-scale conservation restoration.

The participants who did comment on NIA conservation management primarily referred to activities at Burbage and Blacka Moor, the sites where restoration activities were most dramatic though even here the majority reported no change during the core survey period. Rhododendron removal at Blacka Moor and the felling of most of a conifer plantation at Burbage were the main activities discussed. The majority of participants who commented on these activities during the core survey period felt they had improved site quality but negative reactions were also reported. Rhododendron removal was conducted due to its invasive nature and negative impact on native biodiversity, especially native tree regeneration (Tyler, Pullin and Stewart, 2006) and the conifer plantation was felled to allow regeneration of native woodland. Thus both management activities were to improve the amount and quality of native woodland, the NIA management objective that received greatest support. This implies confusion regarding conservation aims and the actions required to meet them as has been apparent in other studies (Gobster, 2000; Connelly, Knuth and Kay, 2002). Indeed, there was a notable difference in the language used by those in favour and against the rhododendron removal at Blacka Moor. Those who felt its removal had improved site quality largely referred to “the rhododendron” or “invasive rhododendron” while those who considered it a decline generally discussed “the plants” or “vegetation” suggesting that a limited understanding of the issues surrounding rhododendron are associated with negative attitudes towards its control.

During the additional surveys at Burbage which took place nine months later than the core surveys allowing for the full extent of the plantation felling to be realised, there was a much larger negative reaction. This is unsurprising given the general public’s affinity for trees (Henwood and Pidgeon, 2001) and that felling of mature trees has triggered considerable opposition to other restoration programmes (e.g. Gobster 2000; Ostergren et al. 2008). However, once told that the plantation site would be restored to native broadleaf woodland, all but three participants (11%) said they felt much more positive about the change. Frustrations about how the site currently looked and about the length of time it would take for the woodland to grow, however, were voiced. Other studies have had mixed success of improving restoration support through such educational actions (Kearney, 2001; Van Marwijk *et al.*, 2012). A restoration programme that converted forest habitats to prairie systems that are much sparser in tree cover, for example, met with continued resistance despite efforts to address public concerns and raise awareness and understanding (Gobster, 2000). We suspect that the swift change in attitude towards the plantation felling at Burbage once respondents were given more information is because of it being replaced with another wooded landscape. Nonetheless, the Burbage and Blacka Moor examples demonstrate that raising awareness and understanding of the actions required to meet management objectives can substantially increase support for restoration in some circumstances.

*Impact of access management*

Despite the majority of visitors reporting no change in site quality in the previous two years, there was a significant increase in the proportion reporting improvements in site quality in the later phase of the programme. This, however, was the case across both control and treatment sites and thus was not a result of conservation management. Improvements were driven largely by perceived access improvements, primarily path conditions. Although some of these access improvements referred to specific management activities being conducted, others did not and instead reflect differences in path conditions compared to the respondents’ previous visits caused by factors such as weather. Access (again, largely trail conditions) was also the most reported reason for perceived declines in site quality. The vast majority of these referred to path erosion with less than 1% in response to access works being undertaken. Although the majority of participants found nothing disappointing about their visit, those who did, mostly also stated access issues. Interestingly, support for improving the amount and quality of access although high, was lower than for improving the quality of moorland and amount and quality of native woodland. Many participants mentioned that access was already good or that they were concerned about overcrowding resulting from access improvements despite less than 3% stating crowds as their most disappointing aspect and less than 1% saying increases in the number of people had reduced site quality.

Although access improvements were not rated as the most important management objective, it appears to be the most important factor in terms of changes in site quality. This contrasts with a number of other studies that frequently, but not consistently, conclude that other concerns (such as litter and crowds) are more important than access (Lynn and Brown, 2003; Cole and Hall, 2009). Our findings imply management to reduce path erosion is of key importance for improving the visitor experience. Doing so is also likely to benefit conservation activities by reducing soil erosion and disturbance to species by encouraging visitors to remain on a fixed path rather than straying over wider areas (Pearce-Higgins and Yalden, 1997; Finney, Pearce-Higgins and Yalden, 2005).

#### Perceived species richness

There was no evidence that perceived species richness was altered by NIA management though it was associated with site visit rate. Whilst there is equivocal evidence regarding people’s ability to accurately estimate species richness (Fuller *et al.*, 2007; Dallimer *et al.*, 2012), this lack of perceived change is not particularly surprising given only limited improvements to biodiversity were recorded across the NIA (Rogers, Proctor and Pendleton, 2015; Spencer and Proctor, 2015) as a result of the time lag between restoration and the biodiversity response. Interestingly, however, estimates of perceived butterfly richness increased across all sites (both treatment and control) in the late phase of the programme. This could be due to increases in butterfly abundance across the UK throughout the project duration (Brereton *et al.*, 2014). Using abundance as a cue for species diversity could potentially explain the discrepancies observed in people’s abilities to estimate species richness (Fuller *et al.*, 2007; Dallimer *et al.*, 2012).

### Cultural benefit delivery

#### Visitor numbers, type and site visitation rate

A key aim of the NIA was to improve access to the countryside. We found no evidence to suggest any impact of conservation management on engagement. Interestingly, however, sites perceived to be richer in plant species were visited more frequently. This suggests that there is potential for engagement to increase with time as a result of restoration once the biodiversity improvements take effect. Despite the importance of access to respondents (see 4.5.2), we found no evidence of access works having improved the number of people visiting the sites, nor how often they were visiting. There was also no change in the diversity of people visiting the sites between phases of the programme. These outcomes have important implications for site management demonstrating that active interventions that increase nature engagement and diversity of visitors is required.

#### Psychological well-being

In concordance with sense of place theory (Proshansky, Fabian and Kaminoff, 1983; Altman and Low, 1992), we found that those who visited the sites more frequently reported greater psychological well-being for all three dimensions, i.e. reflection and restoration, attachment and continuity with the past (sense of identity). This finding is consistent with other studies (Farnum, Hall and Kruger, 2005; White, Virden and Van Riper, 2008; Korpela *et al.*, 2010) and prove the importance of enhancing engagement with nature and frequency of visits to maximise psychological well-being. Theory and empirical evidence suggest that those with a stronger sense of attachment and identity with a particular place are more likely to be affected by changes to that location (Walker and Ryan, 2008; Devine-Wright and Howes, 2010). Whether the changes are regarded as positive or negative can depend on the individual’s perception of the change as either enhancing or diminishing the place (Devine-Wright and Howes, 2010). Despite finding consistently high levels of reflection, attachment and continuity with the past across all treatment sites, we found no evidence these were influenced by restoration activities. This is perhaps not surprising for the core survey analysis, as despite some quite drastic changes to site features, most visitors did not state that these influenced site quality. However, even when considering Burbage only once the additional surveys were incorporated and the majority felt the management work had caused a decline in site quality, there was no detrimental impact on psychological well-being. Importantly, these results show that large-scale conservation management can take place without negatively impacting psychological well-being.

We found no associations between psychological well-being and perceived species richness despite previous findings of positive relationships between the two (Fuller et al. 2007; Dallimer et al. 2012). This may because of differences between the environments surveyed in different studies with Fuller et al. (2007) focussing on urban parks and Dallimer et al. (2012) along urban riparian systems compared to the large, open areas of countryside and habitat mosaics we sampled. Dallimer et al. (2012) suggest that people may use tree cover as a cue to assess species richness in the urban riparian systems and well-being increased with tree cover. It may be that in more open countryside environments such as ours with comparatively low tree cover, people use other cues to assess species richness and these cues are not associated with well-being. Further investigation of how people judge species richness and what influence different levels of actual and perceived species richness influences well-being is thus required.

#### Support for conservation

Support for broad conservation aims of improving moorland quality, the amount and quality of native woodland and the amount and quality of hay meadows, was high with the vast majority of participants either agreeing or strongly agreeing these were important. There is, however, often a gap between attitudes towards conservation and conservation action (see Chapter 2) thus we also measured willingness to support conservation in relation to the sites being visited through theoretical donations of time and money. There is limited evidence in the literature for what motivates people to volunteer and donate to environmental projects with studies that do so generally focussing on people who are already actively involved (Gooch, 2003; Bruyere and Rappe, 2007). What impact restoration has on support for conservation is, as far as we are aware, unknown. We found mixed evidence for the restoration management activities impacting on support for conservation with significant increases in the amount of time participants were willing to volunteer at treatment sites only during the late phase but no difference in how much they were willing to donate financially. The precise mechanisms driving this increased support for conservation are unclear, but our use of experimental and control sites suggests it is driven by visitors’ exposure to ecological restoration rather than being part of a general trend of increased interest in volunteering. Increased conservation support (both time and money) was positively associated with perceived bird richness (though there was no association with plant or butterfly species richness). This suggests there is potential for restoration to further enhance support through time as the biodiversity value of sites increases. Further investigation is required though given the uncertainties between actual and perceived biodiversity levels (Dallimer *et al.*, 2012) as well as to be sure of causality. There is also evidence that frequent use of, and attachment to particular areas are motivators for conservation volunteers and willingness to pay to protect them (Gooch, 2003; Bruyere and Rappe, 2007; Lo and Jim, 2010). Indeed, we find significant increases in willingness to donate both time and money with more frequent visits. The importance of enhancing engagement with areas undergoing restoration is thus apparent given its potential to increase support for such projects.

Whether or not being a member of a conservation or environmental organisation influenced willingness to donate and volunteer depended on whether members of the National Trust were included in the analyses. When they were included, members of conservation or environmental organisations were willing to give significantly less time and money than non-members. Although this could be a result of conservation organisation members feeling that they already do there bit (and there were comments to this effect) and are therefore less generous with their time and money than non-members. In addition it is plausible that when including National Trust members, a greater proportion of respondents’ primary interests are not conservation orientated (given the additional focus of the National Trust of conserving historic buildings) thus reducing willingness to support conservation activities.

### Limitations

*Site selection*

In order to ensure a large sample size and logistical feasibility of coordination of volunteer teams conducting simultaneous surveys, all sites had to be car accessible. We were aware that not including more remote sites could potentially bias our results through not exposing participants to alternative management activities that were taking place in such landscapes (e.g. bare peat restoration), or by perhaps attracting a different type of visitor. We attempted to address these concerns by trialling an additional site at Kinder Downfall, an area much further away from any roads (and hence car parks, bus or train stops) compared to our other six sites. Unfortunately surveying at this site proved unsustainable as our partner organisations could not allow their volunteers to work at this site for health and safety reasons and coordination of volunteer teams by myself while trying to sample the more remote Kinder site was very difficult logistically. The sample sizes obtained from the trial were unfortunately not sufficient to gain any insight into potential biases of excluding more remote sites.

Selecting control sites to closely match treatment sites was difficult given the numerous habitat types and their composition at the landscape scale. We ensured that all habitat types represented at the treatment sites featured at the control sites, however there were still some major differences. Both control sites, for example, have large bodies of water that the treatment sites do not. Such differences, while potentially causing differences in baseline levels of cultural benefit delivery between treatment and control sites, with waterside environments delivering greatest restorative effects (Korpela *et al.*, 2010), should not have influenced benefit delivery through time. Thus such feature differences are unlikely to have impacted on our ability to determine conservation management effects.

*Site use*

Although verbal descriptions were given of what area we were considering each site to be, it is possible that participants were also considering areas beyond the sites when responding to the survey given the lack of clear distinction between areas in the landscape. This may have been the case particularly if participants had visited other areas that day, by doing an all-day walk, for example. Such experiences will likely have been very different to compared those of people who only visited a smaller area. Thus the length of exposure to areas undergoing management and the context of time spent in these areas compared to the rest of their visit is likely to have influenced responses. However, these are the realities how visitors engage with these type of areas and so our findings do represent a good overview of management impacts on the overall visitor experience. Research that incorporates how different types of site use and engagement, however, would provide a richer understanding of management impacts on visitors and cultural benefit delivery.

*Change in quality*

When participants were asked whether they felt the sites had changed in quality, quality was not defined. We wanted to capture any changes participants felt were important to their visit and did not want to influence their answers by giving any definitions. We found that very few visitors commented on changes in site quality related to the restoration management activities. As a result we conclude that restoration had little impact on the majority of visitors but in doing so we make several assumptions that need further exploration. We did not explore what the term “site quality” meant to people and whether this terminology lent itself to specific trains of thought regarding the visitor experience. While management activities were discussed by some visitors suggesting site quality did encompass restoration for some visitors, we cannot be sure whether the terminology influenced responses.

Although participants were asked to describe reasons for changes in site quality, we did not specifically ask them to list them all with the majority giving one or two answers. Issues not mentioned by visitors could be assumed to not be important to them but it is possible that other factors, though perhaps not as important as those commented on, could still be influencing participants perceptions of site quality. We have some evidence for this being the case from the additional survey carried out at Burbage. A much greater proportion of visitors said that the management activity at this site had influenced site quality when asked specifically about it as compared to when asked about site quality as a whole (without drawing attention to the management activities). Thus it is possible that a greater proportion of visitors from across all sites did feel that restoration had influenced site quality, just to a lesser extent than the issues they chose to discuss. However, it must be kept in mind that the management at Burbage (felling of a plantation) was the most visually dramatic and even here some people did not notice it or feel it influenced their visit, thus more work is required to explore these issues. Despite the uncertainties about perceived impact of restoration on site quality, we found no evidence to suggest negative impacts on cultural benefit delivery.

*Willingness to pay*

The willingness to pay (WTP) approach used to assess conservation support in this study has been shown to be subject to number of limitations (Diamond and Hausman, 1994). As it is a purely theoretical approach, answers can be hard to validate and may be influenced by the knowledge that participants will not have to act on their responses. This is known as hypothetical bias and usually results in provision of values higher than what people would be willing to give in reality though the extent of this effect has been shown to vary between studies (Murphy *et al.*, 2005). Higher reported amounts can also result from social desirability bias whereby participants do not answer truthfully but instead with a response they believe to be socially desirable (Grimm, 2010). However, strategic bias can also occur whereby people state amounts lower than their true intentions for fear that they might have to pay such fees in the future (Diamond and Hausman, 1994). Income constraints can also influence WTP results. We control for income of participants in our analyses which should thus account for discrepancies in the amount people were willing to donate as a result of differences in earnings as well as employment status which would impact on time availability regarding willingness to volunteer. However, as stated above, such income constraints may be ignored by people given the hypothetical nature of the question. Although we did have respondents selecting a range of options both in terms of time and money they were willing to donate, we cannot be certain that answers were not subject to the biases outlined above.

### Conclusion

We found high support for conservation objectives but that there is some confusion about the actions necessary to achieve them as some visitors objected to key, but visually dramatic, conservation restoration activities. In a rare, fully controlled experiment of the impacts of landscape scale restoration on visitor experience we found negligible evidence that active ecological restoration reduced cultural benefit delivery for the majority of participants. Whilst our findings are reactions to the immediate impact of management activities, this is often the most controversial stage thus we consider it unlikely that the visitor experience will decline with time. Conversely, we provide evidence that some measures of conservation support increase as a result of restoration and there is potential for further enhancements to cultural benefit delivery in the long-term as biodiversity improves though further monitoring is required. We also find that access is key to assessments of site quality. We highlight the importance of enhancing nature engagement to improve both psychological well-being and conservation support with the need for action beyond just improving site access. Though further work is required to better quantify visitor perceptions of management activities and determine how applicable our findings are to other landscape-scale initiatives, we conclude that large-scale conservation management that considerably alters landscape features can take place without negatively impacting on cultural benefit delivery, especially when actions are taken to raise awareness and understanding of more controversial management techniques.

## Appendix 4.1

*Psychological well-being factor analysis*

Groups of statements measuring single components of psychological well-being were identified using principal axis factoring (pair-wise deletion of missing data with oblique oblimin rotation; Table 4A.1) following the approach taken by Fuller et al. (2007) and Dallimer et al. (2012) based on methods described by Tabachnick and Fidell (2001). Factors were retained based on visual inspection of the data and eigenvalues greater than one. Factor structure was based on items with loadings of +/- 0.4 or above, and alpha coefficients of at least 0.70 (Cronbach, 1951). No items loaded on more than one factor +/- 0.40 level.

One factor was retained from the analysis of the cognitive restoration/reflection statements which accounted for 50.68% of the total variance and had good internal consistency (Cronbach’s alpha = 0.79; Cronbach 1951) Table 4.7. Analysis of the sense of place statements resulted in two factors being retained, one representing continuity with the past which accounted for 40.95% of the total variance explained and the other representing attachment, accounting for 15.18% of the total variance explained giving a total combined variance of 56.13%. Both factors consisted of five statements each with good internal consistency (continuity with the past Cronbach’s alpha = 0.83, attachment Cronbach’s alpha = 0.74; Cronbach 1951).

**Table 4A.1**. Oblique factor loadings for statements within three factors of psychological well-being.

|  |  |  |  |
| --- | --- | --- | --- |
| *Statement* | *Reflection* | *Continuity with the past* | *Attachment* |
| I feel peaceful when I’m here | 0.487 |  |  |
| I can easily think about personal matters when I come here | 0.498 |  |  |
| I gain perspective on life when I come here | 0.780 |  |  |
| Coming here clears my head | 0.757 |  |  |
| Being here makes me feel more connected to nature | 0.661 |  |  |
| When I am here I feel part of something that is greater than myself | 0.629 |  |  |
|  |  |  |  |
| I’ve had a lot of pleasant memorable experiences here |  | 0.424 |  |
| This site feels almost like a part of me |  | 0.783 |  |
| Lots of things at this site remind me of past experiences |  | 0.606 |  |
| When I am here, I feel strongly that I belong here |  | 0.828 |  |
| I will really miss this site when I am away from it for a long time |  | 0.751 |  |
|  |  |  |  |
| I like this site |  |  | 0.693 |
| I look forward to coming to this site in the future |  |  | 0.523 |
| I am not satisfied with this site |  |  | 0.529 |
| I feel happy when I am here |  |  | 0.476 |
| I do not gain pleasure from using this site |  |  | 0.634 |
| Eigenvalue | 3.04 | 4.10 | 1.52 |
| Percentage of total variance | 50.68 | 40.95 | 15.18 |
| Scale mean (SD) | 4.67 (0.41) | 3.77 (0.80) | 4.16 (0.63) |
| Scale median | 4.80 | 3.80 | 4.17 |
| Alpha coefficient | 0.79 | 0.83 | 0.74 |

# General Discussion

Although there is substantial evidence for an association between green-spaces and human benefits delivered from them (Sandifer, Sutton-Grier and Ward, 2015; van den Berg *et al.*, 2015), many uncertainties remain. This thesis has built upon previous research using rigorous sampling strategies incorporating participants across the socio-economic spectrum, with the full range of green-space users and moved beyond photo elicitation and captured real time reactions to restoration activities in situ. This was achieved using both established as well as novel, holistic indicators of health and well-being, conservation support and biodiversity knowledge thereby expanding and improving our knowledge of how these can be measured. Doing so has furthered our understanding of cultural benefit delivery from green-spaces including both direct and indirect influences of external factors such as urbanisation and conservation management and influences of different green-space types. There are, however, still many questions remaining and limitations from our research which need addressing to be able to inform both policy and management of environmental settings to maximise cultural benefit delivery.

## Key findings

### Relationships between cultural ecosystem services and cultural benefits

Central to the framework of this thesis, as outlined in section 1.5, was improving understanding of the links between cultural ecosystem services in the form of green-spaces (environmental settings) and cultural benefit delivery. We focussed on two types of environmental settings; urban green-space and the countryside and three different cultural benefits; educational benefits, conservation support and mental well-being benefits. We found evidence to suggest that the long made assumption of engaging with natural environments improves both knowledge of nature and support for its conservation with people who visited green-spaces more frequently scoring higher on both knowledge and conservation support indices (Chapter 2). Our findings thus build on the very few studies that have considered associations between knowledge of nature and nature engagement outside of formal educational activities (Pilgrim, Smith and Pretty, 2007; Randler, Höllwarth and Schaal, 2007; Booth, Gaston and Armsworth, 2009). We also build on the literature addressing nature engagement and support for conservation by incorporating the full spectrum of engagement frequencies (as opposed to just the extremes of not visiting versus regular visits; (Teisl and O’Brien, 2003; Cooper *et al.*, 2015). Although past research on the relationships between informal nature engagement and both knowledge of nature and conservation support has produced mixed outcomes, such studies demonstrate positive associations more frequently than not (e.g. Cooper et al. 2015 & Randler 2007) and our findings are thus in agreement. Importantly, however, these studies, as well as our own, are all observational thus cause and effect cannot be easily or fully distinguished. We cannot be certain whether it is more frequent engagement with nature that leads to increases in knowledge and support or that people with greater knowledge choose to engage with nature more frequently. We controlled for factors such as being motivated to visit green-spaces for nature-related reasons, garden use and natural history programme engagement and found the positive associations to still hold true. However, without experimental manipulations addressing the relationships between informal nature engagement and both educational benefits and support for conservation we cannot be certain of the direction of the relationship. Such experiments will also help to identify whether the relationship is a positive feedback loop with, for example, increased visits to green-space promoting an interest in and knowledge of nature and support for its conservation, which in turn further increases the desire to visit green-space and experience nature.

