Quantifying the Well-Being Benefits of Urban Green Space

Submitted to the school of Environmental Sciences at the University of East Anglia for the degree of Doctor of Philosophy.

On 12th September 2014

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Abstract

Rapid urbanisation compounded by underlying population growth has placed increasing pressures upon green space areas within cities. Anecdotal evidence suggests that such areas are major sources of wellbeing yet the complex nature of the services provided by such areas and the non-market, unpriced characteristics of the benefits they yield raise concerns that they are inadequately incorporated within decision making and planning systems. This thesis seeks to address the problem of quantifying the well-being benefits of urban green space through the extension of two complementary strands of research. The first seeks to contribute to the incorporation of urban green space benefits within conventional decision making systems. Within this strand of the research the authors report two studies designed to address various challenges associated with the estimation of economic values for the non-market benefits generated by urban green space. The first of these studies contributes to the literature on the estimation and transferral of valuation functions across locations to allocate available resources at an inter-city, national level. The second valuation study operates at an intra-city level through an experimental study the dimensions of which are designed to reveal optimal locations in the presence of potential local dis-amenities (a potentiality which is confirmed through the application of advanced statistical analysis techniques). The second strand of research addresses the complexities of relationships between urban green space and individual well-being. Here recent methodological advances in the field of applied social-psychology are extended to yield a richer picture of the diverse impact of both direct experience and passive viewing of green space upon wellbeing. An experiment is designed to permit enhanced controls for the potential correlation between environment and activity in determining experiential perceptions of well-being effects. A common theme of all applications is the explicit incorporation of spatial complexity and variation in the environment within each study and across the various methodologies employed. From a practical perspective it is argued that these results provide inputs to both the decision making and planning fields. More fundamentally, the work presented within this thesis represents a useful methodological contribution to both the applied economic valuation and social-psychology research literatures.

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List of Abbreviations

CVM: Contingent Valuation Method

DRM: Day Reconstruction Method

EMA: Ecological Momentary Assessment

GIS: Geographical Information System

NA: Negative Affect

ONS: Office for National Statistics

PA: Positive Affect

PANAS: Positive and Negative Affect Schedule

SWB: Subjective Well-Being

WTP: Willingness to Pay

Acknowledgements

This thesis could not have been completed without the help of my supervisor Prof. Ian Bateman, and my friends and colleagues. I would especially like to thank my mother, Rebecca Bogucki for teaching me everything I know.

Introduction

"It seems to me that the natural world is the greatest source of excitement; the greatest source of visual beauty; the greatest source of intellectual interest. It is the greatest source of so much in life that makes life worth living."

David Attenborough[1]

The natural environment is the ultimate source of human values and well-being, underpinning all economic, social and cultural activities. Today however the majority of the world's population live in urban areas (Heilig, 2012) increasingly alienated from the natural habitats in which the human race evolved. While an absence of nature is characteristic of modern urban environments the role that urban green spaces play as contributors to the well-being of urban residents has in the past been under-appreciated. Within this thesis various types of urban green spaces are examined, each being defined in its respective empirical chapter. Within this introductory chapter urban green space is defined as any natural features in the urban environment including parks, public gardens, allotments, domestic gardens as well as road side verges and street trees. This thesis examines different methods for quantifying the benefits that urban green spaces have on well-being. As such this Chapter provides information regarding the context of the research conducted including a discussion of the research area, the research aims, and an outline of how these aims are addressed in the following empirical research chapters.

1.1. Well-being and the Influence of the Urban Environment

Research into the influence of the environment on human health and well-being dates back as far as the ancient Greek physician Hippocrates of Cos (460-370 BC) who noted that "Airs, waters, places"[2] were all determinants of the diseases of a city's population. The arrival of industrialisation and the mass migration of rural workers into cities created changes in attitudes towards nature and health. As populations became increasingly separated from nature so green areas were increasingly juxtaposed as places of retreat and recuperation. The Romantic Movement highlighted the beauty and emotional experience of nature and expressed distain for urban sprawl and this coincided with efforts to bring nature into cities through the creation of public parks and gardens. Modern urban environments are characterised by high levels of stressors (such as noise and air pollution) and a paucity of natural features. Never in history have humans spent so little time in physical contact with plants and animals and the consequences for human well-being are poorly understood (Katcher and Beck, 1987). Existing research asserts that an excess of artificial stimulations and existing purely in human environments may cause exhaustion and produce a loss of vitality and health (Stilgoe, 2001) it is thus crucially important to understand the influence that everyday environments have on human well-being.

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[1] Nightingale, N. (2011). Wildlife Film-making: Looking to the Future. P. Warren (Ed.). Wildeye.

[2] A translation can be viewed at http://classics.mit.edu/Hippocrates/airwatpl.mb.txt

1.2. Evolutionary Theories for the Benefits of Nature

Before examining evidence for the positive effects of urban green space on well-being it is worth considering why natural features may benefit well-being. Numerous psycho-evolutionary theories have been proposed to explain how natural environmental features have a significant influence on well-being (see Hartig el al., 2011 for a review). Such theories focus on how evolutionary pressures have shaped human preferences and physiology which traditionally relied on the natural environment. The following section gives a brief overview of some of these theories.

The term Biophilia was first introduced by Eric Fromm (1964)[3] and later popularised by Wilson (1984) who defined it as 'the connections that human beings subconsciously seek with the rest of life' (pg.350). The theory relies on the observation that the rate of change in human living environments (particularly over the relatively recent past) has far exceeded that of human evolution through natural selection. The result being an evolved preference for the environment of human evolution over more recent man made environments.

Along the same evolutionary lines, Savannah theory (Orians, 1980) asserts that early humans assessed habitat suitability in terms of resource availability and protection from predators resulting in a preference for tropical Savannahs. Strong immediate emotional responses to good and bad habitats helped early humans effectively find suitable habitat. Some support has been found for an innate preference for Savannah type environments even for those who are unfamiliar with such environments (Falk & Balling, 2009; Balling & Falk, 1982). However conflicting results have been found with Han (2007) showing support for an alternative forest hypothesis.

Appleton's (1975) prospect refuge theory asserts that seeing without being seen would have been of primary importance to early humans and that this forms the basis of our affective response to the environment. In this theory the environment is analysed in terms of prospects, refuges and hazards. Here prospects are defined as either direct, being views of the landscape, or indirect prospects, being secondary vantage points from which further views can be obtained. Refuges offer shelter and places to hide from sight. Hazards can be animate (e.g. predators) or inanimate such as an obstacle to movement or the absence of the requirements for survival. The aesthetic experience of landscapes is thus influenced by the presence of prospect and refuge symbols. Prospect refuge theory is somewhat Gibsonian in the way in which it conceives of prospect and refuge affordances. Affordances are action possibilities that are defined by the latent physical information in the environment but are uniquely perceived by an agent relative to their capabilities and skills (Gibson, 1977).

Cognitive theories based on evolutionary adaptations to the rapid processing and acquisition of data from the environment have been proposed by Kaplan and Kaplan (1989). Such theories re cast the relationship between natural features and well-being in terms of an absence of the negative effects of the built environment. Here the information dense nature of urban

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[3] Fromm (1964) used the term Biophilia to describe attraction to all that is alive and vital.

environments impact on stress and attentional levels so that its absence results in stress recovery and restoration of the capacity for directed attention (Kaplan, 1995).

1.3. Evidence for the Benefits of Urban Green Space

Modern urban environments are a far cry from the Savannahs of our evolutionary past being characterised by high concentrations of potential environmental stressors (such as noise and air pollution) and an absence of natural features (such as plants and animals). Despite this dramatic change in everyday living environments the benefits that natural features in the urban matrix have for mental and physical well-being have been frequently documented (Ulrich, 1981, Kaplan & Kaplan, 1989). Proximity to green spaces may provide relieve from air pollution and the urban heat island effect (Whitford et al., 2001) and may also lead to people spending more time outside and being more physically active as a result. For example, the proximity of green spaces has been shown to influence levels of physical activity (Humpel et al., 2002). Kim and Kaplan (2004) suggested that natural features and open spaces play an important role in feelings of attachment towards the community and peoples interactions with other residents in residential areas. The apparent positive influence of green infrastructure on well-being has also been attributed to the stress ameliorating effects of viewing nature with evidence of improved attention functioning and emotional gains (Hartig et al., 1991) as well as lowered blood pressure in natural settings (Hartig et al., 2003). It has even been found that exposure to natural environments can be beneficial to children with attention deficit disorder (Taylor et al., 2001; 2009). It should be noted that experiences of natural areas are not always positive and when natural areas are overgrown or unmanaged they also have the potential to elicit anxiety caused for example by fear of crime (Kuo et al., 1998).

A range of psychological studies have attempted to measure the potential benefits of urban green space using an array of both direct and in-direct measures of individuals' well-being. Well-being is a complex multi-dimensional construct concerning optimal experience and functioning (Ryan & Deci, 2001). It is often used interchangeably (especially the communication of such research to the media) with the term happiness which for many represents but one component of well-being (Ryff, 1989; Ryan & Deci, 2001). For the most part research on well-being can be split into two contrasting perspectives; hedonic well-being and eudaimonic (or psychological well-being). The first rather concisely defines well-being in terms of what the 18th century philosopher Bentham referred to as the "sovereign masters" of pleasure and pain. Here well-being is achieved through the attainment of pleasure and the avoidance of pain. The second perspective, eudaimonic well-being, is attained through self-realisation of an individual's unique potential such that the person is fully functional. Ryff & Singer (2008) operationalise their measurements of eudaimonic well-being in terms of self-acceptance, positive relations with others, personal growth, purpose in life, environmental mastery and autonomy. Throughout this thesis the term well-being is used to refer to hedonic subjective well-being (SWB) which is defined by Kahneman (Kahneman et al., 1999) as the sum of positive and negative emotions an individual experiences over a set period of time. While numerous definitions and frameworks for quantifying well-being exist (see Chapter 2 for a more detailed discussion of definitions of well-being) operationalising well-being in hedonic terms is the most established method for measuring well-being with a large amount of research being conducted on the reliable measurement of hedonic subjective well-being much of which concludes that current measures provide sufficient reliability to be useful (Andrews & Whithey, 1976; Diener et al., 1985; Kahnemann & Flett, 1983; Krueger & Schkade, 2008; Steptoe et al., 2005).)