We also found that engaging with nature on a more regular basis was positively associated with increases in mental well-being benefits (Chapters 3 and 4) in line with previous studies (Sandifer, Sutton-Grier and Ward, 2015). Our research builds on studies that have considered the short-term impacts of nature engagement interventions on mental well-being (Beil & Hanes 2013; White et al. 2013) revealing that sustained regular interaction over longer time periods is associated with greater mental well-being benefits. Though once again, experimental work on the impact of nature engagement in the long-term on mental well-being is required to ensure that causality can be correctly determined.

This thesis also aimed to determine whether different environmental settings delivered different cultural benefits. We found that increased educational benefits and support for conservation were only associated with visits to the countryside and not urban green-spaces (Chapter 2) and that different aspects of mental well-being were associated with the two green-space types (Chapter 3). Previous studies considering cultural benefit delivery have rarely distinguished between green-space types and instead either compare green-spaces with street or indoor environments or different amounts of green-space (e.g. Laumann et al. 2003; Berman et al. 2008; Park et al. 2010) thus the discrepancies between urban green-spaces and the countryside provides new insight. One possible explanation for the observed differences is the discrepancy in biodiversity value between urban green-spaces and the countryside. Green-space in highly developed urban environments typically supports fewer and less specialist species than more natural environments (Evans *et al.*, 2011; Aronson *et al.*, 2014). Thus it could be that this exposure to a greater diversity of species and habitats during visits to the countryside results in increased knowledge of them and support for their conservation. There is also some evidence to suggest that biodiversity value of sites can influence mental well-being benefits (Fuller et al. 2007) though other studies report mixed results (Luck et al. 2011; Dallimer et al. 2012). There is, however, uncertainty about how accurate people’s perceptions of biodiversity are and mixed conclusions about the relationship between perceived and actual levels of biodiversity and mental well-being benefit (Fuller *et al.*, 2007; Dallimer *et al.*, 2012). Although Fuller et al. (2007), for example, found both actual and perceived levels of biodiversity to be positively associated with aspects of mental well-being, Dallimer et al. (2012) only found positive relationships between perceived biodiversity and mental well-being. We found no association between perceptions of biodiversity in countryside environments and mental well-being (Chapter 4). The indices used to measure well-being and species richness across these three studies were very similar, however, they were conducted in different landscapes; urban parks (Fuller et al. 2007), riparian systems (Dallimer et al. 2012) and open countryside (Chapter 4). Dallimer et al. (2012) suggest that people may use tree cover as a cue to assess species richness in the urban riparian systems and well-being increased with tree cover. It may be that in more open countryside environments such as those within the Dark Peak used here with comparatively low tree cover, people use other cues to assess species richness and these cues are not associated with well-being. Unfortunately, this was not something we addressed in this thesis but would be interesting to do in future follow up work. It is also worth highlighting that although, generally speaking, urban green-spaces are of lower biodiversity value than the countryside, this will not always be the case. Some urban green-spaces (e.g. botanical gardens) can be particularly species rich whilst some areas of the countryside (e.g. intensive agriculture) are species poor. A wide range of environmental settings with divergent biodiversity values will undoubtedly have been visited by the participants of our study. Further work using experimental manipulations of biodiversity levels are thus required to improve understanding of the potential influence of differing levels of biodiversity on cultural benefit delivery as well as the role of people’s perceptions of biodiversity and the cues used to make such judgements.

An alternative explanation for the differences observed between mental well-being benefits delivered from urban green-spaces and the countryside is location and accessibility. Though some well-being metrics were associated with visits to both green-space types, reductions in levels of anxiety were only associated with more frequent visits to urban green-space. In contrast, the degree to which participants felt the things they do in their lives to be worthwhile was only associated with visits to the countryside. Urban green-spaces have been shown to be important mediators of stress and anxiety (Natural England 2009; Kaplan 1995; van den Berg et al. 2007; Hartig et al. 2014). It seems plausible that regular use of urban green-spaces would therefore help manage the stress and associated anxiety of everyday urban life, potentially more so than the countryside which is less accessible on a regular basis (and we did find that participants visited urban green-spaces more frequently than the countryside). Visits to areas of greater wilderness outside of the urban environment have been shown to allow opportunity for self-reflection and contemplation in a manner different to being in nature at home (Fredrickson and Anderson, 1999) and could therefore explain why only countryside visits were associated with feelings of participant’s lives being worthwhile though further exploration of these concepts is required.

Although assessing the associations between domestic gardens and cultural benefit delivery was not a key aim of this thesis, we did control for influences of garden use in our analyses. Although having a garden has been associated with improved well-being (Nielsen and Hansen, 2007) and intuitively it would seem to make sense for people with gardens to have an improved knowledge and understanding of nature, we found no association between garden use and knowledge of nature, financial conservation support (both Chapter 2) or mental well-being (Chapter 3) though behavioural support did increase with more frequent use (Chapter 2). We did not include any differentiation between garden type and quality nor what activities were conducted in the garden which we suspect is likely to have influenced our results. Gardening has been shown to delivery multiple benefits (Clatworthy, Hinds and Camic, 2013) but less is known about other common main uses such as using the garden for smoking or hanging washing out for example. Thus further work is required to determine how both garden quality and engagement type influence cultural benefit delivery.

To summarise, we provide further evidence for the relationships between environmental settings and cultural benefit delivery and find that different green-spaces differ in their delivery of benefit type with only countryside being associated with levels of biodiversity knowledge and conservation support and both urban green-space and the countryside combined providing a more comprehensive suite of mental well-being benefits with further work necessary to determine the influence of domestic gardens.

### Relationships between drivers of change and cultural benefit delivery

Another key aim of this thesis was to address potential impacts of two human-derived drivers of change, urbanisation and landscape-scale restoration, on the relationships between cultural services and cultural benefit delivery. As outlined in the introduction (section 1.5), urbanisation and restoration could theoretically influence cultural benefit delivery via two key mechanisms. Firstly, if different green-space types vary in their delivery of cultural benefits, or if management activities within a green-space changes benefit delivery, then urbanisation and restoration activities could influence cultural benefit delivery through these physical changes to environmental settings. Urbanisation and restoration could also influence cultural benefit delivery by altering access and exposure to green-spaces or different green-space types. We found evidence to suggest that urbanisation influences cultural benefit delivery through both these mechanisms. As described above, urban green-spaces and the countryside differed in their delivery of cultural benefits suggesting that the physical differences between these green-space types does indeed influence benefit delivery (though further experimental work is required to confirm this as other factors could also be contributing, see above). Furthermore, we found the intensity of urbanisation at the local scale was negatively associated with visits to the countryside (Chapters 2 and 3) suggesting that urbanisation also influences exposure. More intensely urbanised areas tend to be located in inner city locations. Although this is not always the case (e.g. Radford & James 2012) residents from more urbanised locations are likely to have further to travel to access green-spaces, and studies have repeatedly shown the importance of distance to green-spaces in determining their use (e.g. Thompson 2008; Natural England 2013). However, if reduced accessibility of green-space in highly urbanised areas was the sole explanation for the observed lower frequencies of countryside engagement from more intensely urban areas, we would have expected a difference in countryside visit frequency between large and small urban areas (the latter having less distance to travel to access countryside from inner urban area locations) which was not the case. One explanation is that a threshold distance exists beyond which people are unlikely to travel to visit the countryside and that distance is less than the boundary of our small urban areas. Results from the Monitor of Engagement with the Natural Environment survey found that 66% of all visits to the natural environment were to green-spaces within two miles of the home (Natural England, 2013) thus this could be a contributing factor. However, given that not all visits were within a two mile distance of the home suggests that other factors may also be contributing to our observation of less countryside engagement by residents of more intensely urbanised areas. The MENE surveys have also shown that socio-economic and demographic factors often associated with more intensely urban areas such as higher deprivation, unemployment and members of black and ethnic minority population, engage less frequently with the natural environment (Natural England, 2013). Controlling for these factors in our research revealed that socio-economics and demographics were indeed contributing to the observed pattern of reduced countryside engagement by residents of more intensely urban areas but did not entirely account for it, suggesting that something about the intensity of urbanisation itself is also likely to be contributing. This could be due to a disconnection from nature whereby people who are exposed to little nature in their everyday lives through living in areas deprived of natural environments and spending more time indoors lose or never form a connection with nature, and thus have little interest in visiting the countryside or even fear doing so (Pyle, 2003; Zylstra *et al.*, 2014; Romanelli *et al.*, 2015). The impacts of urbanisation on cultural benefit delivery thus appear to be driven by direct and indirect mechanisms. Concerns regarding the association between urbanisation and cultural benefit delivery (Pyle, 2003; Moss, 2012) appear to be well founded as we provide evidence to suggest that urbanisation reduces engagement with the countryside which is associated with levels of biodiversity knowledge and conservation support as well as additional well-being benefits that urban green-spaces do not appear to deliver.

Very limited evidence exists on the impacts of landscape-scale restoration on cultural benefit delivery as evidence by cultural services being excluded from a meta-analysis on restoration impacts on ecosystem services as they were not explicitly measured in any of the 89 studies considered (Rey Benayas *et al.*, 2009). We provide a rare rigorous assessment of landscape restoration on cultural benefits and find limited evidence for any impact either as a result of directly altering the environmental settings themselves or by influencing people’s exposure to these settings (Chapter 4). The vast majority of participants did not report any changes in site quality as a result of restoration activities and there was no impact on psychological well-being benefits nor numbers of people visiting the sites or visit frequencies. Though there was no change in participants’ willingness to donate to support conservation, we did find an increase in willingness to volunteer post-restoration at treatment sites only suggesting this was a result of management activities. These findings were somewhat unexpected given a substantial literature of studies reporting negative reactions to conservation management (Gobster, 1997; Ostergren et al., 2008; Buijs et al., 2011). A possible explanation for this is a difference in methodology. Unlike studies which ask participants to state their preferences for different management scenarios or (e.g. Barro & Bright 1998; Solecki 1998) or rank photographs of the various stages of restoration (e.g. van Marwijk et al. 2012; Petursdottir et al. 2013) we did not specifically draw attention to restoration management activities for the majority of our surveys so as not to influence visitor responses. While this enabled us to capture relative importance of management activities compared to other issues visitors discussed we were not able to fully quantify the proportion of visitors who simply had not noticed management activities taking place or those that had noticed but did not feel they impacted on site quality. In an additional survey at the site with the most visually dramatic management activity (felling of a plantation forest) we did ask participants about the management activities directly which revealed that both mechanisms of not being aware of management work and feeling that restoration activities were not affecting the quality of the site as a whole explained the limited reaction to management activities. This, as far as we are aware, has not been captured in previous studies. Furthermore, provision of information regarding the ecological reasoning for management activities and the long-term management for the plantation felling dramatically improved negative responses. The utility of information provision for improving public opinion to restoration management and resulting landscape changes has been questioned but our findings build on other research finding a beneficial impact of doing so (Kearney, 2001; Hill and Daniel, 2007).

Importantly, we have only been able to assess the immediate impacts of management activities on cultural benefit delivery and not responses to the longer-term changes to biodiversity value of the sites. Given that the initial management activities is usually the most controversial phase of restoration (Vining, Tyler and Kweon, 2000), however, we presume it unlikely for these to be negative. We found that both the amount of time people were willing to volunteer and money people were willing to donate was positively associated with perceived bird species richness suggesting that if the intended aim of improving species richness of sites comes to fruition as a result of restoration activities, there is potential for enhancements to levels of conservation support with time. However, increases in conservation support or indeed other cultural benefits cannot be guaranteed as a result of increasing biodiversity value of sites given the uncertainty of the role biodiversity has to play in cultural benefit delivery as outlined above.

In summary we found that the immediate impacts of restoration activities at the landscape-scale had no negative impact on cultural benefit delivery for the majority of visitors.

## Limitations and future work

In addition to the limitations of our research specific to each chapter (sections 2.5.8, 3.5.5 and 4.5.4), there are two additional important limitations that affect all three studies. Firstly, the effect sizes reported in our analyses reporting associations between cultural services and cultural benefits are low (ranging from *r2* of 0.10-0.18) suggesting that the magnitude of the relationships described are small. Small effect sizes have, however, been shown to be common in complex systems as described by Møller & Jennions (2002). They conducted a meta-analyses on data from 43 meta-analyses of ecology and evolution studies and found a mean *r2* value of 0.19 and explain that difficulty of controlling for numerous confounding factors and accurate measurements of complex traits such as behaviour among other issues account for these low values. These same issues will also very much apply to the complex human-nature interactions we present in this thesis. Although our effect sizes are a little smaller than the average reported by Møller & Jennions (2002), this does not necessarily mean that our predictors have negligible impact. In order to determine how important these effects are we ideally need to compare our effect sizes to those reported by other studies considering impacts of different factors on our same variables of interest, i.e. nature knowledge, conservation support and mental well-being. Unfortunately, meta-analyses of studies addressing determinants of indicators of cultural benefits are not, as far as we are aware available and so we are unable to do this. As more quantitative studies address determinants of knowledge of nature, support for conservation and wellbeing, we should be able to build a better picture of how important a role nature exposure has to play in delivering these benefits compared to other drivers. Experimental as opposed to observational studies that are more able to control for different confounding factors and manipulate different aspects of nature engagement can also help to improve understanding of the strength of relationships between cultural services and benefit delivery.

Secondly, it is important to bear in mind that we have only addressed certain indicators of each of the cultural benefits considered in this thesis. Knowledge of nature, conservation support and mental well-being are all complicated, multifaceted issues and we cannot therefore assume that other indicators of these cultural benefits will respond to nature engagement and drivers of change in the same way. We found, for example, that measures of the public’s knowledge of nature varied depending on which of our three indicators we used (Chapter 2), as did the association between alternative aspects of mental well-being and visits to different environmental settings (Chapter 3). Thus assessments of cultural benefit delivery will require use of multiple indicators to build a more comprehensive understanding of factors that influence their delivery.

## Relevance for policy

Our findings suggest that in order to enhance people’s abilities to develop and maintain biodiversity knowledge and support for conservation as well as their mental well-being, policies and action should focus on creating less dense cities, rather than smaller but more intensely urbanized ones, as well as improving access and engagement with both urban green-spaces and the countryside on a regular basis over long time scales. Furthermore, the benefits derived from engagement with the countryside are unlikely to be negatively impacted by landscape-scale restoration activities (especially if efforts to raise awareness and understanding of some of the more controversial management techniques are taken) and may, in fact, improve in the long term as the biodiversity value of the areas improve. However, further work as outlined above, is required to address the limitations of our research to ensure that findings are both robust and applicable in other settings.

# Bibliography

Altman, I. and Low, S. (1992) *Place Attachment: Human Behavior and Environment.* Plenum Press. New York, USA.

Alvey, A. A. (2006) ‘Promoting and preserving biodiversity in the urban forest’, *Urban Forestry and Urban Greening*, 5(4), pp. 195–201.

Ambrosius, J. D. and Gilderbloom, J. I. (2014) ‘Who’s greener? Comparing urban and suburban residents’ environmental behaviour and concern’, *Local Environment*, 9839, pp. 1–14.

Arcury, T. A. and Christianson, E. H. (1993) ‘Rural-urban differences in environmental knowledge and actions’, *The Journal of Environmental Education*, 25, pp. 19–25.

Aronson, M. F. J., A La Sorte, F., Nilon, C. H., Katti, M., Goddard, M. A, Lepczyk, C. A, Warren, P. S., Williams, N. S. G., Cilliers, S., Clarkson, B., Dobbs, C., Dolan, R., Hedblom, M., Klotz, S., Kooijmans, J. L., Macgregor-fors, I., Mcdonnell, M., Mörtberg, U., Pysek, P., Siebert, S., Werner, P., Winter, M., Williams, S. G., Sushinsky, J. and Pys, P. (2014) ‘A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers’, *Proceedings of the Royal Society B*, 281, p. 20133330.

Balmford, A., Beresford, J., Green, J., Naidoo, R., Walpole, M. and Manica, A. (2009) ‘A global perspective on trends in nature-based tourism’, *PLoS Biology*, 7(6), pp. 1–6.

Balmford, A., Clegg, L., Coulson, T. and Taylow, J. (2002) ‘Why Conservationists Should Heed Pokemon’, *Science*, 295, p. 2367.

Balmford, A., Leader-Williams, N., Mace, G. M., Manica, A., Walter, O., West, C. and Zimmermann, A. (2007) ‘Message received? Quantifying the impact of informal conservation education on adults visiting UK zoos’, in Zimmermann, A., Hatchwell, M., Dickie, L., and West, C. (eds) *Zoos in the 21st Century Catalysts for Conservation*. Cambridge, UK: Cambridge University Press, pp. 120–136.

Bamberg, S. and Möser, G. (2007) ‘Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour’, *Journal of Environmental Psychology*, 27(1), pp. 14–25.

Barro, S. C. and Bright, A. D. (1998) ‘Public views on ecological restoration. Restoration and Management Notes’, *Restoration & Management Notes*, 16(1), pp. 59–65.

Barton, J. and Pretty, J. (2010) ‘Urban ecology & human health & well-being – the relationships between nature and human health and well-being in urban areas, and the consequences’, in K, G. and et al. (eds) *Urban Ecology*. British Ecological Society and Cambridge University Press, pp. 202–229.

Bates, D., Maechler, M., Bolker, B. and Walker, S. (2014) ‘lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-7, http://CRAN.R-project.org/package=lme4’.

Beck, A. T., Steer, R. A. and Brown, G. K. (1996) *Manual for the Beck Depression Inventory-II. Psychological Corporation,* San Antonio, USA.

Beil, K. and Hanes, D. (2013) ‘The influence of urban natural and built environments on physiological and psychological measures of stress- A pilot study’, *International Journal of Environmental Research and Public Health*, 10(4), pp. 1250–1267.

Berenguer, J., Corraliza, J. A. and Rocio, M. (2005) ‘Rural-urban differences in environmental concern, attitudes, and actions’, *European Journal of Psychological Assessment*, 21, pp. 128–138.

van den Berg, A. E., Hartig, T. and Staats, H. (2007) ‘Preference for nature in urbanized societies: Stress, restoration, and the pursuit of sustainability’, *Journal of Social Issues*, 63(1), pp. 79–96.

van den Berg, A. E., Koole, S. L. and van der Wulp, N. Y. (2003) ‘Environmental preference and restoration: (How) are they related?’, *Journal of Environmental Psychology*, 23(2), pp. 135–146.

van den Berg, A. E., Maas, J., Verheij, R. A and Groenewegen, P. P. (2010) ‘Green space as a buffer between stressful life events and health.’, *Social science & medicine (1982)*, 70(8), pp. 1203–10.

van den Berg, A. E., van Winsum-Westra, M., de Vries, S. and van Dillen, S. M. E. (2010) ‘Allotment gardening and health: a comparative survey among allotment gardeners and their neighbors without an allotment.’, *Environmental health : a global access science source*, 9(1), p. 74.

van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W. and Maas, J. (2015) ‘Health benefits of green spaces in the living environment: A systematic review of epidemiological studies’, *Urban Forestry & Urban Greening*, 14(4), pp. 806–816.

Berg, N. (2005) ‘Non-response bias’, in Kempf-Leonard, K. (ed.) *Encyclopedia of Social Measurement*. London: Academic Press, pp. 865–873.

Berman, M. G., Jonides, J. and Kaplan, S. (2008) ‘The cognitive benefits of interacting with nature.’, *Psychological science*, 19(12), pp. 1207–12.

Berto, R. (2005) ‘Exposure to restorative environments helps restore attentional capacity’, *Journal of Environmental Psychology*, 25(3), pp. 249–259.

Bertram, C. and Rehdanz, K. (2015) ‘The role of urban green space for human well-being’, *Ecological Economics*, 120, pp. 139–152.

Booth, J. E., Gaston, K. J. and Armsworth, P. R. (2009) ‘Public understanding of protected area designation’, *Biological Conservation*, 142(12), pp. 3196–3200.

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M. and Pullin, A. S. (2010) ‘A systematic review of evidence for the added benefits to health of exposure to natural environments.’, *BMC public health*, 10, p. 456.

Boyd, J. and Banzhaf, S. (2007) ‘What are ecosystem services? The need for standardized environmental accounting units’, *Ecological Economics*, 63(2–3), pp. 616–626.

Brereton, T. M., Botham, M. S., Middlebrook, I., Randle, Z. and Roy, D. B. (2015) *United Kingdom Butterfly Monitoring Scheme report for 2014*. *Centre for Ecology & Hydrology & Butterfly Conservation,* UK.

Brown, K. M., Hoye, R. and Nicholson, M. (2012) ‘Self-esteem, Self-efficacy, and social connectedness as mediators of the relationship between volunteering and well-being’, *Journal of Social Service Research*, 38(4), pp. 468–483.

Browning, R. C., Baker, E. A., Herron, J. A. and Kram, R. (2006) ‘Effects of obesity and sex on the energetic cost and preferred speed of walking.’, *Journal of Applied Physiology*, 100(2), pp. 390–398.

Bruyere, B. and Rappe, S. (2007) ‘Identifying the motivations of environmental volunteers’, *Journal of Environmental Planning and Management*, 50(4), pp. 503–516.

Buijs, A. E. (2009) ‘Public support for river restoration. A mixed-method study into local residents’ support for and framing of river management and ecological restoration in the Dutch floodplains’, *Journal of Environmental Management*, 90(8), pp. 2680–2689.

Buijs, A. E., Arts, B. J. M., Elands, B. H. M. and Lengkeek, J. (2011) ‘Beyond environmental frames: The social representation and cultural resonance of nature in conflicts over a Dutch woodland’, *Geoforum*, 42(3), pp. 329–341.

Buijs, A. E. and Elands, B. H. M. (2013) ‘Does expertise matter? An in-depth understanding of people’s structure of thoughts on nature and its management implications’, *Biological Conservation*, 168, pp. 184–191.

Cameron, R. W. F., Blanuša, T., Taylor, J. E., Salisbury, A., Halstead, A. J., Henricot, B. and Thompson, K. (2012) ‘The domestic garden - Its contribution to urban green infrastructure’, *Urban Forestry and Urban Greening*, 11(2), pp. 129–137.

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., Narwani, A., Mace, G. M., Tilman, D., Wardle, D. a, Kinzig, A. P., Daily, G. C., Loreau, M., Grace, J. B., Larigauderie, A., Srivastava, D. S. and Naeem, S. (2012) ‘Biodiversity loss and its impact on humanity.’, *Nature*, 486(7401), pp. 59–67.

Chamberlain, D. E., Gough, S., Vaughan, H., Vickery, J. A. and Appleton, G. F. (2007) ‘Determinants of bird species richness in public green spaces’, *Bird Study*, 54(1), pp. 87–97.

Chawla, L. (1999) ‘Life paths into effective environmental action’, *The Journal of Environmental Education*, 31(1), pp. 15–26.

Chawla, L. (2001) ‘Significant life experiences revisited once again: response to Vol. 5(4) “Five critical commentaries on significant life experience research in environmental education”’, *Environmental Education Research*, 7(4), pp. 451–461.

Christensen, R. H. B. (2015) *ordinal - Regression models for ordinal data. R package version 2015.6-28, http://www.cran.r-project.org/package=ordinal/.*

Church, A., Burgess, J., Ravenscroft, N., Bird, W., Blackstock, K., Brady, E., Crang, M., Fish, R., Gruffudd, P., Mourato, S., Pretty, J., Tolia-Kelly, D., Turner, K. and Winter, M. (2011) *Cultural Services. In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC,* Cambridge, UK.

Clatworthy, J., Hinds, J. and Camic, P. M. (2013) ‘Gardening as a mental health intervention: a review’, *Mental Health Review Journal*, 18, pp. 214–225.

Clergeau, P., Croci, S., Jokimäki, J., Kaisanlahti-Jokimäki, M. L. and Dinetti, M. (2006) ‘Avifauna homogenisation by urbanisation: Analysis at different European latitudes’, *Biological Conservation*, 127(3), pp. 336–344.

Coldwell, D. F. and Evans, K. L. (2017) ‘Contrasting effects of visiting urban green-space and the countryside on biodiversity knowledge and conservation support’, *Plos One*, 12(3), p. e0174376.

Cole, D. N. and Hall, T. E. (2009) ‘Perceived effects of setting attributes on visitor experiences in wilderness: Variation with situational context and visitor characteristics’, *Environmental Management*, 44(1), pp. 24–36.

Coley, R. L., Sullivan, W. C. and Kuo, F. E. (1997) ‘Where does community grow? The social context created by nature in urban public housing’, *Environment and Behavior*, 29, pp. 468–494.

Connelly, N. A., Knuth, B. A. and Kay, D. L. (2002) ‘Public support for ecosystem restoration in the Hudson River Valley, USA’, *Environmental Management*, 29(4), pp. 467–476.

Conversano, C., Rotondo, A., Lensi, E., Vista, O. Della, Arpone, F. and Reda, M. A. (2010) ‘Optimism and its impact on mental and physical well-being’, *Clinical Practice & Epidemiology in Mental Health*, 6(1), pp. 25–29.

Cooper, C., Larson, L., Dayer, A., Stedman, R. and Decker, D. (2015) ‘Are wildlife recreationists conservationists? Linking hunting, birdwatching, and pro-environmental behavior’, *The Journal of Wildlife Management*, 79(3), pp. 446–457.

Cotton, D. R. and Alcock, I. (2013) ‘Commitment to environmental sustainability in the UK student population’, *Studies in Higher Education*, 38(10), pp. 1457–1471.

Dallimer, M., Irvine, K. N., Skinner, A. M. J., Davies, Z. G., Rouquette, J. R., Maltby, L. L., Warren, P. H., Armsworth, P. R. and Gaston, K. J. (2012) ‘Biodiversity and the feel-good factor: understanding associations between self-reported human well-being and species richness’, *BioScience*, 62(1), pp. 47–55.

Davies, S. (2006) *Recreation and Visitor Attitudes in the Peak District Moorlands. Report No. 12. Moors for the Future,* UK*.*

Davis, J. L., Le, B. and Coy, A. E. (2011) ‘Building a model of commitment to the natural environment to predict ecological behavior and willingness to sacrifice’, *Journal of Environmental Psychology*, 31(3), pp. 257–265.

Dean, J., van Dooren, K. and Weinstein, P. (2011) ‘Does biodiversity improve mental health in urban settings?’, *Medical hypotheses*, 76(6), pp. 877–80.

Depledge, M. H., Stone, R. J. and Bird, W. J. (2011) ‘Can natural and virtual environments be used to promote improved human health and wellbeing?’, *Environmental Science & Technology*, 45(11), pp. 4660–5.

Devine-Wright, P. and Howes, Y. (2010) ‘Disruption to place attachment and the protection of restorative environments: A wind energy case study’, *Journal of Environmental Psychology*, 30(3), pp. 271–280.

Diamond, P. and Hausman, J. (1994) ‘Contingent Valuation: Is Some Number better than No Number?’, *The Journal of Economic Perspectives*, 8(4), pp. 45–64.

Diener, E., Inglehart, R. and Tay, L. (2012) ‘Theory and validity of life satisfaction scales’, *Social Indicators Research*, pp. 497–527.

van Dillen, S. M. E., de Vries, S., Groenewegen, P. P. and Spreeuwenberg, P. (2012) ‘Greenspace in urban neighbourhoods and residents’ health: adding quality to quantity.’, *Journal of Epidemiology and Community Health*, 66(6), p. e8.

Dolan, P. and Metcalfe, R. (2012) ‘Measuring subjective wellbeing: recommendations on measures for use by national governments’, *Journal of Social Policy*, 41(2), pp. 409–427.

Dunn, R. R., Gavin, M. C., Sanchez, M. C. and Solomon, J. N. (2006) ‘The pigeon paradox: dependence of global conservation on urban nature.’, *Conservation Biology*, 20(6), pp. 1814–6.

Ellaway, A., Macintyre, S. and Bonnefoy, X. (2005) ‘Graffiti, greenery, and obesity in adults: secondary analysis of Euopean cross sectional survey’, *BMJ (Clinical research ed.)*, 331(7517), pp. 611–612.

Evans, K. L., Chamberlain, D. E., Hatchwell, B. J., Gregory, R. D. and Gaston, K. J. (2011) ‘What makes an urban bird?’, *Global Change Biology*, 17(1), pp. 32–44.

Faber Taylor, A., Kuo, F. E. and Sullivan, W. C. (2001) ‘Coping with add: the surprising connection to green play settings’, *Environment and Behavior*, 33(1), pp. 54–77.

Faber Taylor, A., Kuo, F. E. and Sullivan, W. C. (2002) ‘Views of nature and self-discipline: evidence from inner city children’, *Journal of Environmental Psychology*, 22(1), pp. 49–63.

Fan, Y., Das, K. V. and Chen, Q. (2011) ‘Neighborhood green, social support, physical activity, and stress: Assessing the cumulative impact’, *Health and Place*, 17(6), pp. 1202–1211.

Farnum, J., Hall, T. and Kruger, L. E. (2005) *Sense of Place In Natural Resource Recreation and Tourism : An Evaluation and Assessment of Research Findings. General Technical Report, PNW-GTR-660 United States Department of Agriculture, Pacific Northwestern Research Station*, USA.

Fernandez-Juricic, E. (2000) ‘Bird community composition patterns in urban parks of Madrid: the role of age, size and isolation’, *Ecological Research*, 15(4), pp. 373–383.

Ferrer-i-Carbonell, A. and Frijters, P. (2004) ‘How Important is Methodology for the Estimate of the Determinants of Hapiness?’, *The Economic Journal*, 114(497), pp. 641–659.

Finney, S. K., Pearce-Higgins, J. W. and Yalden, D. W. (2005) ‘The effect of recreational disturbance on an upland breeding bird, the golden plover Pluvialis apricaria’, *Biological Conservation*, 121(1), pp. 53–63.

Fischer, A. and Young, J. C. (2007) ‘Understanding mental constructs of biodiversity: Implications for biodiversity management and conservation’, *Biological Conservation*, 136(2), pp. 271–282.

Fisher, B. and Turner, R. K. (2008) ‘Ecosystem services: Classifcation for valuation’, *Biological Conservation*, 1(2007), pp. 8–10.

Frederiks, E. R., Stenner, K. and Hobman, E. V (2015) ‘Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour’, *Renewable and Sustainable Energy Reviews*, 41, pp. 1385–1394.

Fredrickson, L. M. and Anderson, D. H. (1999) ‘A qualitative exploration of the wilderness experience as a source of spiritual inspiration’, *Journal of Environmental Psychology*, 19(1), pp. 21–39.

Frick, J., Kaiser, F. G. and Wilson, M. (2004) ‘Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample’, *Personality and Individual Differences*, 37(8), pp. 1597–1613.

Fuller, R. A. and Gaston, K. J. (2009) ‘The scaling of green space coverage in European cities’, *Biology Letters*, 5(3), pp. 352–355.

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H. and Gaston, K. J. (2007) ‘Psychological benefits of greenspace increase with biodiversity.’, *Biology letters*, 3(4), pp. 390–4.

Gaston, K. J., Warren, P. H., Thompson, K. and Smith, R. M. (2005) ‘Urban domestic gardens (IV): The extent of the resource and its associated features’, *Biodiversity and Conservation*, 14(14), pp. 3327–3349.

Gifford, R. and Nilsson, A. (2014) ‘Personal and social factors that influence pro-environmental concern and behaviour: A review’, *International Journal of Psychology*, 49(3), pp. 141–157.

Giles-Corti, B. and Donovan, R. J. (2002) ‘The relative influence of individual, social and physical environment determinants of physical activity.’, *Social Science & Medicine*, 54(12), pp. 1793–812.

Gobster, P. H. (1997) ‘A Survey of the Arguments’, *Restoration & Management Notes*, 15(1), pp. 32–37.

Gobster, P. H. (2000) ‘Restoring nature: human actions, interactions, and reactions’, in Gobster, P. H. and Hull, R. B. (eds) *Restoring Nature*. Washington, D.C.: Island Press, pp. 1–20.

Godbey, G., Roy, M., Payne, L. and Orsega-Smith, E. (1998) *The Relation between Health and Use of Local Parks.* *National Recreation Foundation*, Bloomington, USA.

Goldberg, D. and Williams, P. (1991) ‘A user’s guide to the General Health Questionnaire. Windsor: Nfer-Nelson.’

Gooch, M. (2003) ‘A sense of place: ecological identity as a driver for catchment volunteering’, *Australian Journal on Volunteering*, 8(2), pp. 23–32.

Grahn, P. and Stigsdotter, U. A. (2003) ‘Landscape planning and stress’, *Urban Forestry & Urban Greening*, 2(1), pp. 1–18.

Grimm, P. (2010) ‘Social desirability bias. Wiley International Encyclopedia of Marketing.’

de Groot, R. S., Wilson, M. A. and Boumans, R. M. (2002) ‘A typology for the classification, description and valuation of ecosystem functions, goods and services’, *Ecological Economics*, 41(3), pp. 393–408.

Haines-Young, R. and Potschin, M. (2011) *Common International Classification of Ecosystem Services (CICES):2011 Update for the European Environment Agency*. *Centre for Environmental Management*, UK.

Harris, S. J., Massimino, D., Newson, S. ., Eaton, M. A., Marchant, J. H., Balmer, D. E., Noble, D. G., Gillings, S., Procter, D. and Pearce-Higgins, J. . (2016) *The Breeding Bird Survey 2015. BTO Research Report 687. British Trust for Ornithology,* Thetford, UK.

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S. and Gärling, T. (2003) ‘Tracking restoration in natural and urban field settings’, *Journal of Environmental Psychology*, 23(2), pp. 109–123.

Hartig, T., Mitchell, R., de Vries, S. and Frumkin, H. (2014) ‘Nature and health’, *Annual review of public health*, 35, pp. 207–28.

Heerwagen, J. H. (1990) ‘Psychological aspects of windows and window design’, in Selby, R. I., Anthony, K. H., and Orland, J. C. & B. (eds) *Proceedings of the 21st Annual Conference of the Environmental Design Research Association.* Oklahoma City: EDRA, pp. 269–280.

Henwood, K. and Pidgeon, N. (2001) ‘Talk about woods and trees: threat of urbanization, stability, and biodiversity’, *Journal of Environmental Psychology*, 21(2), pp. 125–147.

Hill, D. and Daniel, T. C. (2007) ‘Foundations for an ecological aesthetic: can information alter landscape preferences?’, *Society & Natural Resources*, 21(1), pp. 34–49.

Hines, J. M., Hungerford, H. R. and Tomera, A. N. (1987) ‘Analysis and synthesis of research on responsible environmental behavior: a meta-analysis’, *The Journal of Environmental Education*, 18(2), pp. 1–8.

Hodder, K. H., Newton, A. C., Cantarello, E. and Perrella, L. (2014) ‘Does landscape-scale conservation management enhance the provision of ecosystem services?’, *International Journal of Biodiversity Science, Ecosystem Services & Management*, 10(1), pp. 71–83.

Huddart-Kennedy, E., Beckley, T. M., McFarlane, B. L. and Nadeau, S. (2009) ‘Rural-urban differences in environmental concern in canada’, *Rural Sociology*, 74(3), pp. 1–21.

Hur, M., Nasar, J. L. and Chun, B. (2010) ‘Neighborhood satisfaction, physical and perceived naturalness and openness’, *Journal of Environmental Psychology*, 30(1), pp. 52–59.

Huynh, Q., Craig, W., Janssen, I. and Pickett, W. (2013) ‘Exposure to public natural space as a protective factor for emotional well-being among young people in Canada.’, *BMC public health*, 13(407), pp. 1–14.

Irvine, K. N., Warber, S. L., Devine-Wright, P. and Gaston, K. J. (2013) ‘Understanding urban green space as a health resource: a qualitative comparison of visit motivation and derived effects among park users in Sheffield, UK.’, *International journal of environmental research and public health*, 10(1), pp. 417–42.

Jefferson, R. G. (2005) ‘The conservation management of upland hay meadows in Britain: A review’, *Grass and Forage Science*, 60(4), pp. 322–331.

Junker, B. and Buchecker, M. (2008) ‘Aesthetic preferences versus ecological objectives in river restorations’, *Landscape and Urban Planning*, 85(3–4), pp. 141–154.

Kabisch, N. and Haase, D. (2014) ‘Green justice or just green? Provision of urban green spaces in Berlin, Germany’, *Landscape and Urban Planning*, 122, pp. 129–139.

Kaplan, R. and Kaplan, S. (1989) *The Experience of Nature: A Psychological Perspective.* Cambridge University Press. Cambridge, UK.

Kaplan, S. (1987) ‘Mental fatigue and the designed environment’, in Harvey, J. and Henning, D. (eds) *Public Environments*. Washington, D.C.: EDRA, pp. 55–60.

Kaplan, S. (1995) ‘The restorative benefits of nature: toward an integrative framework’, *Journal of Environmental Psychology,* 15, pp. 169–182.

Kareiva, P. (2008) ‘Ominous trends in nature recreation.’, *Proceedings of the National Academy of Sciences of the United States of America*, 105(8), pp. 2757–8.

Kearney, A. R. (2001) ‘Effects of an informational intervention on public reactions to clear-cutting’, *Society & Natural Resources*, 14(9), pp. 777–790.

Keniger, L. E., Gaston, K. J., Irvine, K. N. and Fuller, R. A (2013) ‘What are the benefits of interacting with nature?’, *International journal of environmental research and public health*, 10(3), pp. 913–35.

Kirtland, K. A., Porter, D. E., Addy, C. L., Neet, M. J., Williams, J. E., Sharpe, P. A., Neff, L. J., Kimsey, C. D. and Ainsworth, B. E. (2003) ‘Environmental measures of physical activity supports: Perception versus reality’, *American Journal of Preventive Medicine*, 24(4), pp. 323–331.

Kohn, D. D. and Walsh, D. M. (1994) ‘Plant species richness - the effect of island size and habitat diversity’, *Journal of Ecology*, 82(2), pp. 367–377.

Kollmuss, A. and Agyeman, J. (2002) ‘Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?’, *Environmental Education Research*, 8(3), pp. 239–260.

Kormos, C. and Gifford, R. (2014) ‘The validity of self-report measures of proenvironmental behavior: Ameta-analytic review’, *Journal of Environmental Psychology*, 40, pp. 359–371.

Korn, C. W., Sharot, T., Walter, H., Heekeren, H. R. and Dolan, R. J. (2014) ‘Depression is related to an absence of optimistically biased belief updating about future life events.’, *Psychological medicine*, 44(3), pp. 579–92.

Korpela, K. M., Ylén, M., Tyrväinen, L. and Silvennoinen, H. (2010) ‘Favorite green, waterside and urban environments, restorative experiences and perceived health in Finland.’, *Health promotion international*, 25(2), pp. 200–9.

Kuo, F. E., Bacaicoa, M. and Sullivan, W. C. (1998) ‘Transforming inner-city landscapes: trees, sense of safety, and preference’, *Environment and Behavior*, 30(1), pp. 28–59.

Kuo, F. E. and Sullivan, W. C. (2001) ‘Aggression and violence in the inner city: effects of environment via mental fatigue’, *Environment and Behavior*, 33, pp. 543–571.

Kuo, F. E. and Sullivan, W. C. (2001) ‘Environment and crime in the inner city: does vegetation reduce crime?’, *Environment & Behavior*, 33(3), pp. 343–367.

Kuo, F. E., Sullivan, W. C. and Coley, R. L. (1998) ‘Fertile ground for community: inner-city neighborhood common spaces 1’, *American Journal of Community Psychology*, 26(6), pp. 823–851.

Kweon, B. S., Sullivan, W. C. and Wiley, A. R. (1998) ‘Green common spaces and the social integration of inner-city older adults’, *Environment and Behavior*, 30(6), pp. 832–858.

Larson, L. R., Green, G. T. and Cordell, H. K. (2011) ‘Children’s time outdoors: results and implications of the National Kids Survey’, *Jornal of Park and Recreation Administration*, 29(2), pp. 1–20.

Larson, L. R., Jennings, V. and Cloutier, S. A. (2016) ‘Public parks and wellbeing in urban areas of the United States’, *PLoS ONE*, 11(4), pp. 1–19.

Larson, L. R., Whiting, J. W. and Green, G. T. (2011) ‘Exploring the influence of outdoor recreation participation on pro-environmental behaviour in a demographically diverse population’, *Local Environment*, 16(1), pp. 67–86.

Laumann, K., Gärling, T. and Stormark, K. (2003) ‘Selective attention and heart rate responses to natural and urban environments’, *Journal of Environmental Psychology*, 23(2), pp. 125–134.

Lederbogen, F., Kirsch, P., Haddad, L., Streit, F., Tost, H., Schuch, P., Wüst, S., Pruessner, J. C., Rietschel, M., Deuschle, M. and Meyer-Lindenberg, A. (2011) ‘City living and urban upbringing affect neural social stress processing in humans.’, *Nature*, 474(7352), pp. 498–501.

Leopold, A. (1949) *A Sand County Almanac and Sketches Here and There*. Oxford University Press, New York, USA.

Leslie, E., Sugiyama, T., Ierodiaconou, D. and Kremer, P. (2010) ‘Perceived and objectively measured greenness of neighbourhoods: are they measuring the same thing?’, *Landscape and Urban Planning*, 95(1–2), pp. 28–33.

Liere, K. D. Van and Dunlap, R. E. (1980) ‘The social bases of environmental concern: review of hypotheses, explanations and empirical evidence’, *American Association for Public Opinion Research*, 44(2), pp. 181–197.

Lindemann-Matthies, P. and Bose, E. (2008) ‘How many species are there? Public understanding and awareness of biodiversity in Switzerland’, *Human Ecology*, 36(5), pp. 731–742.

Lindemann‐Matthies, P. (2006) ‘Investigating nature on the way to school: responses to an educational programme by teachers and their pupils’, *International Journal of Science Education*, 28(8), pp. 895–918.

Lindenmayer, D., Hobbs, R. J., Montague-Drake, R., Alexandra, J., Bennett, A., Burgman, M., Cale, P., Calhoun, A., Cramer, V., Cullen, P., Driscoll, D., Fahrig, L., Fischer, J., Franklin, J., Haila, Y., Hunter, M., Gibbons, P., Lake, S., Luck, G., MacGregor, C., McIntyre, S., Mac Nally, R., Manning, A., Miller, J., Mooney, H., Noss, R., Possingham, H., Saunders, D., Schmiegelow, F., Scott, M., Simberloff, D., Sisk, T., Tabor, G., Walker, B., Wiens, J., Woinarski, J. and Zavaleta, E. (2008) ‘A checklist for ecological management of landscapes for conservation’, *Ecology Letters*, 11(1), pp. 78–91.