Observational studies have compared individual's self-reported well-being to various direct and indirect measures of exposure to urban green space. Kaplan (2001) studied six low-rise apartment communities and using verbal survey methods found that premises with natural elements in their views contributed substantially to resident's satisfaction with their neighbourhood as well as various aspects of well-being (including being at peace) in comparison to those with built views. Grahn & Stigsdotter (2003) used a questionnaire to measure the prevalence of stress related illnesses and their usage of different urban green spaces in Sweden. Results showed that regardless of individual characteristics i) those who visited green spaces more frequently reported fewer stress related illnesses and ii) access to a garden was decisive in mediating this relationship. Bjork et al., (2008) found that while Swedish residents generally had poor access to green spaces, access and recreational quality of natural environments was strongly associated with neighbourhood satisfaction and physical activity.

Experimental studies have drawn links between exposure to images of various environmental features and well-being. Ulrich (1981) exposed subjects to images of natural scenes containing water, natural scenes dominated by vegetation and urban environments without water or vegetation. The natural images were found to have a more positive influence on participant's psychophysiological states than the urban images. Berto (2005) tested the restorative effects of viewing photos of natural and urban scenes on participants who had been fatigued by performing an attention draining task. Only participants who were exposed to natural scenes improved their performance on the attention test when they repeated the test following exposure to the photos. White et al., (2010) used a collection of 120 photos of natural and built scenes to test the influence of visual exposure to water on preference affect and restorativeness ratings. Results showed that both natural and built scenes containing water were associated with higher preferences, positive affect and restorativeness ratings than those which did not contain any water. However the authors also noted that images of built environments containing water were rated just as highly as natural images containing water. Ryan et al., (2010) report an experiment in which participants were shown photos of either natural scenes or buildings, exposure to natural scenes was found to increase vitality (as measured on a subjective vitality scale). This empirical work supports the long held idea that including parks and other green spaces in the urban landscape provides relief from urban stresses as well as providing valuable restorative experiences.

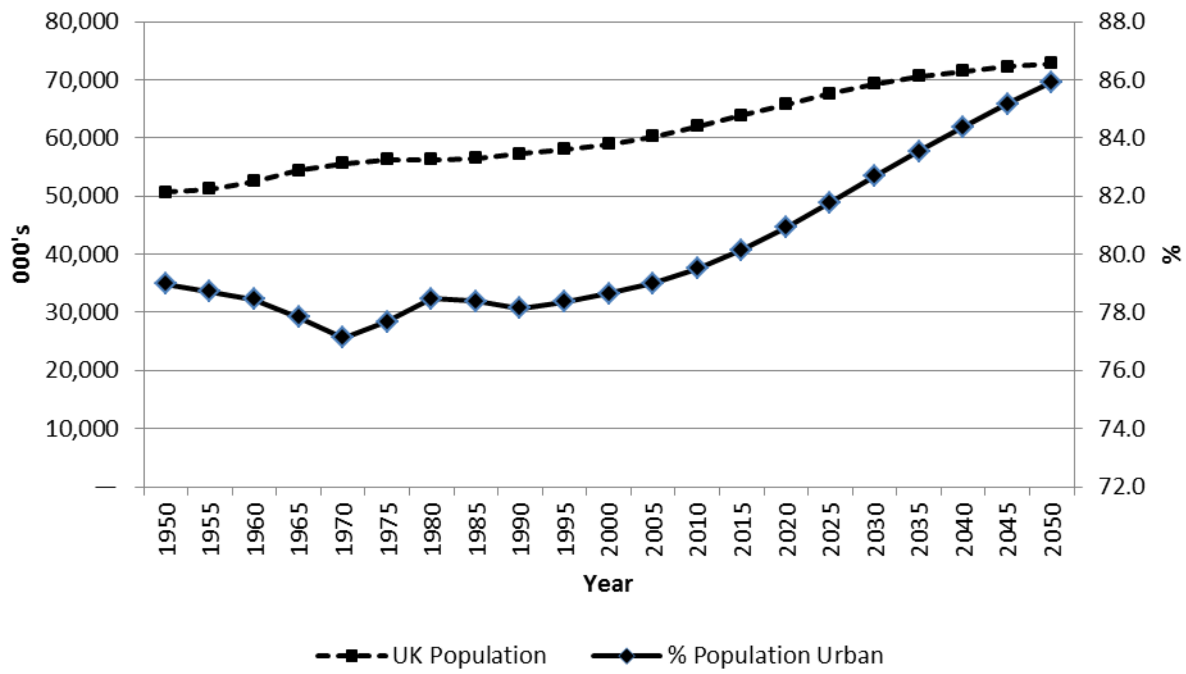
In addition to laboratory based experimental research, a range of studies have used short term interventions to test the influence of exposure to natural and man-made features on well-being. Such studies offer improved ecological validity compared to experimental studies which test relationships outside of the context in which they would usually occur. Hartig et al., (2003) exposed half of the subjects to attention demanding tasks before walking in a nature reserve or in urban surroundings; both attentional capacity and positive affect were found to increase for those in the nature reserve walk. Pretty et al., (2007) used participants in a green exercise program to show that self-esteem and mood disturbance improved following green exercise activities. Berman et al., (2008) compared the restorative effects of interactions with natural and urban environments using both photos and walking exposure treatments. Using attention demanding tasks the authors showed that both walking in nature and viewing photos of nature improved participants capacity for directed attention. Martens et al., (2011) investigated the potential difference in benefits that walking in a tended urban forest had compared to a wild forest. It was found that a greater change in affect was detectable for the tended forest exposure than the wild forest exposure. Several famous studies have used natural experiments to exploit existing exposure conditions such as those created by views from windows. Ulrich (1984) showed that post-operative patients who had views of nature from their hospital beds had shorter postoperative stays in addition to fewer negative evaluative comments from nurses and consumption of fewer pain killers. Kuo & Sullivan (2001) used a public housing estate to examine the effects that variations in nearby nature (trees and grass) had on levels of aggression and mental fatigue. Residents living in buildings with little nearby nature reported greater levels of aggression and mental fatigue than those in buildings with greener surroundings. Further it was shown that the relationship between nearby green and aggression was mediated by attentional functioning (mental fatigue).

1.4. The UK's Urban Green Spaces

Despite awareness within government of the many benefits that urban green spaces can provide (Natural England, 2010), the UK's parks and other urban green-spaces have been in decline. Between 1979 and 1997 10,000 playing fields were sold off for development (DCMS, 2009) and in comparison to post war levels (when allotments were at their peak) only 10% of the UKs allotments remain (Campbell & Campbell, 2009). Local authorities in England are not legally obliged to provide public parks, and as such they are rarely prioritised over other revenue generating activities and statutory services (CABE, 2006). Furthermore the absence of measures of the benefits that urban green spaces provide makes it difficult to justify both maintenance costs of existing parks and costs related to the creation of new parks. While today the UK is extremely lucky to have inherited a large number of philanthropic parks, today there is little space left to build large parks. This context of decline has been compounded by significant funding cuts for public parks and green spaces (estimated at £1.3 billion between 1979 and 2000) (NAO, 2006). Further cuts to local authority budgets as a result of the recent recession have resulted in a decrease in spending on open spaces by 10.5% between 2010/11 and 2012/13. Worryingly these cuts have been disproportionately distributed with much greater reductions in the North-East of the country (38.7% compared to 3.4% in the South East) (Drayson, 2013). Funding cuts have also resulted in the closing of government organisations charged with managing and promoting parks and public space. CABE Space and GreenSpace were closed due to a lack of funding and the new umbrella organisation the Parks Alliance, set up to fill the gap, has yet to define its remit or secure funding sources (Drayson, 2013). These cuts have contributed to a decline in the quality of public parks in the UK (Urban Green Spaces Taskforce, 2002). With surveys of local authority park and green space teams revealing that 80% expected quality standards to fall as a result of budget cuts (Urban Parks Forum, 2001). A case study of 11 residential areas in Merseyside UK found a loss of general green-space between 1975 and 2000 (Pauleit et al., 2005) with the main causes of loss being infill development (where gardens were developed for housing) and the conversion of derelict land for development.

Urban areas account for only 6.8% of the UK land area (covering some 1,663,700 ha) (Fuller et al. 2002) however approximately 80% of the population of the UK live in these urban areas (UN, 2012). Registered public parks cover only 52,243 ha of the UK (CABE, 2010), with both population growth and urbanisation projected to increase (see Figure 1.1) per capita access to parks and other urban green spaces can be expected to decline. Projections of urban growth from 1991 to 2016 estimate that 171,600 ha of rural land will be urbanised from 1991 to 2016 (Bibby & Shepard 1997). In addition the UK government has announced plans to increase the number of new residential developments to meet existing demands. The £570 million Get Britain Building investment fund together with incentives for local councils to increase the number of homes (New Homes Bonus) is set to increase the number of newly built homes in the UK to approximately 200,000 homes a year (Department for Communities and Local Government, 2011). New residential developments, the expansion of existing urban areas and the increased density of existing urban areas will require the creation of new parks and green spaces if the current levels of access are to be maintained. However while the development of existing urban and rural land for housing has a high market value the value that new urban green spaces offer is spread across many individuals so that no one individual has the incentive to create new green spaces. As a result the continual provision of urban green space benefits requires public provisioning, crucial to which is the measurement of the magnitude and distribution of their benefits.

Figure 1.1: UK population and percentage of that population living in urban areas from 1950 to 2050 (Source UN 2012).



1.5. Two Perspectives on Quantifying the Benefits of Urban Green Space

In order to secure the continual provision of the varied well-being benefits of urban green spaces it is essential that these benefits are understood and measured appropriately. This is particularly important in the case of the UK's urban green spaces which are unevenly distributed throughout the UK with accessibility lowest in the most densely populated inner city areas (Davies et al., 2011). Addressing this uneven distribution of access may help alleviate income related health inequalities as it has been shown that urban green space has a positive effect on perceived health (Maas et al., 2006) and populations which have access to greater amounts of urban green space exhibit lower levels of income related health inequality (Mitchell & Popham, 2008). As such this thesis explores two perspectives on the measurement of urban green space benefits. The first utilises the monetary valuation of urban green spaces via environmental valuation and the second takes a more direct approach, utilising recent developments in the measurement of subjective well-being. The following section gives an outline of these two perspectives.

In the first economic perspective, the benefits that non-market goods such as urban green spaces provide are operationalised in terms of utility. While the definition of utility has changed over time (see Chapter 2) today the term utility is used almost exclusively to refer to what is known as decision utility (Kahneman et al., 1997). Here utility is a measure of the well-being of individuals over time based on the preferences that an individual reveals through their choices. Within neoclassical economic theory preferences are understood to be the cognitive schema that determine, and are revealed by an individual's choices. This approach to measuring welfare underlies environmental economic approaches to valuing urban green spaces and other non-market goods. Such approaches include revealed preference methods such as hedonic pricing that use variations in the market prices of property to infer the value of related non-market goods. For example the price of a house may be influenced by its distance to the nearest park. The value of distance to the park can thus be inferred by examining how property prices change relative to changes in distance to the nearest park. A range of hedonic pricing studies have quantified the value of various urban natural features including forests (Garrod & Willis, 1992; Powe et al., 1997), wetlands (Doss & Taff, 1996) and urban green spaces in general (Morancho, 2003; Kong et al., 2007; Gibbons et al., 2014). Common alternatives to the valuation of environmental goods using revealed preferences are stated preference techniques such as the contingent valuation method (CVM). Here participants are required to state their willingness to pay (WTP) for public goods within a hypothetical market place, responses to well-designed CVM[4] surveys are used to derive economic preferences which are consistent with consumer theory (Champ et al., 2003). Such methods have the advantage of generating monetary valuations for changes in non-market goods which are highly compatible with economic decision making frameworks used in policy and decision making. As such they provide a common metric for the comparison of non-market goods with alternative projects that have well-defined economic values. Examples include Chen et al., (2006) who estimated the value of conserving urban green space in Hangzhou city China. They

[4] Note that the design of CVM's is crucially important and has been shown to influence WTP results.

found the majority of residents were concerned with the conservation of urban green space and were willing to pay additional taxes to ensure their protection. Breffle et al., (1998) used a CVM to estimate WTP to preserve an undeveloped parcel of urban green space in Colorado. Tyrväinen & Väänänen (1998) applied the CVM to small urban forest parks in Finland.

Both revealed and stated preference methods such as CVM produce monetary values for non-market goods thus making them highly compatible with existing decision making frameworks. However several problems with these economic methods have been identified. These include the fact that WTP is fundamentally constrained by an individual's budget, observations of context and framing effects (Bateman & Mawby, 2004; Bateman et al., 1995), anomalous disparities between WTP for public and private goods (Green, 1992) and the need to take care regarding the economic definition of the goods being valued (Powe and Bateman, 2003, 2004). One of the fundamental assumptions of this preference based conception of utility is that individuals are rational agents who always make decisions that will maximise their well-being, this assumption of rationality allows economists to avoid the question of what choices will be best for an individual's well-being as it assumed that the observable choices an individual make will always act to maximise their utility.

Several authors have questioned the application of a choice based utility model to responses to CVM surveys, expressing concern that responses to such hypothetical questions are better thought of as a reflection of attitudes rather than economic preferences (Kahneman & Ritov 1994; Kahneman et al., 1999). While proponents of the CVM approach have argued that inconsistencies in WTP response are the result of poor elicitation techniques and the use of open ended CVM questions (Arrow et al., 1993) its critics maintain that such inconsistencies are the result of CVM responses being more congruent to a psychological theory of attitudes rather than an economic theory of preferences. Even if CVM responses are considered to be economic preferences they may still be inconsistent and non-extensional and thus not compatible with an economic theory of choice utility.

While economic theory views preferences as extensional (Arrow, 1982) in the sense that they are grounded in the mutual exclusivity of the physical world, attitudes exist purely in the mind and thus often overlap and contradict each other. While preferences are highly contextual in the sense that they are grounded by real world experiences, attitudes may exist for affordances not yet experienced (and even never likely to be experienced) by the individual (including historic figures and abstract concepts). As such attitudes are considered to be positive or negative evaluative tendencies (Eagly & Chaiken, 1993) which are highly susceptible to framing and elicitation effects (Kahneman & Ritov, 1994). Attitudes are expressed as a very quick emotional response to a stimulus. Research in neuroscience has revealed that human cognition and emotion are intimately linked from the point of perception through to decision making and reasoning, rejecting the concept of functional localisation of emotion and cognition (Phelps, 2005, Pessoa, 2008). Several studies have found significant correlation between WTP responses and other affective evaluations suggesting that contingent valuation responses are more accurately viewed as expressions of attitudes than economic preferences (Kahneman et al., 1999).

Such choices may therefore reflect the anticipation of a certain affective state such as the pain of giving up something or may reflect a desire for social cooperation (Fehr & Fischbacher, 2003; Gintis, 2002). A further problem of using choice based measures of utility to measure the well-being of individuals is the existence of adaptation. In the face of adaptation individuals commonly fail to accurately predict their future hedonic state. This durability bias (Gilbert et al., 1998) means that individuals typically overestimate the durability that objective changes such as increases in income will have on their well-being. For example an often cited study found that the well-being of lottery winners a few months after their win were not significantly different from that of non-winners (Brickman et al., 1978). More fundamentally the monetary valuations derived from economic stated and revealed preference methods are constrained by an individual's budgetary constraint, so that only those with sufficient disposable income are able to express the decision utility they derive from the good being valued.

An alternative to the measurement of urban green space benefits with economic stated and revealed preference measures is to measure these well-being benefits directly through examining possible relationships between exposure to urban green spaces and measures of subjective well-being. This use of subjective well-being and specifically experienced well-being measures (Kahneman & Sugden, 2005) to quantify urban green space benefits represents the second perspective of quantifying these benefits that is explored in this thesis. In contrast to the ex-ante economic perspective of decision utility experienced well-being (or experienced utility) is an ex post concept, representing the hedonic experience that results from decisions (Kahneman & Sugden, 2005). As such the use of experienced utility measures can be seen as a return to Bentham's original definition of utility as the sovereign masters of pleasure and pain. While the initial Benthamite conception of utility was rejected there are several reasons for increased interest in measures of experienced utility which can be traced back to the observation that increases in wealth and economic progress have not resulted in increased happiness (Easterlin, 1995). In the UK wealth has doubled since 1970 but satisfaction with life has hardly changed, and 81% of Britons believe that the government should prioritise creating the greatest happiness and not the greatest wealth (Abdallah & Shah, 2012). The use of well-being as an indicator of social progress is also considered essential to achieving strong sustainability as it avoids automatically conflating progress and welfare with growth and consumption (Gowdy, 2005). This can be seen at both a national and international level with initiatives by the EU (Beyond GDP) (European Commission, 2009) and the OECD (Measuring the progress of society) (OECD, 2013). The UK government have announced the inclusion of general well-being measures in government official statistics (Matheson, 2011) as well as examining the use of well-begin measures in several government offices (i.e. Foresight Mental Capital and Well-being project, 2008; sutainable-development.gov.uk, 2007). Measures of experienced utility offer an alternative to measuring the benefits of environmental features using existing economic methods. This can be done either directly by examining the effects that variations in environmental features have on well-being or in monetary values by estimating the change in income which would produce a change in well-being of the same magnitude as that observed for the environmental features. Attempts to derive monetary values from well-being measures have consistently resulted in implausibly high values (i.e. Ferreira & Moro, 2010) as such the derivation of monetary values from well-being measures will not be investigated in this thesis.

1.6. Thesis Aims and Research Questions

It is clear that urban green spaces provide important benefits to well-being and that if these known benefits are to be maintained for future generations they need to be quantified to facilitate their inclusion in decision making and project planning. The aim of this thesis is thus to explore the application of both established economic methods for estimating the value of changes in public goods as well as more recent subjective well-being measures to quantifying the well-being benefits of urban green spaces. Through the use of spatial data and analysis techniques this methodological exploration promises to provide insights into how existing methods can be improved and how modern spatial techniques can facilitate the development of new methods for incorporating the environment into decision making. While economic and psychological perspectives may offer contrasting views on value applying them to explicitly spatial goods such as urban green space highlights the role that spatial relationships have in determining the received benefits of such resources. From these broad aims several research questions can be derived which guide this thesis:

1) How can economic and psychological methods of quantifying well-being be used to incorporate the environment into decision making and specifically to measure the well-being benefits of urban green spaces?
2) What role does GIS and the incorporation of spatial complexity play in both psychological and economic methods of quantifying the well-being benefits of urban green space?