Liu, X., Vedlitz, A. and Shi, L. (2014) ‘Examining the determinants of public environmental concern: evidence from national public surveys’, *Environmental Science & Policy*, 39, pp. 77–94.

Lo, A. Y. and Jim, C. Y. (2010) ‘Willingness of residents to pay and motives for conservation of urban green spaces in the compact city of Hong Kong’, *Urban Forestry and Urban Greening*, 9(2), pp. 113–120.

Lohr, V. I. (2007) ‘Benefits of Nature: What we are learning about why people respond to nature’, *Journal of Physiological Anthropology*, 26(2), pp. 83–85.

Louv, R. (2005) *Last child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill, NC: Algonquin Books. New York.

Luck, G. W., Davidson, P., Boxall, D. and Smallbone, L. (2011) ‘Relations between urban bird and plant communities and human well-being and connection to nature’, *Conservation Biology*, 25(4), pp. 816–826.

Luck, G. W., Davidson, P., Boxall, D. and Smallbone, L. (2011) ‘Relations between urban bird and plant communities and human well-being and connection to nature.’, *Conservation Biology*, 25(4), pp. 816–26.

Lückmann, K. and Menzel, S. (2013) ‘Herbs versus trees: influences on teenagers’ knowledge of plant species’, *Journal of Biological Education*, 48(2), pp. 80–90.

Lynn, N. A. and Brown, R. D. (2003) ‘Effects of recreational use impacts on hiking experiences in natural areas’, *Landscape and Urban Planning*, 64(1–2), pp. 77–87.

Maas, J., Verheij, R. A, Spreeuwenberg, P. and Groenewegen, P. P. (2008) ‘Physical activity as a possible mechanism behind the relationship between green space and health: a multilevel analysis.’, *BMC public health*, 8, p. 206.

Mace, G. M., Bateman, I., Albon, S., Balmford, A., Brown, C., Church, A., Haines-young, R., Jules, N., Turner, K., Vira, B. and Winn, J. (2011) ‘Conceptual Framework and Methodology’, *UK National Ecosystem Assessment Technical Report*, p. 7.

Van Marwijk, R. B. M., Elands, B. H. M., Kampen, J. K., Terlouw, S., Pitt, D. G. and Opdam, P. (2012) ‘Public perceptions of the attractiveness of restored nature’, *Restoration Ecology*, 20(6), pp. 773–780.

Mccormack, G. R., Cerin, E., Leslie, E. and Owen, N. (2008) ‘Destinations correspondence and predictive validity’, *Environment And Behavior*, pp. 401–425.

Mental Health Foundation (2015) *Fundamental facts About mental health*. Available at: https://www.mentalhealth.org.uk/publications/fundamental-facts-about-mental-health-2015.

Michaelson, J., Mahoney, S. and Schifferes, J. (2012) *Measuring well-being: a guide for practitioners. New Economics Foundation,* London, UK.

Milcu, A. I., Hanspach, J., Abson, D. and Fischer, J. (2013) ‘Cultural ecosystem services: A literature review and prospects for future research’, *Ecology & Society*, 18(3), pp. 44–88.

Milfont, T. L. and Duckitt, J. (2010) ‘The environmental attitudes inventory: a valid and reliable measure to assess the structure of environmental attitudes’, *Journal of Environmental Psychology*. 30(1), pp. 80–94.

Millennium Ecosystem Assessment (2005) *Ecosystems and human well-being: synthesis. Island Press,* Washington, DC, USA.

Miller, J. R. (2005) ‘Biodiversity conservation and the extinction of experience.’, *Trends in Ecology & Evolution*, 20(8), pp. 430–4.

Mitchell, R. (2013) ‘Is physical activity in natural environments better for mental health than physical activity in other environments?’, *Social science & medicine (1982)*, 91, pp. 130–4.

Møller, A. P. and Jennions, M. D. (2002) ‘How much variance can be explained by ecologists and evolutionary biologists?’, *Oecologia*, 132(4), pp. 492–500.

Moses, L. E., Emerson, J. D. and Hosseini, H. (1984) ‘Analyzing data from ordered categories’, *The New England Journal of Medicine*, 311, pp. 442–448.

Moss, S. (2012) *Natural childhood*. National Trust. London.

Murphy, J. J., Allen, P. G., Stevens, T. H. and Weatherhead, D. (2005) ‘A meta-analysis of hypothetical bias in stated preference valuation’, *Environmental and Resource Economics*, 30(3), pp. 313–325.

Nakagawa, S. (2004) ‘A farewell to Bonferroni: The problems of low statistical power and publication bias’, *Behavioral Ecology*, 15(6), pp. 1044–1045.

Nakagawa, S. and Schielzeth, H. (2013) ‘A general and simple method for obtaining R2 from generalized linear mixed-effects models’, *Methods in Ecology and Evolution*, 4(2), pp. 133–142.

Natural England (2009) *Experiencing Landscapes: capturing the cultural services and experiential qualities of landscape. Natural England commissioned report NECR024.* Natural England, Sheffield, UK.

Natural England (2010) *Nature Nearby: Accessible Natural Green-space Guidance.* Available at: http://www.ukmaburbanforum.co.uk/docunents/other/nature\_nearby.pdf.

Natural England (2012) *Nature Improvement Areas: about the programme*. Available at: https://www.gov.uk/government/publications/nature-improvement-areas-improved-ecological-networks/nature-improvement-areas-about-the-programme.

Natural England (2013) *Monitor of Engagement with the Natural Environment: The national survey on people and the natural environment. Annual Report from the 2012-13 survey NECR122*. Available at: http://publications.naturalengland.org.uk/publication/5331309618528256

Natural England (2014) *A review of the Monitor of Engagement with the Natural Environment (MENE) survey. Natural England Research NERR058*. Available at: http://publications.naturalengland.org.uk/publication/6331146807803904

Nielsen, T. S. and Hansen, K. B. (2007) ‘Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators.’, *Health & Place*, 13(4), pp. 839–50.

O’Brien, L., Townsend, M. and Ebden, M. (2010) ‘“Doing something positive”: volunteers’ experiences of the well-being benefits derived from practical conservation activities in nature’, *Voluntas*, 21(4), pp. 525–545.

Office for National Statistics (2010) ‘English indices of deprivation. http://www.neighbourhood.statistics.gov.uk/dissemination/LeadHome.do?m=0&s=1444056330844&enc=1&nsjs=true&nsck=false&nssvg=false&nswid=1366’.

Office for National Statistics (2011) ‘Labour Market Statistics. http://www.ons.gov.uk/ons/rel/lms/labour-market-statistics/october-2011/index.html’.

Oguz, S., Merad, S. and Snape, D. (2013) *Measuring National Well-being - What matters most to Personal Well-being? Office for National Statistics.* London, UK.

Ostergren, D. M., Abrams, J. B. and Lowe, K. a. (2008) ‘Fire in the forest: public perceptions of ecological restoration in north-central Arizona’, *Ecological Restoration*, 26(1), pp. 51–60.

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T. and Miyazaki, Y. (2010) ‘The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan.’, *Environmental health and preventive medicine*, 15(1), pp. 18–26.

Parry, O., Bancroft, A., Gnich, W. and Amos, A. (2001) ‘Nobody home? Issues of respondent recruitment in areas of deprivation’, *Critical Public Health*, 11(4), pp. 305–317.

Pasta, D. J. (2009) ‘Learning when to be discrete: continuous vs. categorical predictors’, *SAS Global Forum 2009, Statistics and Data Analysis*, pp. 1–10.

Pazhouhanfar, M. and Mustafa Kamal, M. S. (2014) ‘Effect of predictors of visual preference as characteristics of urban natural landscapes in increasing perceived restorative potential’, *Urban Forestry and Urban Greening*, 13(1), pp. 145–151.

Peak District National Park Authority (2004) *State of the Park Report.* Bakewell, UK.

Pearce-Higgins, J. W. and Yalden, D. W. (1997) ‘The effect of resurfacing the Pennine Way on recreational use of blanket bog in the Peak District National Park, England’, *Biological Conservation*, 82(3), pp. 337–343.

Penedo, F. J. and Dahn, J. R. (2005) ‘Exercise and well-being: a review of mental and physical health benefits associated with physical activity’, *Current Opinion in Psychiatry*, 18(2), pp. 189–193.

Pergams, O. R. W. and Zaradic, P. A. (2008) ‘Evidence for a fundamental and pervasive shift away from nature-based recreation.’, *Proceedings of the National Academy of Sciences of the United States of America*, 105(7), pp. 2295–300.

Petursdottir, T., Aradottir, A. L. and Benediktsson, K. (2013) ‘An evaluation of the short-term progress of restoration combining ecological assessment and public perception’, *Restoration Ecology*, 21(1), pp. 75–85.

Pienaar, E. F., Lew, D. K. and Wallmo, K. (2015) ‘The importance of survey content: Testing for the context dependency of the new ecological paradigm scale’, *Social Science Research*, 51, pp. 338–349.

Pilgrim, S. E., Cullen, L. C., Smith, D. J. and Pretty, J. (2008) ‘Ecological knowledge is lost in wealthier communities and countries’, *Environmental Science and Technology*, 42(4), pp. 1004–1009.

Pilgrim, S. E., Smith, D. J. and Pretty, J. (2007) ‘A cross-regional assessment of the factors affecting ecoliteracy: Implications for policy and practice’, *Ecological Applications*, 17(6), pp. 1742–1751.

Proshansky, H. M., Fabian, A. K. and Kaminoff, R. (1983) ‘Place-identity: physical world socialization of the self’, *Journal of Environmental Psychology*, 3(1), pp. 57–83.

Pyle, R. M. (2003) ‘Nature matrix: reconnecting people and nature’, *Oryx*, 37(2), pp. 206–214.

Radford, K. G. and James, P. (2012) ‘Changes in the value of ecosystem services along a rural–urban gradient: A case study of Greater Manchester, UK’, *Landscape and Urban Planning*, 109, pp. 117-127.

Randler, C., Höllwarth, A. and Schaal, S. (2007) ‘Urban park visitors and their knowledge of animal species’, *Anthrozoos*, 20(1), pp. 65–74.

Rey Benayas, J., Newton, A., Diaz, A. and Bullock, J. (2009) ‘Enhancement of Biodiversity and Ecosystem Services by Ecological Restoration: A Meta-Analysis’, *Science*, 8, pp. 1121–1124.

Rhemtulla, M., Brosseau-Liard, P. É. and Savalei, V. (2012) ‘When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions.’, *Psychological Methods*, 17(3), pp. 354–373.

Rogers, K., Proctor, S. and Pendleton, E. (2015) *Dark Peak Nature Improvement Area grassland botanical surveys*. Moors for the Future, UK.

Romanelli, C., Cooper, D., Campbell-Lendrum, D., Maiero, M., Karesh, W. B., Hunter, D. and Golden, C. D. (2015) ‘Connecting global priorities: biodiversity and human Health’, *World Health Organization and Convention on Biological Diversity*.

Royal Mail (2013) *Royal Mail postcode finder*. Available at: http://www.royalmail.com/find-a-postcode.

RSPB (2013) ‘Connecting with nature - finding out how connected to nature the UK’s children are. http://www.rspb.org.uk/Images/connecting-with-nature\_tcm9-354603.pdf’.

Sandifer, P. A., Sutton-Grier, A. E. and Ward, B. P. (2015) ‘Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation’, *Ecosystem Services*, 12, pp. 1–15.

Schenk, A., Hunziker, M. and Kienast, F. (2007) ‘Factors influencing the acceptance of nature conservation measures-A qualitative study in Switzerland’, *Journal of Environmental Management*, 83(1), pp. 66–79.

Schultz, P. W. (2000) ‘Empathizing with nature: the effects of perspective taking on concern for environmental issues’, *Journal of Social Issues*, 56(3), pp. 391–406.

Self, A. and Randall, C. (2013) *Measuring National Well-being -Review of domains and measures. Office For National Statistics.* London, UK.

Seress, G., Lipovits, Á., Bókony, V. and Czúni, L. (2014) ‘Quantifying the urban gradient: A practical method for broad measurements’, *Landscape and Urban Planning*, 131, pp. 42–50.

Shanahan, D. F., Fuller, R. A., Bush, R., Lin, B. B. and Gaston, K. J. (2015) ‘The health benefits of urban nature: How much do we need?’, *BioScience*, 65(5), pp. 476–485.

Shwartz, A., Turbé, A., Julliard, R., Simon, L. and Prévot, A.-C. (2014) ‘Outstanding challenges for urban conservation research and action’, *Global Environmental Change*, 28, pp. 39–49.

Smith, R. M., Gaston, K. J., Warren, P. H. and Thompson, K. (2005) ‘Urban domestic gardens (V): Relationships between landcover composition, housing and landscape’, *Landscape Ecology*, 20(2), pp. 235–253.

Solecki, W. D. (1998) ‘Local attitudes on regional ecosystem management: A study of New Jersey Pinelands residents’, *Society & Natural Resources*, 11(5), pp. 441–463.

Spencer, T. and Proctor, S. (2015) *Dark Peak Nature Improvement Area monitoring of native woodland restoration and creation: woodland bird surveys*. *Moors for the Future,* England.

Srivastava, K. (2009) ‘Urbanization and mental health’, *Industrial Psychiatry Journal*, 18(2), pp. 75–76.

Stewart-Brown, S., Tennant, A., Tennant, R., Platt, S., Parkinson, J. and Weich, S. (2009) ‘Internal construct validity of the Warwick-Edinburgh Mental Well-being Scale (WEMWBS): a Rasch analysis using data from the Scottish Health Education Population Survey.’, *Health and quality of life outcomes*, 7, p. 15.

Sugiyama, T., Leslie, E., Giles-Corti, B. and Owen, N. (2008) ‘Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships?’, *Journal of Epidemiology and Community Health*, 62(5), p. e9.

Swanwick, C., Dunnett, N. and Woolley, H. (2003) ‘Nature, role and value of green space in towns and cities: an overview’, *Built Environment*, 29(2), pp. 94–106.

Tabachnick, B. and Fidell, L. (2001) *Using Multivariate Statistics, 4th ed. Harper. Collins,* Boston, USA.

Takano, T., Nakamura, K. and Watanabe, M. (2002) ‘Urban residential environments and senior citizens’ longevity in megacity areas: the importance of walkable green spaces’, *Journal of Epidemiology and Community Health*, 56(12), pp. 913–918.

Talbot, J. and Kaplan, R. (1984) ‘Needs and fears: the response to trees and nature in the inner city.’, *Journal of Arboriculture*, 10, pp. 222–228.

Tanner, T. (1980) ‘Significant life experiences: A new research area in environmental education’, *Environmental Education*, 11, pp. 20–24.

Teisl, M. F. and O’Brien, K. (2003) ‘Who cares and who acts? Outdoor recreationists exhibit different levels of environmental concern and behavior’, *Environment & Behavior*, 35(99), pp. 506–522.

Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M. C., Schwager, M. and Jeltsch, F. (2004) ‘Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures’, *Journal of Biogeography*, 31(1), pp. 79–92.

Theodori, G. L., Luloff, a E. and Willits, F. K. (1998) ‘The association of outdoor recreation and environmental concern’, *Rural Sociology*, 63(1), pp. 94–108.

Thomas, J., Randall, C. and Statistics, N. (2012) *Measuring national well-being: life in the UK. Office for National Statistics,* London, UK.

Thompson, C. W. (2002) ‘Urban open space in the 21st century’, *Landscape and Urban Planning*, 60(2), pp. 59–72.

Thompson, C. W. (2008) ‘Adult visits to green places’, *Environment And Behavior*, pp. 111–143.

Thompson, C. W., Aspinall, P. and Montarzino, A. (2007) ‘The childhood factor: adult visits to green places and the significance of childhood experience’, *Environment and Behavior*, 40(1), pp. 111–143.

Timur, S., Timur, B. and Karakas, A. (2014) ‘Investigating pre-service teachers’ knowledge and behaviors toward environment’, *Anthropologist*, 17(1), pp. 25–35.

Tinkler, L. and Hicks, S. (2010) *Measuring Subjective Well-being. London, Office for National Statistics,* London, UK.

Toet, A. and van Schaik, M. G. (2012) ‘Effects of signals of disorder on fear of crime in real and virtual environments’, *Journal of Environmental Psychology*, 32(3), pp. 260–276.

Tratalos, J., Fuller, R. A., Evans, K. L., Davies, R. G., Newson, S. E., Greenwood, J. J. D. and Gaston, K. J. (2007) ‘Bird densities are associated with household densities’, *Global Change Biology*, 13(8), pp. 1685–1695.

Tremblay, K. R. and Dunlap, R. E. (1978) ‘Rural-urban residence and concern with environmental quality: a replication and extension’, *Rural Sociology*, 43, pp. 474–491.

Trzyna, T. (2014) *Urban protected areas: profiles and best practice guidelines. Best Practice Protected Area Guidelines Series No. 22.* Switzerland.

Tyler, C., Pullin, A. S. and Stewart, G. B. (2006) ‘Effectiveness of management interventions to control invasion by Rhododendron ponticum’, *Environmental Management*, 37(4), pp. 513–522.

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y. and Kagawa, T. (2014) ‘The influence of urban green environments on stress relief measures: a field experiment’, *Journal of Environmental Psychology*, 38, pp. 1–9.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J. and James, P. (2007) ‘Promoting ecosystem and human health in urban areas using green infrastructure: a literature review’, *Landscape and Urban Planning*, 81(3), pp. 167–178.

Ulrich, R. S. (1983) ‘Aesthetic and affective response to natural environment.’, in Altman, I. and Wohlwill, J. F. (eds) *Behavior and the Natural Environment*. New York: Plenum Press, pp. 85–125.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A. and Zelson, M. (1991) ‘Stress recovery during exposure to natural and urban environments’, *Environmental Psychology*, (11), pp. 201–230.

United Nations (2014) *World’s population increasingly urban with more than half living in urban areas*. Available at: http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html.

Vining, J., Tyler, E. and Kweon, B. S. (2000) ‘Public values, opinions, and emotions in restoration controversies’, in Gobster, P. H. and Hull, R. (eds) *Restoring nature: perspectives from the social sciences and humanities*. Washington DC: Island Press, pp. 143–161.

de Vries, S., Verheij, R. a, Groenewegen, P. P. and Spreeuwenberg, P. (2003) ‘Natural environments - healthy environments? An exploratory analysis of the relationship between greenspace and health’, *Environment and Planning A*, 35(10), pp. 1717–1731.

Walker, A. J. and Ryan, R. L. (2008) ‘Place attachment and landscape preservation in rural New England: A Maine case study’, *Landscape and Urban Planning*, 86(2), pp. 141–152.

Wallace, K. J. (2007) ‘Classification of ecosystem services: problems and solutions’, *Biological Conservation*, 139(3–4), pp. 235–246.

White, D. D., Virden, R. J. and Van Riper, C. J. (2008) ‘Effects of place identity, place dependence, and experience-use history on perceptions of recreation impacts in a natural setting’, *Environmental Management*, 42(4), pp. 647–657.

White, M. P., Alcock, I., Wheeler, B. W. and Depledge, M. H. (2013) ‘Would you be happier living in a greener urban area? A fixed-effects analysis of panel data.’, *Psychological science*, 24, pp. 920–928.

White, M. P., Pahl, S., Ashbullby, K., Herbert, S. and Depledge, M. H. (2013) ‘Feelings of restoration from recent nature visits’, *Journal of Environmental Psychology*, 35, pp. 40–51.

Whitmarsh, L. (2009) ‘Behavioural responses to climate change: Asymmetry of intentions and impacts’, *Journal of Environmental Psychology*, 29(1), pp. 13–23.

Whittingham, M. J., Stephens, P. A, Bradbury, R. B. and Freckleton, R. P. (2006) ‘Why do we still use stepwise modelling in ecology and behaviour?’, *The Journal of Animal Ecology*, 75(5), pp. 1182–9.

WHO (2004) *Promoting mental health: concepts, emerging evidence, practice (Summary Report). WHO,* Geneva, Switzerland.

World Health Organization (2008) ‘The global burden of disease: 2004 update’, *2004 Update*, p. 146.

Wright, P. and Matthews, C. (2014) *Building a culture of conservation - state of knowledge report on connection people to nature in parks*. Available at: http://cpaws.org/uploads/buildingacultureofconservation-web.pdf

Yamaguchi, M., Deguchi, M. and Miyazaki, Y. (2006) ‘The effects of exercise in forest and urban environments on sympathetic nervous activity of normal young adults.’, *The Journal of International Medical Research*, 34, pp. 152–159.

Zaradic, P. A., Pergams, O. R. W. and Kareiva, P. (2009) ‘The impact of nature experience on willingness to support conservation’, *PLoS ONE*, 4(10), pp. 10–14.

Zylstra, M. J., Knight, A. T., Esler, K. J. and Le Grange, L. L. L. (2014) ‘Connectedness as a core conservation concern: an interdisciplinary review of theory and a call for practice’, *Springer Science Reviews,* 12(1), 119-143.

# Appendix A

The manuscript below arose from a collaboration between myself and Dr. Ian Alock at Exeter University. I originally contacted Dr Alcock to ask for permission to use the Willingness to Sacrifice and Commitment to Environmental Sustainability scales he had devised and used in previous research. This led to a discussion about the work below and led to my collecting of additional data for it. My contribution was providing the additional data to enable UK level estimates that complement the core datasets as well as reading and editing draft manuscripts. A draft manuscript is currently under review at the journal of Global Environmental Change following resubmission in response to reviewers’ comments.

**Please note, as this the paper is still under review, it should not be cited (October 2014).**

**‘Green’ on the ground but not in the air: Pro-environmental attitudes are related to household behaviours but not discretionary air travel**

**Highlights**

* Relationships between pro-environmentalism and air travel were explored using two UK surveys.
* Climate concern and environmental attitude were not related to propensity to fly.
* The propensity to fly was not related to pro-environmental household behaviours.
* Pro-environmentalism among air travellers was not related to distances flown.
* Pro-environmental attitudes were related to pro-environmental household behaviours.

**Abstract**

The rise in greenhouse gas emissions from air travel could be reduced by individuals voluntarily abstaining from, or reducing, flights for leisure and recreational purposes. In theory, we might expect that people with pro-environmental value orientations and concerns about the risks of climate change, and those who engage in more pro-environmental household behaviours, would also be more likely to abstain from such voluntary air travel, or at least to fly less far. Analysis of two large datasets from the United Kingdom, weighted to be representative of the whole population, provided new insights. Using zero-inflated Poisson regression models, we found that, after accounting for potential confounders, there was no association between individuals’ environmental attitudes, concern over climate change, or their routine pro-environmental household behaviours, and either their propensity to take non-work related flights, or the distances flown by those who might choose to do so. These findings contrasted with those for pro-environmental household behaviours, where

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associations with environmental attitudes and concern were observed. Our results offer little encouragement for policies aiming to reduce discretionary air travel through pro-environmental advocacy, or through ‘spill-over’ from interventions to improve environmental impacts of household routines.

**Key words**

pro-environmental behaviour; voluntary air travel; discretionary air travel; climate change concerns; attitude-behaviour consistency.

**1**. **Introduction**

Air passenger transport is a major contributor to global greenhouse gas (GHG) emissions (Gössling and Upham, 2009), and this contribution will continue to increase in absolute and proportional terms (IATA, 2014). Recent aviation sector contributions to global anthropogenic GHG emissions of around 3% must be viewed against a background of year on year growth in air travel, and the substantial reductions advocated by the Intergovernmental Panel on Climate Change. As the industry continues to grow, aviation may account for 15%-40% of global CO2 emissions by 2050 (Dubois and Ceron, 2006; Gössling and Peeters, 2007). Widespread air travel in industrialised countries contributes to high per capita GHG emissions; (the OECD average in 2012 was 12.47 tonnes/capita). For example, CO2 emissions per passenger on a return trip from Europe to Thailand (2tCO2) equate to about half the global per capita annual average (Gössling and Upham, 2009). One potentially promising initiative was the inclusion of aviation in the EU’s carbon trading scheme in 2012. However, the vast bulk of any mitigation resulting from this is likely to be in other included sectors due to the relative cost of reducing emissions in aviation (Van Renssen, 2012). No reductions are anticipated in passenger numbers. In the case of the UK, the government predicts passenger traffic will rise from 219 million in 2011, to 445 million by 2050, with CO2 emissions from UK departure flights increasing from 33.3 to 47 MtCO2 (Department for Transport, 2013). Despite the expectation of rising air passenger numbers, there is increasing interest in the potential for policy initiatives to promote more environmentally sustainable behaviour.

Recent UK governments have expressed a strong preference for non-regulatory policy tools with regard to behaviour change interventions, which are claimed to encourage, support and enable people to make better choices for themselves whilst respecting individual freedom (Cabinet Office, 2011). Such policies are said to contrast with legislation and taxation measures, which are viewed as often ineffective or damaging to business (House of Lords, 2011). Consistent with this approach, the Centre of Expertise on Influencing Behaviours within the UK government’s Department for the Environment, Food and Rural Affairs produced a Framework for Sustainable Lifestyles (DEFRA, 2011) which identified ‘Making the most of lower-carbon alternatives to **Please note, as this the paper is still under review, it should not be cited (October 2014).**

flying, for example trains’ as a key behavioural target. The conflict between the immediate benefits to the individual from flying for tourism/recreation and negative consequences to the collective from climate change (Bohr, 2014), often remains unaddressed. At the European level, debate is premised on the absence of any widely communicated social norms on how much air travel is acceptable, and the related political implausibility of limiting currently available options, or even regulating to restrict the advertisement and marketing of holiday flights (Umpfenbach, 2014).

Given this policy background, it is essential to quantify the potential links and spill-overs between pro-environmental attitudes and behaviours. Air travel is generally for either work-related, or discretionary (e.g. holidays, social visits), purposes, with the latter arguably more subject to individual control. Arguably, people with more pro-environmental attitudes, concern about climate change, and engagement in pro-environmental household behaviours will be more likely to also avoid or reduce discretionary flights (Kroesen, 2013). This ‘pro-environmental consistency hypothesis’ is the subject of the current study. There is some support from pro-environmental engagement in other contexts for the idea that different environmentally beneficial behaviours are motivated by common pro-environmental values and concern (Thøgersen and Ölander, 2006). Some studies report a positive association between pro-environmental attitudes, including concerns about climate change, and various pro-environmental behaviours(Ortega-Egea, et al., 2014; Whitmarsh and O’Neill, 2010; O’Connor et al., 1999). Nevertheless, results are inconsistent and evidence of an ‘attitude-behaviour gap’ has also been reported (Lorenzoni et al., 2007). Furthermore, very little research has examined the relationship between routine pro-environmental behaviours in the home, the focus of government behaviour change messages in the UK (DEFRA, 2011), and discretionary air travel.

Of the few small scale and qualitative studies that have begun to address this issue, results have been mixed. Some showed no association between pro-environmental attitudes and household behaviours, and non-work related flights (Cohen et al., 2013; Kroesen, 2013; McKercher et al., 2010; Randles et al., 2009), or even a negative association, with more concerned individuals flying more (Barr et al., 2011), though lower flight frequency amongst those with a more pro-environmental worldview has also been reported (Davison, et al., 2014). Although suggestive, the small sample sizes and inability to control for a host of socio-demographic and potentially relevant psychological variables make interpreting these findings difficult. The present study extended this line of research by using secondary datasets from England (Climate Change and Transport Choices, CCTC, n = 3,923) and the UK (British Household Panel Survey, BHPS Wave 18, n = 14,419) to both make national population level estimates of any relationships, and control for a wide range of potential confounders. Both datasets allowed estimation of associations between flight behaviour, and pro-environmental attitudes and concern about climate change, and the BHPS further allowed estimation of associations between flight behaviour and household behaviours. Both datasets allowed adjusted models to control for the effects of socio-demographic factors, and the BHPS further allowed control on relevant psychological factors and personality traits.

1.1. *Estimating flying behaviour and pro-environmentalism*

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Using self-report data, the current work considered two aspects of voluntary (or non-work related) flying behaviour: a) the characteristics of people who abstain, compared to people who don’t, and b) amongst those who fly, the characteristics of people who fly further. Given that GHG emissions are related to distance flown, we felt that it was important to explore not simply whether ‘greener’ citizens flew less frequently, but also whether they tended to fly less far. In terms of pro-environmentalism we considered individuals’: a) general pro-environmental attitudes (e.g. how important it is to do things that are environmentally friendly); b) concern about the consequences of climate change (e.g. flooding); and c) frequency of household related pro-environmental behaviours (e.g. avoiding products with excess packaging). Distinguishing between these three elements of pro-environmentalism is consistent with previous work. For example, perceptions of the threat that climate change poses, have been shown to be positively associated with pro-environmental behavioural intentions after accounting for the effect of pro-environmental attitudes in general (O’Connor et al., 1999). If the pro-environmental consistency hypothesis is correct, those who show greater tendencies towards pro-environmentalism on these indicators should also exhibit less discretionary flying behaviour.

Since we are using secondary data in the current analysis we were unable to explore and test extant theories concerning the antecedents of pro-environmental attitudes and behaviours (e.g. the Theory of Planned Behaviour (Ajzen, 1991), Value-Belief-Norm theory (Stern, 2000), the Comprehensive Action Determination Model (Klöckner and Blöbaum, 2010), and the Stage Model of Self-regulated Behavioural Change (Bamberg 2013a)), including those used to explore other environmentally-related travel behaviours, such as car use (e.g. Anable, 2005; Bamberg, 2013b), because data on some of the relevant variables were not collected. In consequence this work was not designed to test a theoretical model or framework as applied to flying behaviour, but rather attempted to identify variables in the datasets we used here that could act as markers or proxies for the kind of variables discussed in these theories. In many cases suitable proxies simply did not exist (e.g. personal norms or perceived behavioural control) and thus our work is unable to speak to these constructs. Nonetheless, we were able to identify variables in the datasets that were pertinent to issues such as values, personality, and constraints on behaviour (e.g. income), that have been explored in previous work on pro-environmentalism and below we provide more details about these measures as used in the current work.

1.2. *The need to control for other psychological and socio-demographic variables*

In exploring relationships between flight behaviour and pro-environmentalism, it was necessary to control for a range of individual (psychological) differences and socio-demographic factors which may be related to both flight behaviour and pro-environmentalism and thus account for any relationship between them. Specifically we included a wide range of covariate measures that have been found to be related to pro-environmental behaviours in other contexts (see, for example, reviews by Diamantopoulos et al., 2003, and Gifford and Nilsson, 2014).

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For instance, the role of values in predicting pro-environmental engagement has been emphasised by the integration of Schwartz’s (1994) value model into theoretical models of pro-environmental behaviours such as the Value-Belief-Norm theory (Stern, 2000), and the Comprehensive Action Determination Model (Klöckner and Blöbaum, 2010). These theories suggest general value orientation influences ecological worldview and personal norms, and that these perceived obligations or duties towards the environment in turn impact on environmental behavioural intentions and behaviours (Corner et al., 2014; Dietz et al., 2005). Within Schwartz’s taxonomy (1992, 1994), self-transcendence and self-enhancement are two opposing higher order value orientations, and evidence suggests that self-transcendent (or ‘altruistic’) values which focus concern beyond a person’s immediate social circle are stronger among people who engage in pro-environmental activities (De Groot and Steg, 2008; Steg and Vlek, 2009). In contrast, endorsement of self-enhancing values like materialism or social power tends to be associated with lower levels of engagement with pro-environmental behaviour (Evans et al., 2012), and there is evidence of greater environmental concern among individuals with ‘pro-social’ or ‘post-materialist’ rather than individualistic or competitive social value orientations(Oreg and Katz-Gerro, 2006; Joireman et al., 2001). In the current datasets we identified an item related to the ‘importance of money’, as potentially suggesting higher self-enhancement values, because it has a direct relationship to materialism (Evans et al., 2012). If our suggestion is correct we might expect to see higher discretionary flight use among those high on the ‘importance of money’ item, reflecting the underlying importance of general life values, over and above those relating specifically to the environment (i.e. our central variables of concern). Other factors of this sort that we were able to control on included ‘interest in politics’ (Torgler and Garcia-Valiñas, 2005), ‘religiosity’ (Pepper et al., 2011), and risk aversion (Paladino, 2005; Barile et al., 2015), all of which have been positively associated with pro-environmental choices and behaviours in past work. Controlling for risk aversion is particularly important in the current context because around 40% of people who fly report some degree of anxiety (Martinussen and Hunter, 2009), andit is possible that risk aversion is associated with avoidance of air travel in particular.

Recent research has also examined relationships between pro-environmental behaviour and personality, often operationalised using the five-factor (or Big Five) model (John and Srivastava, 1999). The Big Five is a standard tool which comprises five scale axes held by psychologists to be an adequate summary of personality: ‘extraversion’, (being sociable, talkative and assertive); ‘agreeableness’, (being helpful, cooperative and caring); ‘conscientiousness’, (being reliable, self-disciplined and well-organized); ‘neuroticism’, (being anxious, depressed and insecure); and ‘openness to experience’, (being imaginative, creative, curious and questioning of conventions). Results consistently find pro-environmental outcomes positively associated with openness to experience and there is also some evidence of a positive association with agreeableness and conscientiousness (Milfont and Sibley, 2012; Fraj and Martinez, 2006; Markowitz et al., 2012; Swami et al., 2011; Hirsch 2010; Hirsch and Dolderman 2007). There is even a long-standing interest from the airline industry in the personalities of those who do and do not choose to fly (Plog, 2001). This industry focused research suggested that flyers (rather than non-flyers) are open to new ideas; non-flyers were also found to be less confident and assertive (Plog, 2001). The work did not, however, consider how air travel behaviour related to pro-environmental attitudes

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and behaviours more broadly. Importantly for the current work, one of the datasets we used contained responses to the Big Five personality questionnaire so we were able to control for these five dimensions when exploring the relationships between pro-environmental attitudes and household behaviours, with discretionary flight behaviour. To the extent that personality influences both pro-environmental attitudes and flight behaviour, not controlling for these things may find an ‘illusory’ correlation between them that would simply be accounted for by this far deeper (and much less amenable to change) psychological construct.

Finally, there is also a considerable body of research which has explored socio-demographic factors and pro-environmental engagement (Milfont et al., 2015), much of which speaks to the objective or perceived constraints on pro-environmental behaviours. For instance, income has been shown in some studies to be associated with pro-environmental behaviour (Kemmelmeier et al., 2002; Chen et al., 2011), as has household structure (Longhi, 2013), with greater pro-environmental behaviour reported by unmarried people and couples without children. In other words, the ability to engage in some pro-environmental behaviours (e.g. purchasing local organic produce in small retailers distributed over a large geographical distance) may depend on the ability to overcome financial and/or temporal constraints. In the case of discretionary flight behaviour, however, financial and other practical barriers may act to restrict the number of flights taken, rendering individuals’ behaviour to be classified as ‘pro-environmental’ not because of their environmental beliefs and attitudes, but simply due to their circumstances. Indeed, in the case of air travel in particular, the evidence suggests that there is a significant link with income (Gallet and Doucouliagos, 2014), and that most UK discretionary flights are taken by those in higher socio-economic groups and with above average income (Cairns and Newson 2006). Indeed, year on year increases in UK leisure flights appear to be the result of richer people flying more frequently, rather than cheaper flights making air travel accessible to more people (Cairns and Newson 2006).

Again, controlling for factors such as income and household structure is essential if we want to understand the link between pro-environmentalism in general and flight behaviours in particular, because it statistically accounts for some of the constraints on flying behaviour that would otherwise cloud our understanding of the consistency hypothesis. Other variables of this sort that we controlled for in the models included, age, gender and education, all of which have been shown to be related to pro-environmental attitudes and behaviour in the past (Gifford and Nilsson, 2014; Hunteret al., 2004; Kemmelmeier et al., 2002; Whitmarsh 2011; Whitmarsh and O’Neill,2010). Because these, and the other variables discussed above, are used in the current work to control for potential confounds on the basis of past work, we do not focus on the outcomes of the relationships between these variables and flight behaviour in the main body of the paper. Rather, our focus is on the pro-environmental consistency hypothesis once these factors have been accounted for.

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1.3. *The current work*

In sum, our research tested whether discretionary flight behaviour showed pro-environmental consistency with regard to routine household behaviours, self-rated commitment to individual mitigation efforts, and concern about the progress and impact of climate change. Specifically, we hypothesised that those with more pro-environmental attitudes, concerns and household

behaviours, would be less likely to fly, or to fly shorter distances. Cross-sectional findings on how discretionary flight behaviour is correlated with pro-environmental attitudes and household behaviour are relevant to an understanding of potential positive and negative pro-environmental ‘spill-over’, where an intervention may have an effect on subsequent pro-environmental behaviour which was not the behavioural target of the intervention (Truelove et al., 2015).

Our work extends previous studies examining this issue by using large and population representative UK datasets that also collected data on a large range of potential confounds. Controlling for these factors enabled us to get a far clearer picture of the independent relationship between pro-environmentalism in general and discretionary flight behaviour in particular, for the population as a whole, than is possible in work that is unable, for instance, to account for people’s financial circumstances, their attitudes to money or their personality in general, or whose findings are based on non-representative samples.

2. **Methods**

2.1. *Datasets*

This study used secondary data from two national surveys. The CCTC Survey was conducted to inform the development of the UK Government Department for Transport segmentation model of public attitudes to climate change and transport choices. It employed a random probability sampling technique, and has data from 3,923 face-to-face, in-home interviews conducted between November 2009 and June 2010 with adults (aged 16 plus) living in England (Thornton et al., 2010), (the data is available from https://www.gov.uk/government/publications/climate-change-and-transport-choices-segmentation-study-final-report). The BHPS survey was an 18-year panel survey which began in 1991 with a Wave 1 sample of 5,500 households (around 10,000 individuals) selected using a two-stage clustered probability design and systematic sampling (Taylor et al., 2010). It was structured to enable the modelling of social and economic change over time at the individual and household level in Britain. Additional samples were subsequently added to the original sample to enable UK level estimates. At Wave 18, the individual questionnaire included the items relating to environmental issues which we use in this cross-sectional study. The BHPS data (available under licence through the UK Data Service) includes weights which correct for differential attrition over time, to enable individuals in each wave to be used in cross-sectional (as well as longitudinal) analyses.

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2.2. *Dependent variable: Flight distance km count*

In both the CCTC and BHPS surveys, respondents were asked to state the number of flights they had taken in the previous 12 months to destinations in each of three geographic regions: within the UK; within Europe; and outside Europe. Whilst there is not detailed information about the destinations of respondents and the distances they flew, the three regional classifications do give some information, and rather than lose this information by considering only the total number of flights, we derived the average distances of leisure flights to each geographic region by UK residents at that time, and assumed that each flight taken by respondents was of the relevant average distance. Thus, for each survey, a count scalemeasure of estimated km flown in the previous year was derived from responses to these questions: we multiplied the number of flights to destinations in the three regions by the average flight distance for each region, and summed the region totals. Specifically, the multiplicative constants for each region were derived by estimating the mean return distances flown by UK residents on discretionary flights from all UK departure airports to all destination airports in each region in 2008: within the UK, 857 km; within Europe, 3,181 km; outside Europe, 13,518 km. These estimated mean distances were calculated from routinely collected statistics (CAA, 2008a, 2008b; ONS, 2009, 2014); details are given in Appendix A.

There were two important differences in how the CCTC and BHPS surveys asked respondents to state the number of flights they had taken in the previous 12 months. The CCTC counts of flights to destinations in each of the three regions were capped in the survey response options at ‘3/more’, and therefore counts of 3 had to be assumed in these cases. Secondly, whilst the BHPS asked specifically about non-work related flights, the CCTC survey asked about all flights, without distinguishing discretionary flights. We therefore examined a further CCTC survey item which recorded whether respondents had travelled more than 50 miles on business in the previous year, and treated the air travel data of all who had done so (7.9%) as potentially recording work-related flights rather than voluntary flights. These responses were therefore re-classified as missing, and the flight distance measure for these individuals was imputed (see 2.5 below). A sensitivity analysis compared an alternative strategy to handle the issue: the reported CCTC flight counts for those who had travelled more than 50 miles on business were instead assumed to be all discretionary flights; CCTC models with the dependent variable derived under this assumption showed no differences in substantive findings (results available on request).

2.3. *Independent variables of interest: Environmental variables*

Key predictors derived from CCTC and BHPS variables, which were non-overlapping between the surveys (see Table 1), included: a) pro-environmental attitude (e.g. degree of agreement with statements such as ‘It takes too much time and effort to do things that are environmentally friendly’; CCTC scale Range 0-16, Mean = 10.33, SD = 3.52; BHPS scale Range = 0-12, Mean = 7.42; SD = 2.08); b) beliefs and concerns about climate change (abbreviated to ‘*climate concern*’, e.g. ‘People in the UK will be affected by climate change in the next 30 years’; CCTC scale Range = 0-6, Mean = **Please note, as this the paper is still under review, it should not be cited (October 2014).**

3.74, SD = 1.50; BHPS scale Range = 0-6, Mean = 4.47, SD = 1.72); and c) self-reported pro-environmental household behaviours (abbreviated to ‘*household behaviour*’, e.g. ‘How often do you switch off lights in rooms that aren't being used?’; BHPS scale Range = 0-24, Mean = 12.09, SD = 4.01). Item response sum scores (see Table 1) were used as the environmental variables and higher scores represent more pro-environmental attitudes, climate concern and household behaviour. The selection of the specific questionnaire items for deriving the environmental variables is described in Appendix A.

The distinctiveness of the ‘pro-environmental attitude’ and ‘climate change concern’ measures was investigated using principal components analysis of the items jointly comprising the two scales in each survey. Results are presented in Appendix A. For both surveys, two principal component axes with eigenvalues greater than one were identified, with pro-environmental attitude items loading more heavily on one, and climate change concern items loading more heavily on the other. Furthermore, PC1 items were oppositely signed on PC2 in both surveys, and PC2 items were same signed on PC1 in both surveys. Differentiation between pro-environmental attitude and climate change concern was thus supported.

The properties of the environmental scales, and the relationships between their items, were explored using PCA separately on those items summed to derive the scale scores in each survey. Results are presented in Appendix A, where Cronbach’s α statistics for internal reliability, and matrices of Pearson correlation coefficients for environmental scale items and sum scores are also shown.