1.7. The Case Studies

Given the need identified for quantifying the benefits that urban green space can provide this thesis reports two related strands of empirical work that attempt to measure the well-being benefits of urban green spaces. The first strand utilises the economic perspective outlined above which builds on existing methods to provide highly compatible monetary valuations of urban green space. The second strand utilises recent developments in subjective well-being measures in an attempt to measure the benefits of green space in an ex post manner through the use of experienced well-being measures. This section provides a brief outline of how the above research questions will be addressed in each of the subsequent empirical chapters.

This thesis begins, in Chapter 2, with a discussion of the history and development of research into both economic and psychological approaches to quantifying the benefits of urban green space. The theoretical underpinnings of each of these perspectives is discussed as is their relevance to existing decision making processes finally, the compatibility of these two perspectives is considered.

While environmental valuation in monetary terms is a mainstay of the cost-benefit analysis of environmental policy, the costs of conducting primary valuations can be prohibitive with the valuation itself often subject to cost benefit analysis. As a result of these high costs current valuations typically have very limited scope and thus limited policy relevance. Value transfer techniques promise to overcome these barriers to the widespread valuation of urban green spaces, a task which is taken up in the first[5] empirical study of this thesis (Chapter 3). In this study a highly cost effective methodology for creating large scale monetary valuations of urban green spaces through the use of spatially explicit value transfer techniques is demonstrated. In doing so this study addresses both of the research questions outlined above. Using both meta-analysis and spatial value function transfer techniques secondary data concerning both the value of urban green spaces, their spatial availability and distribution are combined to create for the first time nationwide valuations of the UK's urban green spaces. The spatial methodology demonstrated in this study demonstrates how Geographical Information Systems (GIS) can be utilised to analysis and handle large amounts of data from a wide range of sources. Creating valuations at this national scale represents a unique contribution to the literature and provides decision and policy makers in the UK with unrivalled information on the distribution and total value of urban green space in the UK. This allows decision makers to assess whether the government is providing enough green spaces nationally as well as being able to identify any gaps in provisioning at this larger scale. Through incorporating spatial analysis and secondary data sets into established economic methods this study addresses both of the research questions outlined above.

In Chapter 4 the exploration of economic methods for quantifying the benefits of urban green space continues. Building on the strengths of existing spatially facilitated CVM's advanced statistical techniques are deployed to value the creation of two new parks in the city of Norwich UK. These explicitly spatial techniques allow us to demonstrate how some of the common assumptions made concerning the spatial distribution of green space benefits do not always hold as well as the importance of other regarding motives in driving the strength of participants preferences for spatial goods. Through demonstrating the use of CVM methods within a research design explicitly designed to explore spatial relationships this study also addresses both of the research questions outlined above.

While economic methods allow us to produce measures of urban green space benefits that are highly compatible with existing decision making frameworks, their reliance on economic markets means that they may not be able to capture all of the potential well-being benefits of urban green space. As such the second strand of empirical work reported in Chapter 5 explores the use of SWB measures and specifically the use of experienced well-being measures to measure the well-being benefits of urban green space. This study attempts to overcome some of the problems associated with previous psychological studies by using an ecological assessment type method, the Day Reconstruction Method (DRM) (Kahneman et al., 2004), to collect experienced well-being data and relate this to objective and subjective measures of visual exposure to urban environmental features. Uniquely this study utilises global positioning systems (GPS) with high resolution spatial data to create objective personalised measures of

[5] Readers should note that the studies reported in this thesis were not conducted in the order in which they are reported. The study reported in Chapter 4 was actually conducted first (September 2009) followed by that in Chapter 3 (October 2010) and finally the work reported in Chapter 5 (July 2011). This achronological order was chosen by the author in order to create an impression of progression from conventional methods to the more novel.

visual exposure to urban green space which aim to reduce measurement error of indirect exposure measures. As such this study addresses both of the research questions of this thesis.

Finally in Chapter 6 the results of the three empirical studies are discussed with reference to the two research questions identified above. In addition to discussing the implications of this research to the measurement of urban green space benefits specific methodological implications of the research presented are discussed with a focus on the spatial techniques used. Numerous limitations and short-comings of this research are discussed in reference and in addition to suggestions of improvements and future research directions.

2. Perspectives on Measuring Well Being

2.1. Introduction

It has been shown in chapter one that urban green spaces can provide many benefits to the well-being of urban residents and a case was made for the measurement of these benefits to assist decision makers (policy makers) and ensure that these valuable resources are represented in project planning. In this chapter the theoretical bases for measuring the well-being benefits of urban green space using both economic valuation techniques and subjective well-being measures are examined. Research gaps identified in the development of environmental valuation techniques and subjective well-being measures will form the bases of the following empirical chapters. The UK policy relevance of research into subjective well-being is also considered, as well as the complementarity of economic and subjective well-being based approaches.

2.2. The Development of Environmental Valuation Research

Environmental valuation techniques were developed within environmental economics as a means to avoid the market failure that occurs when resources have significant economic values that have no market and thus no price. The absence of markets for environmental goods and services results in a failure to allocate these resources efficiently as the value they provide is ignored by decision makers and economic institutions. More often than not this conflict between the "conservation and conversion" of land for human capital results in the conversion of land, as the financial returns from conversion exceed those of conservation (Bateman et al., 2003). In this section the development of environmental valuation techniques is discussed and research gaps that will be addressed in this thesis will be examined.

Although the emergence of environmental economics is ascribed to the 1950s, when resource scarcity following WWII triggered the establishment of Resources for the Future (RFF), environmental economics as it is known today was not established until the 1960s when rising environmentalism was combined with economic theory of external effects (Pearce, 2002). Drawing on the work of Pigou (1920) the internalisation of externalities (that is, a detrimental or even beneficial effect to a third party of some activity) which has no price associated with them became a central goal of economics. The existence of externalities is thought to prevent economic systems from maximising well-being and as such intervention to internalise these costs or benefits e.g. to make a polluter pay for exposing a third party to pollutants was justified (Pearce, 2002). The first valuation method was developed in response to a request by the U.S. National Parks Service to establish the value of national parks Hotelling derived what is today known as the travel cost method (Hotelling, 1947). However consensus among the park service was that the value could not be estimated and thus the method was ignored until 10 years later when a study of recreation on the Feather River California (Trice & Wood, 1958) and work by Resources For the Future (Clawson, 1959) popularised the technique. In this revealed preference approach individuals preferences for a site are inferred from the costs they incur through travelling to the site. As different individuals face different costs by travelling varying distances these differential costs can be treated as prices allowing a demand curve to be constructed allowing the total consumer surplus to be estimated. In the travel cost method individuals preferences for a park or other public good are revealed through the choices they make in existing markets, this revealed preference approach to valuation is also applied in the hedonic approach to environmental valuation. Hedonic valuation utilises property prices to derive the value of various environmental characteristics by examining how prices change in relation to environmental characteristics while other known determinants of house prices are held constant. In this way hedonic studies can capture many of the well-being benefits provided by urban green spaces such as those stemming from the provision of recreation and leisure affordances and the visual amenity of viewing wildlife and natural habitats. The first to establish relationships between house prices and environmental characteristics was Ridker (1967) who looked at how air pollution influences property prices. Hedonic studies have been criticised for having narrow geographical scope and small sample sizes. An exception to this is Gibbons et al., (2014) nationwide assessment of the amenity value of natural habitats in England. Using 1 million housing transactions they estimated the value associated with proximity to a wide range of natural habitats and other natural amenities. They found that increasing distance to natural amenities was always associated with reduced housing costs.

Both travel cost and hedonic methods of valuation are examples of revealed preference approaches alternatively stated preference methods attempt to access an individual's preferences by directly asking them questions such as "How much are you willing to pay for….". While the idea of using questionnaires to elicit preferences was first suggested by Ciriacy-Wantrup (1947) again this suggestion was not taken up with the first contingent valuation studies appearing some 10 years later in 1958 (Mack & Myers, 1965). Stated preference techniques have been used extensively in environmental economics and have several desirable properties. The contingent valuation method (CVM) and other stated preference techniques such as choice analysis can elicit all the types of economic value relevant to a project or policy decision crucially this includes values that individuals who have no intention or means of using the resource may hold. These non-use values can only be measured using stated preference techniques as these non-use values have no "behavioural trail" (Krutilla, 1967). While the inclusion of non-use values in aggregated values has been highly controversial they are particularly important when considering resources which may be considered unique (such as the parks and green spaces considered in this thesis).

While the CVM approach uses willingness to pay (WTP) questions to ascertain the value an individual holds for urban green space benefits, in practice aggregate values are of greater relevance to decision makers. In order to aggregate these values both the size of the market for a particular good as well as the heterogeneity in values across that market need to be accounted for. While it is possible to sample every potential receiver of benefits for a particular good this is a costly procedure. Likewise simple mean based aggregations are possible but risk introducing significant error to such estimations. As such the intrinsically spatial natures of these benefits are being used to facilitate both individual and aggregate valuations of these benefits to a spatial scale relevant to policy makers. Here the decay of values with increasing distance from the spatial good (distance decay) can be used to estimate the economic jurisdiction of such goods as well as being used for the aggregation of benefits without the need to sample every potential beneficiary (Bateman et al., 2006). Previous studies have suffered from several problems; these include the level of spatial aggregation of natural features in the urban landscape. This results in the reduced accuracy of such measures which may vary over areas smaller than the areas of aggregation. Another potential problem with the spatial aggregation of environmental exposure measures is that of the Modifiable Areal Unit Problem (Openshaw, 1983) whereby variations in the scale at which spatial measures are aggregated result in different relationships between these measures and well-being.