Due to the novelty of the pro-environmental attitude scale that we constructed from the items in the BHPS it was important to explore the concurrent validity against more standard measures of pro-environmentalism such as the ‘Willingness to sacrifice for the environment (WSE)’ (Daviset al., 2011) and ‘revised New Environmental Paradigm (NEP)’ (Dunlap et al., 2000) scales. To explore this, we constructed a new survey that included all three scales which was then issued to samples from randomly selected post-codes within 3 km of the geographic centres of six cities in England, (sample details are given in Appendix A). Regression of the BHPS derived pro-environmental attitude

*Table 1.* CCTC and BHPS component items in environmental variable scale sum scores.

|  |  |  |  |
| --- | --- | --- | --- |
| Scale | Survey | Scale component item | Item response (item score) |
|  |  |  |  |
| Pro-environmental attitude | CCTC | There is too much concern with the environment. | Definitely agree (0); Tend to agree (1); Neither agree nor disagree (2); Tend to disagree (3); Definitely disagree (4) |
| It's only worth doing environmentally-friendly things if they save you money. | Definitely agree (0); Tend to agree (1); Neither agree nor disagree (2); Tend to disagree (3); Definitely disagree (4) |
| I don't have time to worry about my impact on the environment. | Definitely agree (0); Tend to agree (1); Neither agree nor disagree (2); Tend to disagree (3); Definitely disagree (4) |
| I find it hard to change my habits to be more environmentally-friendly. | Definitely agree (0); Tend to agree (1); Neither agree nor disagree (2); Tend to disagree (3); Definitely disagree (4) |
| BHPS | It takes too much time and effort to do things that are environmentally friendly. | Strongly agree (0); Agree (1); Neither agree nor disagree (2); Disagree (3); Strongly disagree (4) |
| Scientists will find a solution to global warming without people having to make big changes to their lifestyle. | Strongly agree (0); Agree (1); Neither agree nor disagree (2); Disagree (3); Strongly disagree (4) |
| The environment is a low priority compared with a lot of other things. | Strongly agree (0); Agree (1); Neither agree nor disagree (2); Disagree (3); Strongly disagree (4) |
| Climate concern | CCTC | Thinking about the effects of climate change, which of the following best describes your views? | Climate change will have an impact on other countries, but not on the UK (0); Climate change is not happening / will not have an impact on the UK or other countries (0); Climate change will have less of an impact on the UK than on other countries (1); Climate change will have as much of an impact on the UK as on other countries (2) |
| How concerned are you about climate change? | Very unconcerned (0); Fairly unconcerned (0); Neither concerned nor unconcerned (0); Fairly concerned (1); Very concerned (2) |
| Thinking about the effects of climate change, which of the following best describes your views? | Climate change will not have a real impact in my lifetime, but will have a real impact on future generations (0); Climate change is not happening /will never have a real impact (0); Climate change is not yet having a real impact, but will do in my lifetime (1); Climate change is already having a real impact (2) |
| BHPS | Do you personally believe: | ‘Extensive and long-lasting flooding caused by climate change is likely to take place in the UK – No’ & ‘Extensive and long-lasting flooding caused by climate change is likely to take place in low-lying countries like Bangladesh or the Netherlands – No’ (0); ‘Extensive and long-lasting flooding caused by climate change is likely to take place in the UK – No’ & ‘Extensive and long-lasting flooding caused by climate change is likely to take place in low-lying countries like Bangladesh or the Netherlands – Yes’ (1); ‘Extensive and long-lasting flooding caused by climate change is likely to take place in the UK – Yes’ (2) |
| Do you personally believe: | ‘Climate change is likely to cause severe food shortages in the UK – No’ & ‘Climate change is likely to cause severe food shortages in places like Africa and India – No’ (0); ‘Climate change is likely to cause severe food shortages in the UK – No’ & ‘Climate change is likely to cause severe food shortages in places like Africa and India – Yes’ (1); ‘Climate change is likely to cause severe food shortages in the UK – Yes’ (2) |
| Do you personally believe: | ‘People in the UK will be affected by climate change in the next 30 years – No’ & ‘People in the UK will be affected by climate change in the next 200 years – No’ (0); ‘People in the UK will be affected by climate change in the next 30 years – No’ & ‘People in the UK will be affected by climate change in the next 200 years – Yes’ (1); ‘People in the UK will be affected by climate change in the next 30 years – Yes’ (2) |
| Household behaviour | BHPS | How often do you personally switch off lights in rooms that aren't being used? | Always (4); Very often (3); Quite often (2); Not very often (1); Never (0) |
| How often do you personally put more clothes on when you feel cold rather than putting the heating on or turning it up? | Always (4); Very often (3); Quite often (2); Not very often (1); Never (0) |
| How often do you personally decide not to buy something because you feel it has too much packaging? | Always (4); Very often (3); Quite often (2); Not very often (1); Never (0) |
| How often do you personally buy food that has been produced locally? | Always (4); Very often (3); Quite often (2); Not very often (1); Never (0) |
| How often do you personally buy recycled paper products such as toilet paper or tissues? | Always (4); Very often (3); Quite often (2); Not very often (1); Never (0) |
| How often do you personally take your own shopping bag when shopping? | Always (4); Very often (3); Quite often (2); Not very often (1); Never (0) |

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scale, used here, against the two standard environmental attitude scales showed positive relationships: WSEscale (n = 293) r2 = 0.24 (p<.001); revised NEP scale (n = 188) r2 = 0.27 (p<.001). Details of the correlations between the BHPS pro-environmental attitude scale and sub-domains of the revised NEP are presented in Appendix A. We therefore concluded that although our scale was not identical to either previous measure, it did indeed appear to tap into similar latent constructs and was thus applicable to test the current research questions.

2.4 *Independent control variables*

In terms of individual difference controls, the BHPS questionnaire items from which we derived interval scale measures of relevant psychological factors (e.g. importance of money as a proxy for self-enhancement values) and personality traits, are summarised in Appendix A. Given the associations found in previous work (see 1.2 above) measures of religiosity, interest in politics and risk aversion were also included. Measures of the personality traits in the five factor model were derived from data in BHPS Wave 15, which was merged with the Wave 18 data. The 15-item personality inventory available in the BHPS comprises a shortened version of the inventory developed by John et al. (1991).

CCTC and BHPS questionnaire items for socio-demographic control variables (sex, age, education, labour market status, income, marital status, parenting status and disability) are mostly categorical and relatively self-evident. However, it should be noted that ‘labour market status’ is self-reported and includes those self-employed and on maternity leave in the ‘employed’ category, and includes those who are long-term sick or disabled in the ‘unemployed category’; ‘marital status’ classifies as ‘married’ those currently living with a spouse or partner. There are also some slight differences in how some constructs are operationalised across the two surveys. For instance, the CCTC ‘children’ variable classifies ‘presence of children in the household’, whilst the BHPS ‘children’ variable classifies ‘living with own (including adopted) children under the age of 16’. Further, the CCTC ‘disabled’ variable is based on the question “Do you have any disability or other long-standing illness that makes/would make it impossible for you to ride a bicycle?”, whilst the BHPS ‘disabled’ variable is based on the question “Do you consider yourself to be a disabled person?” Finally, whilst the CCTC income variable is a categorical measure of gross household annual income band, the BHPS income control variable is net household annual income, adjusted for household composition.

2.5 *Analytical approach*

Just over 50% of participants in both samples reported no flights in the last 12 months, and thus zero miles flown. However, these individuals are likely to fall into two broad groups: a) ‘Habitual non-flyers’ (i.e. people who would not report flying in any given sample, perhaps because of fear of flying or environmental reasons); and b) ‘Temporary non-flyers’ (i.e. people who have flown in the past, may fly again in the future but did not happen to fly during the current sampling period). Conceptually we would not expect individuals in these two groups to have the same relationship with

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pro-environmental attitudes, and thus to treat them both simply as ‘non-flyers’ would be misleading. An analogous situation might be one were we label all adults with no children currently resident in the household as ‘non-parents’, which would be to conflate those who never had children and never will (i.e. real ‘non-parents’) with those whose children have simply already left home. This latter group are as much in the ‘parents’ category as those whose children are still at home. Similarly in the current context, ‘Temporary non-flyers’ are as much in the ‘Flyers’ category as those who actually report flights in the last 12 months. To account for these kinds of situation, a statistical approach known as zero-inflated Poisson (ZIP) regression is recommended (Long and Freese, 2006).

Specifically, in the current context, the ZIP regression approach does two things. First, it has a logistic component which models the probability that an observed zero-count (i.e., no flights in the past 12 months) is contributed by: 1) an ‘habitual non-flyer’; or 2) a ‘temporary non-flyer’; and uses this information to model associations with being in the ‘non-flyers’ group (i.e. consisting of ‘habitual non-flyers’ only), rather than the ‘flyers’ group (i.e. consisting of both flyers - those who reported flying in the last 12 months - and ‘Temporary non-flyers’, who did not). The pro-environmental consistency hypothesis would predict that greater pro-environmentalism would be associated with greater likelihood of membership of the ‘non-flyers’ group.

The second component of the analysis, the Poisson component, models the number of km flown among ‘flyers’ (including ‘Temporary non-flyers’). Here, the pro-environmental consistency hypothesis would predict that greater pro-environmentalism would be associated with flying fewer kilometres.

The outcome distribution of a zero-inflated Poisson model is defined as follows:

Pr(*Y* = 0) = *π* + (1 - *π*)*e*-*λ*

Pr(*Y*= *h*) = (1 - *π*) , *h*≥ 1

Where the number of miles flown Yj has a non-negative integer value, *λ* is the expected Poisson count; *π* is the probability of belonging to a “non-flyer” group. To estimate the two free parameters in the above equations, λ and π, we jointly modelled the following two regressions:

Log(π/(1- π))= α + **B**Z + ε

Log(λ) = γ + **G**Z + ξ  
  
Where α and γ are intercepts, B and G are vectors of the regression coefficients for common predictors Z included separately in the logistic and Poisson regressions, and ε and ξ are normally distributed error terms with separate variances. Our set of predictors Z included “pro-environmentalism” scales and, in the case of adjusted models, control variables. It is not theoretically necessary to include the same predictors Z in both regressions (i.e., we could have had Z1 and Z2), but here we imagined the same measured variables were relevant to both λ and π.

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Analyses were carried out using STATA 13 software. In order to make inferences about the entire population of England/UK from these analyses, rather than statements about the particular samples collected, our analyses also made use of the survey weights included in the datasets. These samples did not equally recruit from all sections of the target population for inference, and therefore analyses must accord greater weight to observations from demographic groups under-represented in the survey samples and lower weights to demographic groups who are over-represented in the samples. In the case of the CCTC this was fairly straightforward and we simply used the individual weights in the dataset to enable population representative estimates for England (Thornton et al., 2010). Estimation with the BHPS dataset was slightly more complicated and used survey estimation methods (‘svy:’ suite of functions in STATA software, with specification of sample strata, primary sampling units and individual weights) to additionally account for the non-random, clustered sampling method. BHPS sample members are clustered in households, and in geographic sampling units (Taylor et al., 2010), and survey regression accounts for this lack of independence of observations in the calculation of standard errors for parameter estimates. Moreover, accounting for the BHPS sampling design to enable UK national population estimates was further complicated by the fact that the BHPS panel includes a sub-sample of individuals from households in Northern Ireland which were a random sample rather than a design sample, and therefore do not have primary sampling units or strata. Consequently, observations from Northern Ireland were included in the analyses by assigning them to a further stratum, and specifying the household as the highest order clustering unit (Skinner, 1989).

Missing data due to item non-response was imputed using multiple imputation by chained equations (Azuret al., 2011); (imputed data proportions are given in Appendix A). Imputation models producing 50 imputed datasets for each survey applied sample weights and included all variables in the final estimation models. Imputation models used, as applicable for each survey sample, negative binomial regression (for imputation of flight distance kilometre count); linear regression (for imputation of the environmental variables, income, personality traits, risk aversion and importance of money scales); ordered logistic regression (for imputation of age, qualification, income, religiosity and interest in politics categories); multinomial logistic regression (for imputation of labour market status categories); and logistic regression (for imputation of sex, marital status and disability categories); with other variables, including BHPS sample strata (Heeringaet al., 2010), registered as regular. Imputed values were assessed against observed values using diagnostic plots and tables of proportions (Eddings and Marchenko, 2012).

Two alternative approaches to imputation of the environmental variables were implemented. ZIP regression models using imputed (and observed) sum scale scores, were compared in sensitivity tests with estimation models in which missing values for the component items of these scales were instead imputed, and scale sum scores were subsequently derived from these imputed (and observed) item values (Azuret al., 2011). Estimates using observed and imputed sum scale scores (as presented in Results)

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showed no substantive differences from estimates using sum scale scores derived from observed and imputed item scores (results not presented).

Finally, as is standard in epidemiological research, we present both unadjusted (or raw) models, and adjusted models which also include our range of covariates. The unadjusted models allow us to see the simple relationship between the predictor and outcome (which is analogous to previous studies which have only considered the relationship in isolation). By contrast, the adjusted models allow us to see whether any relationships evident in the unadjusted models remain once potential confounds (such as with income and personality) have been taken into account. Should significant relationships in the unadjusted model becomes non-significant in the adjusted model, this would suggest that the relationship in the unadjusted model may be driven by one or more other factors that are affecting both variables, and thus raises important concerns about any conclusions regarding the relationship estimated in the unadjusted model.

3. **Results**

Descriptive data on all variables under consideration are presented in Table 2. Regression results for the variables of interest are summarised in Table 3. Exponents of regression coefficients are presented, which represent, in the logistic component, Odds Ratios (OR) for being a ‘non-flyer’, and in the Poisson component, the relative flight distance (RFD) amongst ’flyers’, associated with a unit increase, or category shift from the reference, in the predictor variables. (Full regression results, including raw coefficients in addition to their exponents, are presented in Appendix B). The models test the pro-environmental consistency hypothesis, i.e. that more pro-environmental attitudes, greater climate change concern and more pro-environmental household behaviours, would all be associated with both greater likelihood of being a ‘non-flyer’, and with reduced distance among those categorised as flyers.

*Table 2*. Descriptive data on the CCTC and BHPS samples.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Climate Change and Transport Choices sample | | | British Household Panel Survey sample | | |
|  | Scale range | Population mean (SE) (SD) | Population % (SE) | Scale range | Population mean (SE) (SD) | Population % (SE) |
|  |  |  |  |  |  |  |
| **Environmental variables** |  |  |  |  |  |  |
| Flight distance (thousand km) |  | 5.89 (0.25) (11.19) |  |  | 5.95 (0.2) (15.47) |  |
| *Flight distance category* |  |  |  |  |  |  |
| 0 km |  |  | 52.15 (1) |  |  | 50.32 (0.78) |
| >0 - <=5000 km |  |  | 18.12 (0.81) |  |  | 20.21 (0.54) |
| >5000 - <=10000 km |  |  | 10.57 (0.61) |  |  | 9.83 (0.42) |
| >10000 - <=20000 km |  |  | 10.17 (0.61) |  |  | 13.24 (0.5) |
| >20000 km |  |  | 8.98 (0.58) |  |  | 6.39 (0.36) |
| Pro-environmental attitudes | 0-16 | 10.33 (0.07) (3.52) |  | 0-12 | 7.42 (0.03) (2.08) |  |
| Climate concern | 0-6 | 3.74 (0.03) (1.50) |  | 0-6 | 4.47 (0.02) (1.72) |  |
| Household behaviour | - | - | - | 0-24 | 12.09 (0.07) (4.01) |  |
| **Psychological variables** |  |  |  |  |  |  |
| Religiosity | - | - | - | 0-3 | 0.96 (0.02) (1.08) |  |
| Interest in politics | - | - | - | 0-3 | 2.27 (0.014) (0.93) |  |
| Importance of money | - | - | - | 0-9 | 5.48 (0.03) (1.92) |  |
| Risk aversion | - | - | - | 0-9 | 4.51 (0.02) (2.17) |  |
| **Socio-demographic characteristics** |  |  |  |  |  |  |
| Female |  |  | 51.12 (0.97) |  |  | 53.23 (0.39) |
| *Age (years)* (CCTC/BHPS) |  |  |  |  |  |  |
| age 16-20/16-25 |  |  | 8.04 (0.62) |  |  | 14.45 (0.48) |
| age 21-29/26-35 |  |  | 15.40 (0.78) |  |  | 12.88 (0.47) |
| age 30-39/36-45 |  |  | 16.60 (0.71) |  |  | 18.43 (0.56) |
| age 40-49/46-55 |  |  | 18.51 (0.74) |  |  | 16.82 (0.45) |
| age 50-59/56-65 |  |  | 14.87 (0.69) |  |  | 15.78 (0.45) |
| age 60-69/66-75 |  |  | 12.86 (0.57) |  |  | 11.54 (0.43) |
| age over69/over 75 |  |  | 13.72 (0.57) |  |  | 10.10 (0.43) |
| *Educational qualifications* |  |  |  |  |  |  |
| no/low qualifications |  |  | 27.38 (0.79) |  |  | 24.39 (0.61) |
| GCSE qualifications |  |  | 22.56 (0.84) |  |  | 15.55 (0.46) |
| A level qualifications |  |  | 21.44 (0.91) |  |  | 12.12 (0.43) |
| diploma qualifications |  |  | 8.45 (0.44) |  |  | 32.92 (0.60) |
| degree qualifications |  |  | 20.16 (0.75) |  |  | 15.01 (0.55) |
| *Labour market status* |  |  |  |  |  |  |
| employed |  |  | 57.60 (0.94) |  |  | 57.35 (0.66) |
| unemployed |  |  | 7.02 (0.48) |  |  | 6.62 (0.33) |
| retired |  |  | 22.34 (0.71) |  |  | 25.34 (0.65) |
| in education |  |  | 7.11 (0.60) |  |  | 5.58 (0.31) |
| family carer |  |  | 5.93 (0.44) |  |  | 5.11 (0.27) |
| Net household annual income (£) |  | - |  |  | 26,017 (252) (14,986) |  |
| *Gross household annual income (£)* |  |  |  |  |  |  |
| under 12,499 |  |  | 23.57 (0.91) |  |  | - |
| 12,500 to 19,999 |  |  | 17.22 (0.93) |  |  | - |
| 20,000 to 34,999 |  |  | 24.28 (1.01) |  |  | - |
| 35,000 to 59,999 |  |  | 21.16 (1.06) |  |  | - |
| over 59,999 |  |  | 13.78 (0.85) |  |  | - |
| Married/co-habiting |  |  | 64.62 (0.91) |  |  | 63.73 (0.66) |
| Children |  |  | 34.31 (0.95) |  |  | 25.11 (0.71) |
| Disability |  |  | 9.73 (0.49) |  |  | 10.55 (0.34) |
| **Personality traits** |  |  |  |  |  |  |
| Agreeableness trait | - | - | - | 0-18 | 13.19 (0.04) (2.98) |  |
| Conscientiousness trait | - | - | - | 0-18 | 12.70 (0.04) (3.24) |  |
| Extraversion trait | - | - | - | 0-18 | 9.46 (0.04) (3.01) |  |
| Neuroticism trait | - | - | - | 0-18 | 7.94 (0.05) (3.88) |  |
| Openness trait | - | - | - | 0-18 | 10.41 (0.05) (3.59) |  |

*Table 3*. Results of Zero-inflated Poisson regression models predicting: a) Odds ratios associated with being an ’habitual non-flyer’ vs. ‘flyer’ (logistic equation model component); and b) Relative flight distance among ‘flyers’ (Poisson equation model component).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Climate Change and Transport Choices sample | | British Household Panel Survey sample | | | | | |
|  | Model 1a Unadjusted model | Model 1b Adjusted model1 | Model 2a Unadjusted model | Model 2b Adjusted model 1,2 | Model 3a Unadjusted model | Model 3b Adjusted model 1,2 | Model 4a Unadjusted model | Model 4b Adjusted model 1,2 |
|  | OR/RFD;  (95% CI) | OR/ RFD; (95% CI) | OR/ RFD  (95% CI) | OR/ RFD  (95% CI) | OR/ RFD  (95% CI) | OR/ RFD  (95% CI) | OR/ RFD  (95% CI) | OR/ RFD; (95% CI) |
| *a) Association with being a ‘non-flyer’* |  |  |  |  |  |  |  |  |
| Pro-environmental attitude | 0.97\*\*  (0.94-0.99) | 0.99  (0.96-1.02) | 0.89\*\*\*  (0.86-0.91) | 0.98  (0.95-1.01) | - | - | 0.87\*\*\*  (0.85-0.90) | 0.97†  (0.95-1.00) |
| Climate concern | 0.94\*  (0.89-0.99) | 0.96  (0.9-1.03) | 1.06\*\*\*  (1.03-1.09) | 1.02;  (0.98-1.05) | - | - | 1.05\*\*  (1.02-1.09) | 1.01  (0.98-1.05) |
| Household behaviour | - | - | - | - | 1.01†  (1.00-1.03) | 1.01  (0.99-1.02) | 1.03\*\*\*  (1.01-1.04) | 1.01  (0.99-1.03) |
|  |  |  |  |  |  |  |  |  |
| *b) Relative flight distance, ‘Flyers’ only* |  |  |  |  |  |  |  |  |
| Pro-environmental attitude | 1.00  (0.98-1.02) | 0.99  (0.97-1.02) | 1.02\*  (1.00-1.04) | 1.00  (0.98-1.02) | - | - | 1.02\*  (1.00-1.04) | 1.00  (0.98-1.02) |
| Climate concern | 1.02  (0.98-1.07) | 1  (0.96-1.06) | 0.98  (0.96-1.01) | 0.99  (0.97-1.02) | - | - | 0.98  (0.96-1.01) | 0.99  (0.97-1.02) |
| Household behaviour | - | - | - | - | 1.00  (0.99-1.01) | 1.00  (0.98-1.01) | 1.00  (0.99-1.01) | 1.00  (0.98-1.01) |

1 adjusted for sex, age, education, labour market status, income, marital status, parental status, disability; 2 further adjusted for social values: religiosity, interest in politics, importance of money, risk aversion; and personality traits: agreeableness, conscientiousness, extraversion, neuroticism, openness. OR = Odds ratio (model component a), RFD = Relative flight distance (model component b) . †p <.1; \* p <.05; \*\*p<.01; \*\*\*p<.001.