While these (and other) valuation techniques provide a practical basis for estimating the monetary value of non-market goods, conducting valuations can be very expensive in the eyes of a policy maker. As a result of limited funds to conduct valuations environmental economists have had to get creative in devising cost effective means of deriving monetary values for non-market goods. One way in which this is achieved is to perform a value transfer (or benefit transfer) defined as the "application of values and other information from a 'study' site with data to a 'policy' site with little or no data" (Rosenberger & Loomis, 2000, pg. 1097). While there is no single methodology for value transfer studies, Bateman et al., (2000) identify three broad categories of value transfer, unit value transfer, adjusted unit value transfer and benefit function transfer. In its simplest form unit value transfer involves the transferral of unadjusted units of value, typically mean or median values are transferred. For example the OECD used this technique for several decades to calculate benefits for US recreational sites such as the amount of recreation activity over a particular time period or area (OECD 1994). Such techniques fail to account for differences that may exist between study and policy sites such as the socio-economic characteristics of populations around the two sites, differences in physical characteristics and differences in the market between the two sites (i.e. the availability of substitute sites). In some cases where the policy and study sites are similar these differences may not constitute a serious problem; however in many cases these units may need adjustment. These adjustments can take the form of expert judgements, such as those used for the controversial cost benefit analysis of the third London Airport (Willis & Garrod, 1994) and re-analysis of study data to identify sub-samples more suited for transfer. Such subdivision of study data relies on the initial sample size being large enough to be divided and can only be used to adjust for respondent related factors and thus cannot account for physical differences between sites. A more rigorous approach to adjusting valuations for transfer to policy sites comes from the use of meta-analysis. Meta-analysis is the statistical analysis of the results of existing empirical work in order to integrate their findings (Wolf. 1986), the results of a meta-analysis are likened to that of a narrative or qualitative analysis (van den Bergh & Button, 1997). For a meta-analysis to be successful it requires studies with well specified methodologies standard study designs and measurements so that these can be controlled for. As the results of a meta-analysis are based on prior empirical work there is a possibility of bias if studies with non-significant and negative results are under-represented in published journals. An example of the application of meta-analysis is Bateman et al., (2000) study of woodland recreation values. By regressing 77 estimates of per person per visit values derived from previous CVM and travel cost studies (conducted in Great Britain) against a number of variables thought to influence the estimated values including the valuation and elicitation method used, the year the study was conducted, and the type of values targeted in the study (i.e. use values or use and option values). This regression model was combined with estimates of visitor numbers to estimate the potential woodland recreation value for the whole of Wales.

An alternative to using adjusted or unadjusted unit transfers is to transfer the entire benefit function that has been estimated for the study site to the policy site. When transferring values for recreational sites this avoids the need to estimate visitor numbers using a separate demand function. In principle transferring benefit functions should create more reliable transfers as function transfers can directly account for both site and user characteristics as well as effectively transferring the assumptions made for the original site to the policy site (Loomis, 1992). Previous attempts at value function transfers have been hindered by a lack of understanding of spatial aspects that determine both the value and demand for certain sites (Bateman et al., 2002).

Value transfer techniques have been subject to numerous tests of the convergent validity of transferred means and model coefficients (Downing & Ozuna, 1995; Kirchhoff et al., 1997; VandenBerg et al., 1995). While results of these and other tests do not show strong support for the accuracy of value transfers it is generally the case that function transfers offer greater accuracy and reliability than unit transfers. Despite this lack of strong support for the feasibility of value transfer practitioners have persisted and the question of how accurate transfers need to be has thus been raised. In response to this question Fillion et al., (1998) suggest that the degree of accuracy depends on how the results will be used suggesting a continuum of accuracy based on the costs of making a wrong decision based on the transfer results. For example if results of a transfer is used to determine appropriate compensation in the case of a natural disaster then the costs of a wrong decision could be high and thus the required accuracy is also high. In the case of policy decisions that could lead to irreversible losses of environmental resources (such as primary habitats or endangered species) the costs of making the wrong decision could be so high that expenditure on a primary valuation study would be justified (Filion et al., 1998).

Despite these problems value transfer offers many benefits for policy and decision makers and is a promising means to overcome the barrier of cost that prevents more primary valuation studies from being conducted. In addition value transfer techniques make it possible to expand the spatial scope of existing valuation studies to improve the relevance to policy making at a nationwide scales. The first empirical study of this thesis reported in Chapter 3 thus demonstrates a cost effective method for creating large scale valuations of urban green spaces. Through the use of spatially aware benefit transfer techniques and secondary data concerning both the value of urban green spaces and their spatial availability and distribution this study presents a unique contribution to the literature providing for the first time nationwide valuations of the UK's urban green spaces. This study forms part of the UK National Ecosystem Assessment, the first comprehensive analysis of the benefits to society that the UKs natural environment provides. The need for such an analysis was motivated by findings of the global Millennium Ecosystem Assessment (MA) (Millennium Ecosystem Assessment, 2005) which highlighted the importance of ecosystem services to human well-being and showed that many key services provided by the natural environment are being degraded. The House of Commons 2007 environmental audit recommended that the UK government should conduct a full MA type assessment of the UKs natural habitats to facilitate the development of policies to respond to the degradation of ecosystem services (House of Commons Environmental Audit, 2007). The intention of the UK NEA is that it will help to inform decisions to ensure the long term delivery of ecosystem services, including the benefits stemming from urban green space.

As such providing valuations at this national scale promises to inform decision making at both national and more local scales. Total values allow decision makers to assess whether enough green spaces are being provided nationally as well as being able to identify any gaps in provisioning at this large scale. The use of explicitly spatial benefit function transfer techniques allows us to overcome limitations of past transfers to account for spatial determinants of demand (Parsons & Kealy, 1994; Loomis et al., 1995).

A common theme amongst all of these valuation methods is the importance of space in measuring and estimating the benefits of public goods. While the importance of space was first recognised by Hotellings (1929) today developments in GIS (and computing technology generally) have resulted in space playing an increasingly important role both in terms of including spatial dynamics in the valuation and aggregation processes and the availability of spatially referenced data on characteristics of the population and the availability and distribution of non-market goods. The observation that WTP values decrease with increasing distance from the good being valued has facilitated the construction of spatially sensitive value functions for the aggregation and transfer of non-market values (e.g. (Bateman and Langford 1997; Pate and Loomis 1997; Bateman, Day et al. 2006). While this distance decay relationship is often presumed to be linear and non-decreasing hedonic pricing studies have found quadratic or inverted U shape relationships with proximity to a range of goods such as schools, transport hubs and shops (Day et al 2007). In the case of urban green spaces problems with crime and anti-social behaviour (CABE, 2004) may result in local disammenities and thus non-linear distance decay relationships. The second empirical study of the economics strand of this thesis, reported in Chapter 4 investigates these spatial dynamics using a study design specifically designed to investigate the influence that spatial positioning of urban green spaces has on WTP values. In addition to investigating distance decay relationships this study examines the role that attitudes have in determining WTP values for two hypothetical parks in the city of Norwich.

2.3. The Development of Research into the Measurement of Subjective Well Being

The concept of well-being broadly concerns the optimal functioning of an individual. While every day individuals show concern and interest for each other's well-being through enquiries such as "how are you?" defining optimal functioning and well-being has been a subject of intense debate for as long as academics have put pen to pencil. Within this debate two broad perspectives can be identified the hedonic (Kahneman et al., 1999) and eudaimonic (Waterman, 1993). Both views of well-being have a long history with Aristippus (a Greek philosopher from the 4th century B.C) being credited as the first hedonist. A student of Socrates, Aristippus strayed far from Socrates in both his views and lifestyle. He taught that seeking pleasure through adapting circumstances to oneself and by maintaining control over adversity and prosperity was the goal of life. Today psychologists who have adopted a hedonic perspective of well-being generally consider well-being to include pleasures of both the mind as well as the body moving beyond physical hedonism by encompassing all judgements about good and bad elements of life including goal fulfilment or valued outcomes (Diener et al., 1998). The second major school of thought, which can be traced back to Aristotle, is that of eudaimonic or psychological well-being (PWB). Aristotle's Nicomachean Ethics (Höffe, 2010) defines eudaimonic well-being as the realisation of ones daimon (or true nature). For Aristotle simply satisfying appetites and desires was a vulgar idea instead Aristotle promoted the pursuit of virtuous activities, with virtuous activities being self-realisation in accordance with an individual's unique disposition or talents. A translation of Aristotle's concept of eudaimonia is offered by Waterman as "the feelings accompanying behaviour in the direction of, and consistent with, one's true potential" (Waterman, 1984, pg.16).

While discussion around what humans should strive for have been the subject of philosophical and theological study since ancient times the subject of positive well-being was for a long time ignored by psychologists who favoured the study of psychological dysfunction (Myerrs & Diener, 1995). In his review of research on the characteristics of happy individuals Wilson, remarked on how few advances in the theory of what constitutes a happy life has not advanced since the ancient Greeks (Wilson, 1967). This changed with the rise of humanistic psychology (roots in Socrates) in the 20th C which emphasised human well-being and creativity. At the same time the behavioural revolution meant that empirical investigations of subjective well-being began as early as 1925 with Flugels investigation of feelings and emotions in everyday life (Flügel, 1925). Today research into well-being is a huge area in both psychology and economics. It is no surprise that increased interest in well-being coincides with periods of relative affluence as observations that material security and luxury do not necessarily increase well-being become more prevalent. Throughout this thesis the term subjective well-being (SWB) will be used to refer to the variety of self-report measures that attempt to capture an individual's cognitive and affective evaluations of their own life (Diener et al., 2002). While subjective well-being measures have emerged from and are fundamentally psychological, the term psychological well-being, while useful as juxtaposition to economic measures is avoided in order to avoid confusion with the use of the term to refer to modern interpretations of eudaimonic well-being (i.e. Ryff & Singer, 2008).

Today researchers frequently use a variety of self-reported measures of subjective well-being to investigate a wide range of issues. Some have commented that subjective well being (SWB) is better thought of as general area of scientific interest rather than a specific construct as there are no agreed upon definitions or boundaries (Diener et al., 1999). These measures of subjective well-being inevitably involve an individual making subjective evaluations of the extent to which an individual thinks and feels that their life is going well (Diener el al., 2009). SWB measures can be broadly categorised as either cognitive or affective valuations, and are generally well encompassed within the three major components of, global life satisfaction judgements, domain satisfactions and individuals' immediate (or online) emotional or affective evaluations (Diener et al., 1999). Early studies of SWB utilised simple single self-report items to measure cognitive evaluations of global judgements of life satisfaction. For example Andrew and Withey (1976) asked respondents "How do you feel about your life as a whole?" providing respondents with a 7 point Likert scale ranging from "delighted" to "terrible". This early research focused on determining individual characteristics that correlate with high levels of well-being. For example Wilson (1967) found that being young, healthy, well-educated, well-paid, extroverted, religious, having modest aspirations and being married were all associated with high well-being. Many of these early findings that focused on demographic correlates have since been overturned with psychologists shifting their focus to psychological factors including personality (Costa & McCrae, 1980), coping strategies (Gross & John, 2003) strong social relationships and the availability of resources to aid goal progression (Diener et al., 1999). As research into subjective well-being progressed, multi-item scales offering improved reliability and validity than single item scales began to appear. The satisfaction with life scale (Diener et al., 1985) captures cognitive evaluations of life satisfaction with 5 items including “In most ways my life is close to my ideal”, “I am satisfied with my life”, “If I could live my life over, I would change almost nothing”. This scale has been shown to have high internal consistency and high temporal reliability (Diener et al., 1985) and to converge well with peer reported measures of subjective well-being and life satisfaction (Pavot et al., 1991). For example Lucas et al., (1996) showed that multi-item life satisfaction, pleasant affect, and unpleasant affect scales formed separable constructs from each other as well as other constructs such as self-esteem. Pavot & Diener’s, (1993).

In contrast to these cognitive measures of subjective well-being, which require an individual to consciously evaluate their life, affective measures involve an individual’s evaluation of their current mood and emotional state (affect). Affect is subsequently broken down into positive (PA) and negative (NA) components, it was recognised early on that PA and NA form two independent factors that should be measured separately (Bradburn & Caplovitz, 1965). With positive and negative moods being associated with different classes of variables with NA (but not PA) related to self-reported stress and frequency of unpleasant events (Clark & Watson, 1986; Stone et al., 1985). In contrast PA (but not NA) has been found to be robustly related to social activities (Clark & Watson 1988). Affective measures of SWB typically contain multiple items for example the Positive and Negative Affect Schedule (PANAS) measures PA and NA by asking respondents to indicate to what extent (over some temporal period) they had experienced a range of emotions (in the form of affect adjectives such as “interested”, “proud”, “afraid” and “scared”) on a 5 point Likert scale ranging from, ”very slightly or not at all” to “extremely” (Clark, & Watson, 1988). Using 10 items (affect adjectives) for PA and NA PANAS has been shown to offer good divergent and discriminant validity, and excellent reliability (Clark, & Watson, 1988; Ostir et al., 2005). Several studies have found more consistent associations with affective state and biology when affect is measured over the course of a day compared to global retrospective reports (Bhattacharyya et al., 2008; Steptoe et al., 2007).

There is clearly a wide range of SWB measures that can be used to directly measure the benefits of urban green space. While previous studies have used both cognitive and affective SWB measures to directly measure benefits of natural features in the environment (Leather et al., 1998; Kaplan & Kaplan, 1989; Ulrich et al., 1991) several methodological challenges exist in this approach. Satisfaction type measures of SWB have been shown to suffer from retrospective and recall bias’s (Fredrickson & Kahneman 1993; Redelmeirer & Kahneman, 1993; Schreiber & Kahneman, 2000; Robinson & Clore, 2002) and may also fall fate to durability bias (Gilbert et al., 1998) if an appropriate temporal scale is not chosen. In addition the measurement of exposure to natural features is an area in which significant improvements can be made. Previous observational studies have struggled to make direct measurements of exposure to environmental features, instead relying on indirect measures which may not reflect individual’s actual experiences of their environments, while experimental and quasi experimental studies which have been able to control exposure in laboratory type conditions suffer from a lack of ecological validity (Hartig et al., 2003; Berman et al., 2008).

An alternative to the use of retrospective SWB measures through surveys or the assessment of emotional experiences over a certain time period, is to measures affect in real-time using ecological momentary assessment (EMA). EMA studies typically use portable electronic devices (increasingly mobile phones) to collect affect ratings from individuals in real time as they go about their everyday activities. Such assessments of mood and experience are considered the gold standard of mood assessment as recall and heuristic biases are minimised while ecological validity is maximised (Shiffman et al., 2008). However EMA studies place a large burden on participants (which makes them unsuitable for certain occupational groups) and as with environmental valuation implementation can be very costly. A cost effective alternative to EMA, the day reconstruction method (DRM) has been proposed by Kahneman et al., (2004). Building on EMA techniques the DRM uses a diary style questionnaire to facilitate the retrospective recall of an individual's affective state as a continuous series of personally meaningful episodes. Through collecting additional information on the onset, duration, location and activities of everyday episodes the accuracy of emotional recall is improved (Robinson & Clore, 2002). The DRM has been compared to established EMA methods and found to provide reliable estimates of affect intensity and variation (Dockray et al., 2010) and offer reasonable test-retest reliability (Krueger & Schkade, 2008).

As such the DRM offers an effective means of investigating numerous different influences on well-being including the experience of pain (Krueger & Stone, 2008), the influence of work on well-being (Kopperud & Vitterso, 2008), personality (Srivastava et al., 2008), behaviour (White & Dolan, 2009) and depression (Bhatacharyya et al., 2008). The DRM requires participants to reconstruct the previous day as a series of personally meaningful episodes using a reflective diary to aid participant's recollections of the previous day. This episode based method of recollection helps reduce biases typically encountered in retrospective reports (Kahneman et al., 2004).

The DRM is particularly suitable for investigation of the influences of urban green spaces on well-being as it combines the collection of experienced well-being data with time use data allowing us to control for potential correlations between activities and environments which could potentially confound such attempts. In an attempt to overcome the problem of reliably measuring exposure to urban green spaces Chapter 5 combines experienced well-being data with both objective and subjective measures of visual exposure to both natural and built features in the urban environment. In order to create objective measures of exposure to environmental features this study uniquely utilises global positioning systems (GPS) with high resolution spatial data to create objective personalised measures of visual exposure to urban green space which aim to reduce measurement error of indirect exposure measures. The use of experiential measures of both exposure and well-being aims to improve the ecological validity of previous experimental and quasi-experimental studies which while able to control exposures and make more direct measures of experiential well-being fail to reflect everyday experiences and may well suffer from a focusing illusion (Diener et al., 1999; Kahneman et al., 2006).

2.4. Well-Being in UK Politics

In the UK well-being has become increasingly prominent in politic, this was clearly expressed by David Cameron's announcement in 2010 that the UK Office for National Statistics (ONS) was to start measuring the well-being of the nation. The aim of the ONS's Measuring National Well-being Programme is to produce accepted and trusted measures of the nation's well-being which can be used by both the public and government to monitor understand and improve well-being. A national debate (held between November 2010 and April 2011) helped to create an initial list of national well-being domains and measures which were subject to a public consultation between October 2011 and January 2012. These measures have been subject to further refinements resulting in a set of published measures in September 2013 (ONS, 2014). The origins of this well-being agenda can be traced back to the previously mentioned Easterlin Paradox and a slow acceptance that pursuit of GDP (gross domestic product) growth and increases in national income do not equate to increased well-being in the population (Bache & Reardon, 2013). Bache & Reardon (2013) trace high level political interest in well-being back to Tony Blair's labour government an initial report from Blair's strategy unit triggered which released several reports focused on both the governments influence on well-being and Donovan & Halpern's (2002) report suggested that government activities directly influenced life satisfaction and that state intervention to boost life satisfaction was thus justified. The use of well-being indicators to complement existing economic approaches to policy appraisal may have transcended the left right divide in UK politics, whether this will have lasting policy effects is yet to be seen (Bache & Reardon, 2013). It is clear that the time is ripe for the deployment of methods for quantifying well-being benefits of public goods, this opportunity should not be limited to the use of SWB measures in this context as environmental valuation methods share similar objectives to the well-being agenda in terms of attempting to improve the well-being of the population through making better public decisions.