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3.1. *Pro-environmental consistency - CCTC results*

In the unadjusted model analysing the CCTC data, and contrary to the consistency hypothesis, people with higher pro-environmental attitude and climate concern scores were less likely to be ‘non-flyers’ (Table 3, model 1a, OR = 0.97; 95% CI = 0.94-0.99 and OR = 0.94; 95% CI = 0.89-0.99 respectively). Once all covariates had been added to the model, however, these negative relationships became non-significant (1b). Furthermore, neither pro-environmental attitude nor climate concern was associated with estimated discretionary flight distances among ’flyers’ in either model.

3.2. *Pro-environmental consistency - BHPS results*

Analysis of BHPS data echoed the CCTC findings (Table 3), with people with greater pro-environmental attitude scores being less likely to be ‘non-flyers’ in the unadjusted model (model 2a, OR = 0.89; 95% CI = 0.86-0.91), though again there was no significant relationship in the adjusted model (2b). Although the odds of being a ‘non-flyer’ were significantly higher among individuals with greater climate concern in the unadjusted model (2a, OR = 1.06; 95% CI = 1.03-1.09), again there was no significant relationship in the adjusted model, once factors such as employment status were controlled for (2b). Again in the unadjusted model, flight distance among those categorised as ‘flyers’ was positively related to pro-environmental attitude, suggesting that ‘greener’ individuals might actually fly more miles annually (2a, RFD = 1.02; 95% CI = 1-1.04). However, once covariates had been controlled for in the adjusted model, this relationship also became non-significant (2b).

Controlling for household behaviour did not affect any of these findings (model 4a, 4b). Without adjustment for pro-environmental attitude and climate concern, household behaviour had no significant relationships to flight behaviours in either the unadjusted or adjusted models (3a, 3b). In the model that adjusted for pro-environmental attitude and climate concern, but not the other covariates, the odds of being a ‘non-flyer’ were, supporting the pro-environmental consistency hypothesis, significantly higher among individuals who reported higher pro-environmental household behaviour scores (4a, OR = 1.03; 95% CI = 1.01-1.04). Again though, once all covariates were added to the model, this finding too was rendered non-significant (4b).

3.3. *Socio-demographic and psychological correlates of discretionary flight behaviour*

In terms of demographics and psychological variables, (see Appendix B), individuals were significantly more likely to be categorised as ‘non-flyers’ if they were: i) aged over 66 years old (BHPS); ii) male (BHPS); iii) unemployed or caring for a relative (CCTC & BHPS); iv) unmarried (BHPS); v) disabled (CCTC & BHPS); and had: vi) children at home (CCTC & BHPS); vii) low household incomes (CCTC & BHPS); viii) few qualifications (CCTC & BHPS); and: ix) reported relatively high risk aversion, but low materialism, interest in politics, conscientiousness and extraversion (all BHPS). Distances flown, among ‘flyers’, were estimated as greater amongst those who were: i) aged under 75 years (BHPS); and had ii) no children at home (BHPS); iii) high household incomes (CCTC & BHPS); and iv) low risk aversion but high materialism **Please note, as this the paper is still under review, it should not be cited (October 2014).**

and interest in politics (BHPS). The general consistency across both datasets, and with previous research (Kroesen, 2013), other datasets (CAA, 2008b), and intuitive beliefs (e.g. those with high risk aversion and from low income households fly less), provides confidence in the results and highlights the importance of considering these factors in any analysis aiming to understand the relationships between pro-environmental attitudes and discretionary flight behaviours.

3.4. *Contrasting pro-environmental attitude consistency with flight and household behaviour*

The lack of consistency observed between pro-environmental attitudes and climate concerns, and flight behaviour, can be contrasted with the strong consistency between pro-environmental attitude and climate concerns, and pro-environmental household behaviours in the BHPS (Table 4). Linear regression showed that both pro-environmental attitudes (*b* = 0.43; 95% CI = 0.38-0.48; p <.001) and climate concerns (*b* = 0.16; 95% CI = 0.1-0.22; p <.001) were positively related to household behaviour in the adjusted model (as well as in the unadjusted model). Thus, although people show pro-environmental attitude-behaviour consistency at the level of household behaviours, this did not generalise to non-work related (i.e. discretionary) flight behaviours. Of potential interest, valuing money highly, indicative of materialism and self-enhancing values, was associated with both less likelihood of being a non-flyer, and lower pro-environmental household behaviour (see Appendix B), suggesting this value, in particular, is related to a broader range of environmentally-related behaviours than may have been appreciated to date.

4. **Discussion**

The current research used data from two large samples, weighted to be representative of the English and UK populations respectively, to explore whether the pro-environmental consistency hypothesis extended to the issue of discretionary (non-work-related) flying behaviour. Given the well-documented environmental costs of air travel, support for the hypothesis would be found if people with more pro-environmental attitudes and greater climate concern, as well as those who engage in more pro-environmental behaviours at the household level (e.g. saving energy), should also fly less often and for shorter distances. Simple models that did not adjust for a range of potentially confounding variables, supported previous focus group work in the UK (Cohen, et al. 2013; Barr et al., 2010), finding, in direct contrast to the hypothesis, that greater pro-environmental attitudes were associated with a decreased likelihood of being categorised as a ‘non-flyer’, and, in the BHPS model, an increased likelihood of flying more miles annually amongst ‘flyers’. Although individuals who had greater concern about the progress and impact of climate change were more likely to be ‘non-flyers’ in the BHPS sample, supporting pro-environmental consistency, this finding was not replicated in the CCTC sample and climate concern was not related to estimated flight distances among ‘flyers’ in either dataset.

Crucially, all of these effects were rendered non-significant in the fully-adjusted models that accounted for potentially confounding demographic and psychological factors. **Please note, as this the paper is still under review, it should not be cited (October 2014).**

Moreover, the lack of any relationship between pro-environmental attitudes and concern, and flying behaviour, can be contrasted with the positive relationships between pro-environmental attitudes and climate concerns, and pro-environmental household behaviours. That is, while we found evidence for the pro-environmental consistency hypothesis at the level of household behaviours, this did not extend to discretionary flying behaviour. Although we found no robust support for pro-environmental consistency in terms of behaviour in the household and discretionary flights contexts, we also found no evidence to support the idea, suggested in one small scale mixed-methods study, that those who reported more pro-environmental household behaviours, “also tended to be those who flew furthest” (Barr et al., 2011 pp.1234), at least in the adjusted models.

4.1 *Relations of the current findings to previous work*

Although a cross-sectional study design of the sort used in this work could not provide direct evidence of spill-over from initiatives aiming to encourage pro-environmental household behaviour to effects on air travel behaviour, nonetheless a positive association between pro-environmental household behaviour and air travel behaviour would be consistent with a positive pro-environmental spill-over effect. Perceived similarity between pro-environmental behaviours (Thøgersen, 2004) and

*Table 4*. Results of zero-inflated Poisson regression model of flight distance, and linear regression model of household behaviour, (BHPS sample).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ZIP regression model of flight distance1 | | | | | | Linear regression model of pro-environmental household behaviour1 | | |
|  | Association with being a ‘non-flyer’ | | | Flight distance among ‘eligible flyers’ | | |
|  | Coefficient | SE | p | Coefficient | SE | p | Coefficient | SE | p |
| **Environmental variables** |  |  |  |  |  |  |  |  |  |
| Pro-environmental attitude | -0.02 | 0.01 | 0.121 | 0 | 0.01 | 0.903 | 0.43 | 0.03 | **<0.001** |
| Climate concern | 0.02 | 0.02 | 0.383 | -0.01 | 0.01 | 0.689 | 0.16 | 0.03 | **<0.001** |

1 adjusted for sex, age, education, labour market status, income, marital status, parental status, disability, religiosity, interest in politics, importance of money, risk aversion, agreeableness, conscientiousness, extraversion, neuroticism, openness.

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their perceived difficulty (Rosentrater et al., 2013; Fujii 2006) have been shown to be important for benign spill-over to occur. The observed lack of positive association may indicate that commonality in their environmental effects are not perceived, and they do not relate to a common social identity as an environmentalist. Equally, the finding may reflect the ease with which people can engage in pro-environmental household routines, in contrast to the hardship of making pro-environmental discretionary air travel choices. The possibility of negative pro-environmental spill-over from household behaviour to air travel behaviour was suggested by qualitative research in which interviewees cited their pro-environmental household behaviour as a justification for discretionary air travel (Barr et al., 2010). The observed lack of negative association in the current work, however, offers no support for such a ‘moral licencing’ spill-over mechanism.

Previous research has also suggested that pro-environmental attitudes and concern have a closer relationship to household behaviour, than to air travel behaviour. In a study designed to test a pathway model of psychological constructs from rationalist and normative theories of pro-environmental behaviour, Davison et al. (2014) found that combined measures of pro-environmental attitude, perceived ease of pro-environmental behaviour, and perceived personal and social pro-environmental norms, together explained two and a half times as much of the variance in intention to adapt household and routine behaviour, compared to intention to reduce flight dependency. Barr et al. (2011) observed markedly higher self-rated concern and commitment to act on environmental matters amongst a sample cluster with the most pro-environmental household behaviours, who were also the highest frequency air travellers. Our analysis using national representative samples brings into focus the issue of why pro-environmental attitudes and concern should be greater amongst those with more pro-environmental household behaviour, whilst having no relationship to more pro-environmental air travel behaviour.

The contrast we observed between consistency regarding household behaviour, and the lack of consistency regarding flight behaviour, may relate to the role of habits in directing pro-environmental behaviour. Conscious decision making, where attitudes and norms are influential in forming behavioural intentions, have been shown to play a greater role in initiating and directing behaviours which are performed only annually or biannually than in behaviour which is performed daily or weekly (Ouellette and Wood, 1998). The stability of the contexts in which household behaviours are performed, and the regular recurrence of contextual cues, allows the development of automatic responses. There is not the same opportunity for pro-environmental discretionary air travel behaviour (i.e. abstinence or reduction) to become a habit since holiday travel is not a frequently recurring context. The occasional rather than routine nature of holiday travel may both mark it out as distinct from household behaviours and therefore prevent a positive spill-over effect, and also prevent the development of habituated behaviour.

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Indeed, Cohen et al. (2013) suggest that ‘breaking from routine’, and even ‘suspension’ of norms and values, may be integral to the tourism experience, where people feel distanced from the scrutiny of their home community, and the extraordinary is anticipated. In addition, tourism is associated with conspicuous consumption, and our results are consistent with previous evidence of a significant link between income and the demand for air travel. For instance, Department of Transport (2013) estimate the income elasticity for discretionary air travel demand amongst UK nationals to be 1.4. Relatedly, Kroesen (2013) found that people articulated a sense of ‘necessary indulgence’ to reconcile any inconsistency between their pro-environmental attitudes and flying behaviour. Thus, tourism as a setting for intrinsically non-routine and indulgent consumption which is removed from community norms, may mean that people feel little dissonance between their pro-environmental attitudes and their discretionary air travel.

4.2. *Limitations and further research*

We believe the consistency in our findings across two large, independent, representative datasets and across models of both propensity to fly and distances flown by flyers, provides considerable robustness to our conclusions that there is a lack of any relationship between discretionary flying behaviour and other indicators of pro-environmentalism. Nonetheless, we also recognise a number of potential limitations with the current work suggesting caution still needs to be taken. For instance, due to data availability our analyses were based on the most recent UK data available, i.e. 2009/10 (CCTC) and 2008/9 (BHPS) fieldwork. Although the successor survey to the BHPS, the UK Household Longitudinal Survey, collected data on flights during 2012/13, the survey items do not allow operationalisation of psychological constructs such as risk aversion and self-enhancing value orientation, which we know to be influential predictors of flight behaviour. Further work is thus needed, when more recent data become available, to explore whether the relationships we found might have changed over the intervening years. We see no theoretical reason why this should be, however, as the relationship between flying and GHG emissions was already widely known in 2008.

We also recognise that our estimates of flight distances are relatively crude and based on country/continental averages and that this may create a certain element of noise in our modelling of distance flown. For instance, it may be that more pro-environmental individuals choose to fly shorter distances than less pro-environmental individuals within the three geographic regions, whilst having the same counts of flight to each region, and this would not be revealed in our analyses. Even if it were true, however, that pro-environmentalism motivated people to holiday to France from the UK rather than to Greece, for example, this would raise the question of why people who hold pro-environmental attitudes are willing to make relatively short-haul flights when other

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alternative forms of transport are actually more feasible than for longer haul flights. Thus although we recognise the limitations of our distance modelling, we think it was the best solution currently available, and our findings were also replicated in the logistic component of both models, which showed no relationships between other forms of pro-environmentalism and whether or not individuals were categorised as ‘flyers’ or ‘non-flyers’. Nonetheless, future work would benefit from more accurate annual flight data at the individual level.

Finally, our use of archive data did not enable us to test traditional pathway models of pro-environmental behaviours (see 1.2) because operationalisations of all the relevant constructs were not available. Further research using representative samples is now needed that includes operationalisations of the constructs in these theories to better explore the relationships between pro-environmental related values, norms, attitudes, beliefs, goals, emotions, objective and subjective constraints, and intentions, to better understand the antecedents of discretionary flight behaviour. Further, such studies would ideally be conducted in multiple countries to explore whether our UK findings extend to other countries where pro-environmental consistency may be higher (e.g. Germany, Bamberg, 2013a).

4.3 *Conclusions and policy implications*.

In sum, although we found support for the pro-environmental consistency hypothesis with respect to attitudes and household behaviours, this did not extent to discretionary flying behaviour. Our findings thus offer little support for a policy approach that relies on improving pro-environmental attitudes, awareness of climate change outcomes and encouraging routine pro-environmental household behaviours , in the hope that this will have positive spill-over effects in terms of a reduction in discretionary air travel (Austin et al., 2011). This suggests that other actions should be considered including the use of economic instruments or regulatory controls to reduce discretionary air travel based emissions instead. Overall, price elasticities for leisure travellers are assumed to be more elastic than those for business travel (Smyth and Pearce, 2008), so increasing prices through taxation or other means is likely to reduce demand, and hence emissions. Policy actions could be at national level (e.g. increasing air passenger duty or aviation fuel duty) or international (e.g. through extension of the EU Emissions Trading Scheme on aviation emissions), or through market based measures developed under the UN’s International Civil Aviation Organization.

**References**

Ajzen, I. (1991) The theory of planned behaviour. Organ Behav Hum Decis Process 50, 179–211.

Anable, J. (2005) ‘Complacent car addicts’ or ‘aspiring environmentalists’? Identifying travel behaviour segments using attitude theory. Transport Policy 12, 65–78.

Austin, A., Cox, J., Barnett, J. and Thomas, C. (2011) Exploring catalyst behaviours: Full Report. A report to the Department for Environment, Food and Rural Affairs. Brook Lyndhurst for DEFRA, London.

Azur, M. J., Stuart, E. A., Frangakis, C. and Leaf, P. J. (2011) Multiple imputation by chained equations: what is it and how does it work? Int J Methods Psychiatr Res 20, 40–49.

Bamberg, S. (2013a). Changing environmentally harmful behaviors: A stage model of self-regulated behavioral change. J Environ Psychol 34, 151–159.

Bamberg, S. (2013b). Applying the stage model of self-regulated behavioral change in a car use reduction intervention. J Environ Psychol33, 68–75.

Barile, L., Cullis, J. and Jones, P. (2015) Will one size fit all? Incentives designed to nurture prosocial behaviour. J Behav Exper Econ 57, 9-16.

Barr, S., Shaw, G., and Coles, T. (2011) Times for (Un)sustainability? Challenges and opportunities for developing behaviour change policy. A case-study of consumers at home and away. Global Environ Change 21, 1234–1244.

Barr, S., Shaw, G., Coles, T., and Prillwitz, J. (2010) “A holiday is a holiday”: Practicing sustainability, home and away. J Transport Geogr 18, 474–481.

Bohr, J. (2014) Barriers to environmental sacrifice: the interaction of free rider fears with education, income, and ideology. Sociol Spectrum 34, 362–379.

CAA (2008a) UK Airport Statistics: 2008: T. 12.1 Intl Air Pax Route Analysis 2008 / 12.2 Dom Air Pax Route Analysis 2008. Available online from http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&sglid=3&fld=2008Annual

CAA (2008b) CAA Passenger Survey Report 2008: Survey of passengers at Bristol, Cardiff, Exeter, Gatwick, Heathrow, London City, Luton, Manchester and Stansted Airports. CAA, Economic Regulation group (2008). Available online from http://www.caa.co.uk/docs/81/2008CAAPaxSurveyReport.pdf

Cabinet Office (2011) Behavioural insights team annual update 2010-2011. Cabinet Office, London.

Cairns, S. and Newson, C. (2006) Predict and decide: aviation, climate change and policy. Oxford, UKERC, Demand Reduction Theme.

Chen, X., Peterson, M. N., Hull, V., Lu, C., Lee, G. D., Hong, D. and Liu, J. Effects of attitudinal and sociodemographic factors on pro-environmental behaviour in urban China. Environ Conserv 38, 45–52 (2011).

Cohen, S. A., Higham, J. E. S. and Reis, A. C. (2013) Sociological barriers to developing sustainable discretionary air travel behaviour. J Sustain Tourism 21, 982–998.

Corner, A., Markowitz, E. and Pidgeon, N. (2014) Public engagement with climate change: the role of human values. Wiley Interdiscip Rev Clim Change 5, 411–422.

Davis, J. L., Le, B., and Coy, A. E. (2011) Building a model of commitment to the natural environment to predict ecological behavior and willingness to sacrifice. J Environ Psychol 31, 257–265.

Davison, L., Littleford, C. and Ryley, T. (2014). Air travel attitudes and behaviours: The development of environment-based segments. J Air Transp Manag 36, 13–22.

DEFRA (2011) The Sustainable Lifestyles Framework. Available online from http://webarchive.nationalarchives.gov.uk/20130822084033/http://archive.defra.gov.uk/environment/economy/documents/sustainable-life-framework.pdf

De Groot J. I. M. and Steg L. (2008) Value orientations to explain beliefs related to environmental significant behavior: How to measure egoistic, altruistic, and biospheric value orientations. Environ Behav 40 330–354.

Department for Transport (2013) UK Aviation Forecasts. January 2013. Available online from https://www.gov.uk/government/uploads/system/uploads/attachment\_data/file/223839/aviation-forecasts.pdf

Diamantopoulos, A., Schlegelmilch, B. B., Sinkovics, R. R. and Bohlen, G. M. (2003) Can socio-demographics still play a role in profiling green consumers? A review of the evidence and an empirical investigation. J Bus Res 56, 465–480.

Dietz, T., Fitzgerald, A. and Shwom, R. (2005) Environmental values. Annu Rev Environ Resour 30, 335–372.

Dubois, G. and Ceron, J. P. (2006) Tourism/leisure greenhouse gas emission forecasts for 2050: factors for change in France. J Sustain Tourism 14, 172–91.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., and Jones, R. E. (2000) New trends in measuring environmental attitudes: measuring endorsement of the New Ecological Paradigm: a revised NEP scale. J Soc Issues 56, 425–442.

Eddings, W. and Marchenko, Y. (2012) Diagnostics for multiple imputation in Stata. Stata J 12, 353–367.

Evans, L., Maio, G., Corner, A., Hodgetts, C. J., Ahmed, S. and Hahn, U. (2012) Self-interest and pro-environmental behaviour. Nat Clim Change 3, 122–125.

Fraj, E. and Martinez, E. (2006) Influence of personality on ecological consumer behaviour. J Consum Behav 5, 167–181.

Fujii, S. (2006) Environmental concern, attitude toward frugality, and ease of behavior as determinants of pro-environmental behavior intentions. J Environ Psychol 26, 262–268.

Gallet, C. A. and Doucouliagos, H. (2014). The income elasticity of air travel: A meta-analysis. Ann Tour Res 49, 141–155.

Gifford, R. and Nilsson, A. (2014) Personal and social factors that influence pro-environmental concern and behaviour: A review. Int J Psychol 49, 141–157.

Gössling, S. and Peeters, P. (2007) ‘It Does Not Harm the Environment!’ An Analysis of Industry Discourses on Tourism, Air Travel and the Environment. J Sustain Tourism 15, 402–417.

Gössling, S. and Upham, P. (Eds.) (2009) Aviation and Climate Change: issues, challenges and solutions. Earthscan: London; Stirling VA.