2.5. The Compatibility of the Economic and Subjective Well-Being Perspectives to Quantifying Urban Green Space Benefits

While it is not within the scope or aims of this thesis to assess whether one of these two perspectives is better than the other, in this section the theoretical basis for these two perspectives is examined and the differences and compatibility that these two perspectives exhibit when applied to quantifying the benefits of urban green space.

As alluded to in Chapter 1, monetary valuation techniques utilise the concept of utility to measure the many and wide variety of benefits that individuals derive from urban green spaces and other public goods. The term utility is highly divisive yet somewhat elusive in economics, this maybe because it's meaning has changed over time. In its original conception, derived from Bentham, utility was interpreted in hedonic terms that is, as a measure of pleasure and pain. This idea of utility as a measure of hedonic well-being was illustrated through Irish economist Edgeworth's (1881) suggestion of an idealised device for measuring well-being. The "hedonimeter" would continually measure the amount of pleasure and pain experienced by an individual, such a device would be able to measure an individual's well-being for any given period. Of course no such device exists and for the past 100 years economists have used the term utility almost exclusively to refer to preference based or decision utility (Kahneman & Sugden, 2005). In this decision based utility framework utility represents an individual's "wantability" (Fisher, 1918), that is revealed by the observable choices an individual makes. Here the well-being individuals derive from goods and services is measured in terms of the extent to which an individual's preferences are satisfied (Dolan et al., 2008). Central to this preference based approach to utility is rational choice theory (Sugden, 1991). Rationality in economics refers to the assumption that an individual acts to balance costs against benefits in order to maximise their personal advantage (Friedman, 1953). This assumption of rationality allows preference based theories of utility to overcome the normative problem of what choices people should make and what desires they should follow. Crucially this allows economists to assess the welfare consequences of institutions and policies without addressing the issue of how these may empirically influence well-being and thus avoids the normative judgements of what actually makes people happy. This shift from the initial Benthamite conception of hedonic utility to preference based utility was a result of the positivist revolution at the start of the 20th century which rejected the subjectivity of experience in favour of the objectivity of observable choices (Kahneman & Sugden, 2005). The combination of utilitarian ideas with the theoretical assumption of rationality has allowed utility to be treated as a representation of choice in formal analysis and informally as a measure of pleasure.

The use of SWB measures (and particularly experienced well-being) to assess decisions and policy can be seen as a return to Bentham's original definition of utility as the sovereign masters of pleasure and pain. By equating experienced well-being with hedonic (or experienced) utility researchers are attempting to create measures that overcome some of the problems associated with decision based utility measures. These include the existence of hedonic adaptation to changes in circumstances (Frederick & Loeweinstein, 1999) which can result in errors of hedonic forecasting (e.g. future tripping). The principle of adaptation is demonstrated by the maxim "Nothing in life is as important as you think it is when you're thinking about it" (Schkade & Kahneman, 1998). This increased interest in measures of experienced utility which can also be traced back to the observation that increases in wealth and economic progress have not resulted in increased happiness (Easterlin, 1995). In the UK wealth has doubled since 1970 but satisfaction with life has hardly changed, and 81% of Britons believe that the government should prioritise creating the greatest happiness and not the greatest wealth (Abdallah & Shah, 2012). The use of well-being as an indicator of social progress is also considered essential to achieving strong sustainability as it avoids automatically conflating progress and welfare with growth and consumption (Gowdy, 2005). This can be seen at both a national and international level with initiatives by the EU (Beyond GDP) (European Commission, 2009) and the OECD (Measuring the progress of society) (OECD, 2013).

Assessing the benefits of urban green space using experienced utility measures differs significantly from assessments which utilise environmental valuation techniques. The former is concerned with the hedonic experience of an outcome (ex-post) while the latter is concerned with the desire or want for a certain outcome (ex-ante) (Dolan & Kahneman, 2007). The difference between these two measures of value essentially boils down to whether the well-being consequences of individual's choices is considered or not, a normative issue which as mentioned above is overcome in preference based utility theory through the assumptions of rational choice. As mentioned above the theoretical differences between experienced and decision utility lies in the temporal frame of reference (i.e. ex post or ex ante) if it were possible for individuals to perfectly predict the well-being outcomes of their choices (hedonic forecasting) then the two measures would be in approximate correspondence. However the presence of adaptation to ones circumstances (Fredrick & Loewenstein, 1999) and the existence of focusing illusions result in systematic failures of hedonic forecasting. In terms of economic sources of well-being adaptation to increases in wealth and income have become known as the hedonic treadmill. Here individuals presume that earning more money will increase their well-being, however adaptation to these increases in wealth result in no net gains in well-being. Several mechanisms of adaptation have been identified including changing standards of evaluation and the redeployment of attention (Kahneman & Sugden, 2005). Numerous studies have provided evidence of adaptation. For example Kahneman & Snell, (1990) repeatedly exposed students to a mundane experience who were asked to predict their future ratings of the same experience. Comparing these predicted ratings to those of the actual experiences revealed that the overall correlation between actual and predicted changes in the ratings was close to zero demonstrating how the participants had no understanding of how future experiences would be experienced. One study of focusing illusions asked student participants about their general life satisfaction and the number of dates the respondent had been on in the recent past. If the life satisfaction question was asked the weak negative correlation between the two responses was observed, however if the date question was asked first a strong positive correlation was found (Strack et al., 1988).

In light of these failures to adequately predict the hedonic experience of choices and circumstances humans cannot be relied upon to make decisions that maximise their well-being. Alternative measures based on an experienced utility framework that avoid these issues have been proposed including satisfaction based (cognitive) measures of SWB. The problem with using life satisfaction measures is that people may not know how satisfied they are and in an attempt to answer such questions have to rely on heuristics that may have nothing to do with their experienced utility. For example social pressure to achieve in life may make it difficult for people to admit that they have failed to lead a satisfied life. More practically the use of satisfaction measures to guide policy is problematic due to the difficulty of establishing statistical relationships between broad measures of satisfaction and specific factors. This has been demonstrated by van Praag & Baarsma, (2005) who showed a statistically significant relationship with air craft noise and satisfaction for people living close to the main airport in The Netherlands. However it is unlikely that smaller scale influences such as the presence of street trees will be able to be disentwined from the wealth of other influences using these broad measures of well-being (Kahneman & Sudgen, 2005). The alternative to using satisfaction based measures to approximate experienced utility is to measure experienced well-being, instead of asking people to assess their overall well-being or satisfaction the quality of individuals actual hedonic experience is assessed moment by moment in the course of their everyday lives. As outlined above these moment based affective ratings of SWB can be measured using ESM or in the case of this thesis DRM techniques. The use of experienced well-being measures such as those captured by the DRM reduce the chances of focusing illusions as participants evaluate the overall affective experience of personally meaningful episodes so that their attention is not drawn towards particular sources of positive or negative well-being, or influenced by the researcher.

There are emergent differences between these two perspectives when they are applied to measuring benefits of environmental resources such as those stemming from urban green spaces. These include the type of environmental resources they can usefully be applied to, and the policy recommendations that they produce. While decision based utility measures such as those used in contingent valuation have been used to value parks and other open access green spaces as is the case with satisfaction based measures of experienced utility they may not be suitable to less visible areas of green space such as street trees and road side verges. Here experienced utility measures are more suited as they can be discretised into moments which due to there specific temporal and spatial references are more conducive to isolating there influence on well-being. While such resources may be less visible there effects on the overall appearance of urban areas and thus individual's experience of these areas may make them a significant source of benefit and thus highly relevant to policy analysis. Of course it may well be the case that experienced well-being measures are less suited to measuring the benefits of parks and large open access green spaces as they provide significant benefits in the form of option and non-use values which will not be captured in experiential measures. Monetary valuations are highly compatible with existing decision making frameworks such as cost benefit analysis however this limits there policy implications to the market in that they can only be used to compare to other goods or services with established prices. In contrast experienced well-being measures can be used to measure policy effects on well-being directly without having to rely on prices (which may not be a perfect reflection of value) making them potentially more applicable to areas of policy concerned with public health and welfare. Finally the application of experienced well-being measures, being an ex-post concept, promises to give a more accurate picture of the well-being benefits that individuals actually gain when exposed to urban green spaces rather than the benefits they expect to receive, thus avoiding the problems of affective forecasting identified above. Of course practically applications of this approach can be quite cumbersome and intensive when compared to say CVM, requiring the comparison of experiences under different experimental or exposure conditions. In contrast CVMs can be implemented by way of questionnaires making them less intrusive.

In summary several research gaps can be identified from the economic and psychological literatures which have inspired the research conducted in this thesis. While environmental valuation techniques have been used for some time now and are highly compatible with existing decision making frameworks they can be extremely costly to implement, and have only just began to take advantage of spatial data and analysis techniques. As discussed above benefit transfer techniques have been developed out of a need for more cost effective means of bringing the environment into policy and decision making. In Chapter 3 these techniques are combined with large spatial data sets to demonstrate how the spatial scale and thus policy scope of traditional transfer techniques can be expanded. The spatial relationships that are often core to benefit transfer and stated preference techniques such as distance decay relationships are often taken as given, however in Chapter 4 we consider the possibility of more complex relationships between distance and WTP for urban green spaces. While measures of subjective well-being have been around for a long time there application to the measurement of urban green space benefits presents several methodological challenges. This has resulted in previous studies being hampered by either a lack of ecological validity or a failure to ascertain direct measures of exposure to environmental features. In Chapter 5 both of these challenges are addressed through the use of advanced spatial measures of personal exposure and experiential measures of subjective well-being.