Heeringa, S. G., West, B. T. and Berglund, P. A. (2010) Applied Survey Data Analysis. Chapman Hall/CRC Press: Boca Raton

Hirsh, J. B. (2010) Personality and environmental concern. J Environ Psychol30*,* 245–248.

Hirsh, J. B. and Dolderman, D. (2007) Personality predictors of consumerism and environmentalism: A preliminary study. Pers Individ Dif 43, 1583–1593.

House of Lords (2011) Science and Technology Committee Second Report. Behaviour Change. Available online from http://www.publications.parliament.uk/pa/ld201012/ldselect/ldsctech/179/17902.htm

Hunter, L. M., Hatch, A. and Johnson, A. (2004) Cross-national gender variation in environmental behaviors. Soc Sci Q 85, 677–694.

IATA (2014) Air Passenger Forecasts. Global Report. International Air Transport Association.

John, O. P., Donahue, E. M. and Kentle R. L. (1991) The “Big Five” Inventory- Versions 4a and 54. Berkley: University of California, Berkley, Institute of Personality and Social Research.

John, O. P. and Srivastava, S. (1999) The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In John, O. P. and Pervin, L. A. (Eds.) Handbook of Personality: Theory and Research. 2nd Edition. New York: Guilford Press. (pp. 114–158).

Joireman, J. A., Lasane, T. P., Bennett, J., Richards, D. and Solaimani, S. (2001) Integrating social value orientation and the consideration of future consequences within the extended norm activation model of proenvironmental behaviour. Br J Soc Psychol 40, 133–155.

Kemmelmeier, M., Kròl, G. and Young, H. K. (2002) Values, economics, and proenvironmental attitudes in 22 societies. Cross Cult Res 36, 256–285.

Klöckner, C.A. and Blöbaum, A. (2010) A comprehensive action determination model – towards a broader understanding of conservationist behaviour. J Environ Psychol 30, 574–586.

Kroesen, M. (2013) Exploring people’s viewpoints on air travel and climate change: understanding inconsistencies. J Sustain Tourism 21, 271–290.

Long, J.S. and Freese, J. (2006) Regression Models for Categorical Dependent Variables Using Stata. 2nd Ed. College Station, TX: Stata Press.

Longhi, S. (2013) Individual pro-environmental behaviour in the household context. ISER Working Paper No. 2013-21. Available online from https://www.iser.essex.ac.uk/research/publications/working-papers/iser/2013-21.pdf

Lorenzoni, I., Nicholson-Cole, S., and Whitmarsh L. (2007) Barriers perceived to engaging with climate change among the UK public and their policy implications. Global Environ Change 17, 445–459.

Markowitz, E. M., Goldberg, L. R., Ashton, M. C. and Lee, K. (2012) Profiling the ‘pro-environmental individual’: a personality perspective. J Personal 80, 81–111.

Martinussen, M. and Hunter, D. R. (2009) Aviation Psychology and Human Factors. London: Taylor and Francis.

McKercher, B., Prideaux, B., Cheung, C. and Law, R. (2010) Achieving voluntary reductions in the carbon footprint of tourism and climate change. J Sustain Tourism 18, 297–317.

Milfont, T. L., Milojev, P., Greaves, L. and Sibley, C. G. (2015). Socio-structural and psychological foundations of climate change beliefs. New Zeal J Psychol 44, 17–30.

Milfont, T. L. and Sibley, C. G. (2012) The big five personality traits and environmental engagement: associations at the individual and societal level. J Environ Psychol 32, 187–195.

O’Connor, R. E., Bord, R. J. and Fisher, A. (1999) Risk perceptions, general environmental beliefs, and willingness to address climate change. Risk Anal 19, 461–471.

ONS (2009) International Passenger Survey, 2008 (SN5993). Office for National Statistics. Social and Vital Statistics Division. (2009). International Passenger Survey, 2008. [data collection]. 5th Edition.UK Data Service. SN: 5993. [data available from https://discover.ukdataservice.ac.uk/catalogue/?sn=5993&type=Data%20catalogue]

ONS (2014) International Passenger Survey. Overseas Travel and Tourism. User Guide (Volume 1) Background & Methodology. Available online from http://www.ons.gov.uk/ons/guide-method/method-quality/specific/travel-and-transport-methodology/international-passenger-survey-methodology/index.html

Oreg, S. and Katz-Gerro, T. (2006) Predicting proenvironmental behavior cross-nationally: values, the theory of planned behavior, and value-belief-norm theory. Environ Behav 38 462–483.

Ortega-Egea, J. M., Garcìa-de-Frutos, N. and Antolìn-Lòpez, R. (2014) Why do some people do ‘‘more’’ to mitigate climate change than others? Exploring heterogeneity in psycho-social associations. PLoS One 9 e106645.

Ouellette, J. A. and Wood, W. (1998) Habit and intention in everyday life: the multiple processes by which past behaviour predicts future behaviour. Psychological Bulletin 124, 54–75.

Paladino, A. (2005) Understanding the green consumer: an empirical analysis. J Customer Behav 4, 69–102.

Pepper M., Jackson T., and Uzzell D. (2011) An examination of Christianity and socially conscious and frugal consumer behaviors. Environ Behav 43 274–290.

Plog, S.C. (2001) Why destination areas rise and fall in popularity: an update of a Cornell quarterly classic. Cornell Hotel and Restaur Adm Q 42, 13–24.

Randles, S. and Mander, S. (2009) Aviation, consumption and the climate change debate: Are you going to tell me off for flying? Tech Anal Strat Manag 21, 93–113.

Rosentrater, L.D., Sælensminde, I., Ekström, F., Böhm, G., Bostrom, A., Hanss, D., O’Connor, R.E. (2013) Efficacy trade-offs in individuals’ support for climate change policies. Environ Behav 45, 935–970.

Schwartz, S. H. (1992) Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In M. P. Zanna (Ed.) Adv Exp Soc Psychol(Vol. 25, pp. 1–65). New York: Academic Press.

Schwartz, S. H. (1994) Are there universal aspects in the structure and contents of human values? J Soc Issues 50, 19–45.

Skinner, C.J. (1989) Introduction to Part A. In Skinner, C.J., Holt, D. and Smith, T.M.F. (Eds.) Analysis of Complex Surveys. Chichester: John Wiley & Sons. (pp. 23–58.)

Smyth, M. and Pearce, B. (2008) Air Travel Demand: Measuring the responsiveness of air travel demand to changes in prices and incomes. IATA Economics Briefing No. 9. IATA.

Steg, L. and Vlek, C. (2009) Encouraging pro-environmental behaviour: an integrative review and research agenda. J Environ Psychol 29, 309–317.

Stern, P. C. (2000) Toward a coherent theory of environmentally significant behavior. J Soc Issues56, 407–424.

Swami, V., Chamorro-Premuzic, T., Snelgar, R. and Furnham, A. (2011) Personality, individual differences, and demographic antecedents of self-reported household waste management behaviours. J Environ Psychol 31, 21–26.

Taylor, M. F., Brice, J., Buck, N. and Prentice-Lane, E. (2010) British Household Panel Survey User Manual Vol. A: Introduction, Technical Report and Appendices. University of Essex: Colchester, UK.

Thøgersen, J. (2004) A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. J Environ Psychol 24, 93–103.

Thøgersen, J., and Ölander, F. (2006) To what degree are environmentally beneficial choices reflective of a general conservation stance? Environ Behav 38, 550–569.

Thornton, A., Evans, L., Bunt, K., Simon, A., King, S. and Webster, T. (2011) Climate Change and Transport Choices. Segmentation Model - A framework for reducing CO2 emissions from personal travel. Available online from https://www.gov.uk/government/uploads/system/uploads/attachment\_data/file/49971/climate-change-transport-choices-full.pdf

Torgler, B. & Garcia-Valiñas, M. A. (2005) The Determinants of Individuals’ Attitudes Towards Preventing Environmental Damage. Fondazione Eni Enrico Mattei (FEEM) Working Paper Series. No. 110.05: Milano.

Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., and Vandenbergh, M. P. (2014) Positive and negative spillover of pro-environmental behavior: an integrative review and theoretical framework. Global Environ Change 29, 127–138.

Umpfenbach, K. and colleagues (2014) Influences on Consumer Behaviour: Policy implications beyond nudging. Final Report for the European Commission (DG Environment), 8 April 2014. Ecologic Institute, Berlin. [Available online from http://ec.europa.eu/environment/enveco/economics\_policy/pdf/Behaviour%20Policy%20Brief.pdf]

Van Renssen, S. (2012) Climate battle for the skies. Nature Climate Change 2, 308–309.

Whitmarsh, L. (2011) Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. Global Environ Change 21, 690–700.

Whitmarsh L., and O’Neill, S. (2010) Green identity, green living? The role of proenvironmental self-identity in determining consistency across diverse proenvironmental behaviours. J Environ Psychol 30, 305–314.

# Appendix B

**Chapters 2 & 3 Questionnaire**

**1. How long have you lived in your current home? \_\_\_\_\_\_** *months or \_\_\_\_\_\_ years*

**2. Have you been on holiday over the last two weeks?** Y □ N □

**3a. How much built up land (i.e. buildings, roads, carparks etc) is there within a 5 minute walk from where you live**

|  |
| --- |
| None Very little A fair amount A lot Completely surrounded |
| □ □ □ □ □ |

**3b. How much greenery is there within a 5 minute walk from where you live**

|  |
| --- |
| None Very little A fair amount A lot Completely surrounded |
| □ □ □ □ □ |

**4. What is your current home postcode?**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**5. If you had £600 to spend on charities from the following sectors, how much (if any) would you give to each type of charity?**

1. Medical research £\_\_\_\_\_\_\_\_
2. Animal and plant conservation £\_\_\_\_\_\_\_\_
3. Environmental organisations £\_\_\_\_\_\_\_\_
4. Human rights £\_\_\_\_\_\_\_\_
5. Animal welfare/protection £\_\_\_\_\_\_\_\_
6. Helping vulnerable people £\_\_\_\_\_\_\_\_ Total\_\_\_\_\_\_

**6. In the last 2 weeks, how many visits have you made to urban green-spaces (excluding your garden)?\_\_\_\_\_\_\_\_\_\_\_**

**7. In the last 2 weeks how many visits have you made to the countryside?\_\_\_\_\_\_\_\_\_\_\_\_\_**

**8. On average over the course of a year, how often do you visit urban green-spaces (exc your garden)?**

Daily □ Several times a week □ Once a week □ Fortnightly □ Monthly □ Once every 2 or 3 months □ Once/twice a year □ Never □

**9. On average over the course of a year, how often do you visit the countryside?**

Daily □ Several times a week □ Once a Week □ Fortnightly □ Monthly □ Once every 2 or 3 months □ Once/twice a year □ Never □

**10. What are the main reasons you visit urban green-spaces?**

**11. What are the main reasons you visit the countryside?**

**12. On average over the course of a year, how often do you spend time in your garden?**

No garden □ Daily □ Several times a week □ Once a week □ Fortnightly □ Monthly □ Once every 2 or 3 months □ Once/twice a year □ Never □

**13. On average over the course of a year, how often do you watch or listen to natural history programmes i.e. wildlife/nature documentaries?**

Daily □ Several times a week □ Once a week □ Fortnightly □ Monthly □ Once every 2 or 3 months □ Once/twice a year □ Never □

**14. Are you a current member of any charities?** Yes □ No □

**If yes**, which ones \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**15a. Have you given any donations to other charities over the past month (either standing orders or one off donations)?** Yes □ No □

**15b. If yes, which ones?** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**16c. And how much to each per month?** *Draw arrows*

£1-£5 £6-£10 £11-£20 £21-£40 £41-£60 £61-80 £81-100 More than £100

Or one off donation £\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**17a. Do you currently volunteer for any groups?** Yes □ No □

**17b. If yes, which ones?** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**17c. And how frequently? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**18. Using scale A on your answer card, could you please tell me how strongly the following statements match your opinion?** *Strongly agree, Agree, Neither agree/disagree, Disagree, Strongly disagree*

**a)** It takes too much time and effort to do things that are environmental friendly \_\_\_\_\_

**b)** Scientists will find a solution to global warming without people having to make big changes to their lifestyle\_\_\_\_

**c)** The environment is a low priority for me compared with a lot of other things in my life \_\_\_\_\_

**19. Can you please take a look at these three sets of photos and for each set rank them in terms of their value for wildlife so for example A is best, then B , then C or A and B are joint best then C.**

**a) Woodland** Order (best first) \_\_\_**\_\_\_\_\_\_\_**

**b) Farmland** Order (best first) \_\_\_**\_\_\_\_\_\_\_**

**c) Wetland** Order (best first) \_\_\_**\_\_\_\_\_\_\_**

**20. Please can you tell me if you can name any of these species and whether they are of conservation concern, i.e. have suffered major declines in numbers or range in the UK**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Name** | **Of Conservation Concern?** | | |
| **Yes** | **No** | **Really No idea** |
| **Bird a** |  |  |  |  |
| Bird b |  |  |  |  |
| Bird c |  |  |  |  |
| Bird d |  |  |  |  |
| **Mammal a** |  |  |  |  |
| Mammal b |  |  |  |  |
| Mammal c |  |  |  |  |
| Mammal d |  |  |  |  |
| **Plant a** |  |  |  |  |
| Plant b |  |  |  |  |
| Plant c |  |  |  |  |
| Plant d |  |  |  |  |

**21. Could you please use scale B) on your answer card and tell us on a scale of 0 to 8 scale, how strongly the following statements match your opinion.** *0=Do not agree at all, 4=Agree somewhat, 8=Agree completely*

a) I am willing to give things up that I like doing if they harm the natural environment \_\_\_\_\_  
b) I am willing to take on responsibilities that will help conserve the natural environment \_\_\_\_  
c) I am willing to do things for the environment, even if I’m not thanked for my efforts \_\_\_\_\_  
d) Even when it is inconvenient to me, I am willing to do what I think is best for the environment \_\_\_  
e) I am willing to go out of my way to do what is best for the environment \_\_\_\_\_

**22. For each of the following questions I’d like you to please give an answer on a scale of 0 to 10, where 0 is ‘not at all’ and 10 is ‘completely’.**

a) Overall, how satisfied are you with your life nowadays? \_\_\_\_\_\_

b) Overall, to what extent do you feel that the things you do in your life are worthwhile? \_\_\_\_\_

c) Overall, how happy did you feel yesterday? \_\_\_\_\_\_

d) Overall, how anxious did you feel yesterday? \_\_\_\_\_\_

**23. Using scale C on your answer card, could you please tell me which best describes your experience over the last two weeks for each of the following statements:**

*1= All of the time 2=Often 3=Some of the time 4=Rarely 5=None of the time*

a) I’ve been feeling optimistic about the future \_\_\_\_

b) I’ve been feeling useful \_\_\_\_

c) I’ve been feeling relaxed \_\_\_\_

d) I’ve been dealing with problems well \_\_\_\_

e) I’ve been thinking clearly \_\_\_\_

f) I’ve been feeling close to other people \_\_\_\_

g) I’ve been able to make my own mind up about things \_\_\_\_

h) I’ve had restless sleep \_\_\_\_

i) I’ve had a lot of energy \_\_\_\_

**24. Which of the following categories apply to you?**

Retired □ Unemployed □ Full-time education □ Full-time paid employment □

Part-time paid employment □ Self-employed □ Home maker/bringing up family □

**25. What’s the highest level qualification that you have?**

None □ O level/GCSE or equivalent □ A level or equivalent □ Undergraduate degree □ Higher degree □ Vocational qualification (state level if known\_\_\_\_) □

**26. What is your current marital status? Are you**

Married □ Living in a civil partnership □ Living with a partner □ Single □ Divorced □ Widowed □

**27. What is the tax band of your household?**

No tax (<£9,440 taxable income) □ Basic rate (£9,440-£32,010) □

Higher rate (£32,011-£150,000) □ Top rate (£>150,000) □

**28. Which age category are you in?**

16-18 □ 19-24 □ 25-34 □ 35-44 □ 45-54 □ 55-64 □ 65-74 □ 75-84 □ 85-94 □ 94+ □

**29. Please take a look at this card and choose one option that best describes your ethnic group or background**

**White**

1. English / Welsh / Scottish / Northern Irish / British   
2. Irish   
3. Gypsy or Irish Traveller   
4. Any other White background, please describe

**Mixed / Multiple ethnic groups**

5. White and Black Caribbean   
6. White and Black African   
7. White and Asian   
8. Any other Mixed / Multiple ethnic background, please describe

**Asian / Asian British**

9. Indian   
10. Pakistani   
11. Bangladeshi   
12. Chinese   
13. Any other Asian background, please describe

**Black / African / Caribbean / Black British**

14. African   
15. Caribbean   
16. Any other Black / African / Caribbean background, please describe

**Other ethnic group**

17. Arab

18. Latin American  
19. Any other ethnic group, please describe

**30. Respondent’s gender** Male □ Female □

# Appendix C

**Chapter 4 Questionnaire**

**Were you aware of the Dark Peak Nature Improvement Area (NIA) before today?** Yes □ No □

**1. How strongly do the following statements match your opinion?** *Please enter number 1 – 5*

*1=Strongly agree 2=Agree 3=Neither agree/disagree 4=Disagree 5=Strongly disagree*

It is important to increase the:

a) quality of moorland in the Dark Peak.

b) amount and quality of native woodland in the Dark Peak.

c) amount and quality of hay meadow in the Dark Peak.

d) amount and quality of access to the countrysidein the Dark Peak*.*

**2. From the following options what are the two most important reasons for you visiting this site today?** *Tick two*

Exercise □ See good scenery □ Get away from it all/tranquility □ Walk the dog □

Socialise □ Experience nature □ Education □  *Is a dog present? Yes □ No □*

**3. What are the two least important reasons for you visiting this site today?** *Tick two*

Exercise □ See good scenery □ Get away from it all/tranquility □ Walk the dog □

Socialise □ Experience nature □ Education □

**4. What was the best aspect of your visit (excluding the weather)?**

**5. What was the most disappointing aspect of your visit (excluding the weather)?**

**6. Have you visited this site in the previous two years?** Yes □ No □

**i) If yes, how has the site changed in quality?**

Large decline □ Slight decline □ No change □ Slight improvement □Large improvement □

**ii) in what way has the site changed?**

**7. How strongly do the following statements match your opinion?**

*1=Strongly agree 2=Agree 3=Neither agree/disagree 4=Disagree 5=Strongly disagree*

This site is important for:

1. nature conservation
2. recreation
3. carbon storage
4. food production
5. providing high quality drinking water
6. cultural heritage
7. reducing flood risk

**8. We are not asking you to do this but in principle:**

**a) how much time (if any) would you be willing to volunteer to help improve the Dark Peak NIA for plants and wildlife**

None □ Half day a month □ 1 day a month □ 2 days a month □ Over 2 days a month □

**b) how much money (if any) would you be willing to volunteer to help improve the Dark Peak NIA for plants and wildlife**

None □ £1-£5 a month □ £6-£10 a month □ £11-£15 a month □ Over £15 a month □

**9. How frequently do you visit this site?**

1st visit □ Daily □ 2-3 times a week □ Weekly □ Fortnightly □ Monthly □ less than monthly □

1. **How often do you visit the countryside in a typical month (including this site)?**

*If living in the countryside how frequently do you actively use it?*

Daily □ 2-3 times a week □ Weekly □ Fortnightly □ Monthly □ Less than monthly □

1. **How often do you visit urban green-spaces in a typical month?**

Daily □ 2-3 times a week □ Weekly □ Fortnightly □ Monthly □ Less than monthly □

**12. What is your home post-code? \_\_\_\_\_\_\_\_\_\_\_**

**13. How strongly do the following statements match your opinion?** *Please enter number 1 – 5*

*1=Strongly agree 2=Agree 3=Neither agree/disagree 4=Disagree 5=Strongly disagree*

1. I like this site
2. I feel peaceful when I am here
3. I’ve had a lot of pleasant memorable experiences here
4. I can easily think about personal matters when I come here
5. This site feels almost like a part of me
6. I look forward to coming to this site in the future
7. I am **not** satisfied with this site
8. I gain perspective on life when I come here
9. Coming here clears my head
10. Being here makes me feel more connected to nature
11. I feel happy when I am here
12. When I am here I feel part of something that is greater than myself
13. I do **not** gain pleasure from using this site
14. Lots of things at this site remind me of past experiences
15. When I am here, I feel strongly that I belong here
16. I will really miss this site when I am away from it for a long time

**14. Are you a member of a wildlife or conservation organisation?** Yes □ No □

If yes which ones (tick all that apply): National Trust □ Wildlife trusts □ RSPB □ Other

**15. Which of the following categories apply to you?**

Retired □ Unemployed □ Full-time education □ Full-time paid employment □

Part-time paid employment □ Self-employed □

**16. Which of these qualifications do you have?**

O level/GCSE or equivalent □ A level or equivalent □ Undergraduate degree □ Higher degree □ Other\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**17. What is the tax band of your household?**

No tax (<£8,105 taxable income) □ Basic rate (£8,105-£34,370) □

Higher rate (£34,371-£150,000) □ Top rate (£>150,000) □

**18. Which age category are you in?**

18 or under □ 19-25 □ 26-35 □ 36-45 □ 46-55 □ 56-65 □ over 66 □

**19. Please take a look at this card and choose one option that best describes your ethnic group or background**

**20. Respondent’s gender** Male □ Female □