3. Perspectives Valuing Great Britain's Urban Green Space: A GIS Based Benefit Transfer Study of the Value of Urban Green Space

3.1. Introduction

This chapter outlines a research project done as part of the UK National Ecosystem Assessment (NEA) done in collaboration[6] with Grischa Perino, Andreas Kontolean and Ian Bateman[7]. A meta-analysis of UK green-space valuation studies is used to construct spatially sensitive value functions concerning the benefits of urban green-space. These value functions are then applied to five case study cities using high resolution spatial data concerning the location and size of green-spaces in these cities. Six policy scenarios devised as part of the UK NEA are then used to calculate the changes in the monetary value of urban green-spaces under different future visions. The findings from these case studies are then used to extrapolate the analysis to all urban areas in Britain with populations over 50,000 applying the same 5 NEA scenarios. As such this study demonstrates a new cost effective application of existing economic approaches through the use of spatial analysis techniques and thus involves both of the research questions outlined in Chapter 1.

3.2. Background

Urban parks and other green-spaces are an essential part of the urban environment, they have long been recognised as a source of value for city dwellers providing aesthetic pleasure and recreational affordances that are otherwise unavailable in an environment dominated by buildings and privately owned land. The benefits of urban green-space include both on site and off site benefits in addition to passive benefits including the aesthetic benefits of viewing green-spaces, reductions in air and noise pollution and the provision of habitats for biodiversity (Ulrich, 1986; Whitford et al., 2000; Bolund & Hunhammar, 1999; Jim 2004). They also include cultural benefits including the preservation of history and memorials and they bring aesthetic value to the landscape, providing visual diversity and increasing the imagibility of cities (Lynch, 1960).

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[6] My contributions to this research have been significant, responsibility for the design of this study was shared equally between myself and Grischa Perino and while Grischa conducted the meta analysis I was responsible for conducting all of the spatial analysis. As such my contribution amounts to approximately 50% of the work conducted.

[7]This research also appears in (see Appendix 3.1) : Perino, G., Andrews, B., Kontoleon, A., & Bateman, I. (2014). The value of urban green space in Britain: a methodological framework for spatially referenced benefit transfer. Environmental and Resource Economics, 1-22.

Within the urban habitat the term 'green-space' can refer to various urban land use types including natural and semi-natural places (e.g. woodlands, SSSIs and grasslands) areas with street trees and roadside verges, public parks and other formal green spaces, domestic gardens and cemeteries and church yards. All of these green-spaces can have an influence on well-being through the goods they supply. Even though the area of urban green-space is relatively small compared to the extent of other natural land uses outside of the urban environment its proximity to the large majority of the population make it extremely influential and thus potentially highly valuable in terms of the contribution it makes to urban residents well-being. Indeed the reported stress reducing effects of contact with natural features may be particularly beneficial to urban residents for whom stress is a part of daily life (van den Berg et al., 1998).

Whilst parks and other formal recreation green-space afford unique activities and experiences not possible in the rest of the urban environment they also provide valuable regulating services in terms of the abatement of air and noise pollution (Whitford et al., 2000; Bolund & Hunhammar, 1999) and the prevention of flooding (Sanders, 1986). Indeed simply the presence of natural features (i.e. trees and vegetation) in the urban environment may have beneficial effects as studies have shown that simply viewing natural scenes reduce stress in comparison to viewing urban scenes (e.g. Ulrich, 1984). Kuo et al., 1998 showed that the presence of trees and grass in common spaces promoted the development of social ties and some studies have even shown that "greener" surroundings result in lower reports of fear and less aggressive and violent behaviour (Kuo and Sullivan, 2001).

While the view of parks and green-spaces as forces for good may be widely held, parks and other green-spaces are generally in decline with 10,000 playing fields being sold off between 1979 and 1997 (DCMS, 2009) and only 10% of the UKs allotments remaining (Campbell & Campbell, 2009). Public owned parks in the UK cover some 143,000 ha (approximately 27,000 parks) with around £630 million being spent on their upkeep annually (in 2001) a report issued in 2001 ‘Public Parks Assessment’ concluded that urban parks in the UK are in serious decline. A case study of 11 residential areas in Merseyside UK found a loss of general green-space between 1975 and 2000 (Pauleit et al., 2005) with the main causes of loss being infill development (where gardens were built over) and the conversion of derelict land. Unfortunately there is a large opportunity cost associated with land used for green space, as parks tend to be located near large residential developments or near business districts where the potential for commercial opportunities is high. Thus these places often become the least cost option for a range of public and private projects. This decline can be partially attributed to a reliance on comparing the monetary costs and benefits of various land use options. This often results in decisions that favour projects with known and easily quantified benefits (such as those that create jobs and economic opportunities) at the cost of public goods like green-space benefits whose monetary value is much more time consuming and costly to quantify. This is further confounded by ever increasing urban population densities that exacerbate the reduction in per capita green-space.

This creates a problem for decision makers as the costs of provisioning green-space (both direct and opportunity) must be matched with the value that these green spaces provide. Thus there is a need to accurately and cost effectively assess the value that these green spaces provide so that the most cost effective use of land can be achieved, indeed if the value of the goods that green-spaces provide are not quantified then more often than not they will be assigned a value of zero. Whilst there is clearly a need to quantify the value that these green-spaces provide in order to make the most effective choices about changes in land use there is also pressure for decision making to be done in a cost effective way with the decision making process itself increasingly subject to cost benefit analysis.

In order to reduce the costs of valuing public goods value transfer (benefits transfer) techniques are increasingly being applied, here existing estimates of non-market values are transferred to a public good that has not been explicitly valued (Brouwer, 2000). Due to the high costs associated with performing primary valuation studies for recreational resources, this technique has received particular attention in the estimation of the benefits of natural environment public goods such as parks and other recreational green-spaces. There is an array of methodologies of varying levels of complexity available for the implementation of value transfers ranging from the simplest transferral of mean or median values from one site to another to the transferral of complete benefit functions (see Bateman et al., 2000 for a review of methodologies). No matter the complexity of the method used several potential sources of error can be identified. The first major source of error is thought to stem from differences between the characteristics of the goods assessed at the study site and those of the policy site (Plummer, 2009), it is fairly obvious that if mean WTP values are for a large well-maintained public park with many facilities for recreation is transferred to a small poorly maintained park with no facilities then the transferred values may overestimate the value of the small park. However more subtle differences such as differences in the number of substitute sites (i.e. differences in the market for the good being valued) can also result in this type of error. The second major source of error comes from failure to account for variations in the population receiving these benefits. Differences in individual characteristics (age, income, education, religion etc.) can influence individual's values between the study and policy sites resulting in transfer errors in individual values, while differences in the size and spatial extent of populations result in errors to aggregated values (Plummer, 2009). Other sources of error identified by Plummer, (2009) include those introduced by welfare change measurement error, such as differences in the proportions of use and non-use values between two sites. Physio-economic linkage measurement errors, whereby the economic values derived at a particular location are dependent on complex interactions of economic behaviour and the physical world which may not have been adequately controlled for. Finally estimation procedure errors can be introduced by the subjective nature of statistical estimation procedures. Indeed all of these types of measurement errors may be inherent to the original study values and as such could be transferred to policy sites if present. While controlling for all of these potential errors is a task which should not be underestimated this study attempts to utilise the spatial relationships that have been observed in past studies of the value of urban green space to overcome errors caused by differences in site and population characteristics. Previous research shows that spatial reference is vital for transferring values of spatially defined goods as locations dictate value which typically decays over increasing distance (Bateman et al., 2002; 2006). Simultaneously this spatial approach to value transfer provides a promising means of expanding the spatial scale and scope of value transfers that have limited the policy relevance of previous studies (Parsons & Kealy, 1994; Loomis et al., 1995; Bateman et al., 1999). While the authors do not claim to have created a definitive model of spatial benefit transfer this study does demonstrate a repeatable methodology that tackles the spatial complexity issue through the incorporation of spatial data and spatial analysis within a GIS.

The aim of this study is to apply spatially aware value transfer techniques (Brainard, 1999) to create for the first time comprehensive nationwide estimates of the value of urban green-space in Great Britain. This is achieved through a two stage process. In the first stage a meta-analysis of existing valuation studies is used to derive a spatially sensitive value function which allows the transfer of existing valuations to sites that have yet to be valued. Using a spatially explicit value function allows us to account for variations in spatial attributes that are known to influence the value of urban green-space (including the location of sites, the location of the population, income levels and the availability of substitute sites). This function is applied to five representative cities using high resolution spatial data to assess the welfare changes that result from a range of future scenarios provided by the UK National Ecosystem Assessment (Haines-Young, et al., 2011). In the second stage findings from these detailed case studies are used to generalise our value function to create an extrapolation function, which can be applied to areas for which detailed spatial data regarding the distribution of urban green spaces was not available. This generalised function is then applied to the whole of Great Britain using the same scenarios, operationalized with secondary data available sets at a less computationally expensive scale. In doing so this study provides a unique contribution in terms of applying these methods at a nationwide scale. Extrapolating in this way presents many methodological challenges but allows us to examine the benefits that urban green-space provide for the whole country and thus provide a tool for decision making at this scale. In order to achieve this scope a spatially referenced benefit transfer method is used based on marginal value functions derived from a meta-analysis of existing UK green-space valuation studies. In doing so a framework is demonstrated that allows the cost effective estimation of urban green-space values that could be applied easily by policy makers at a range of spatial scales to evaluate current and future land use decisions.

3.3. Methods

Figure 3.1: Overview of Methodology

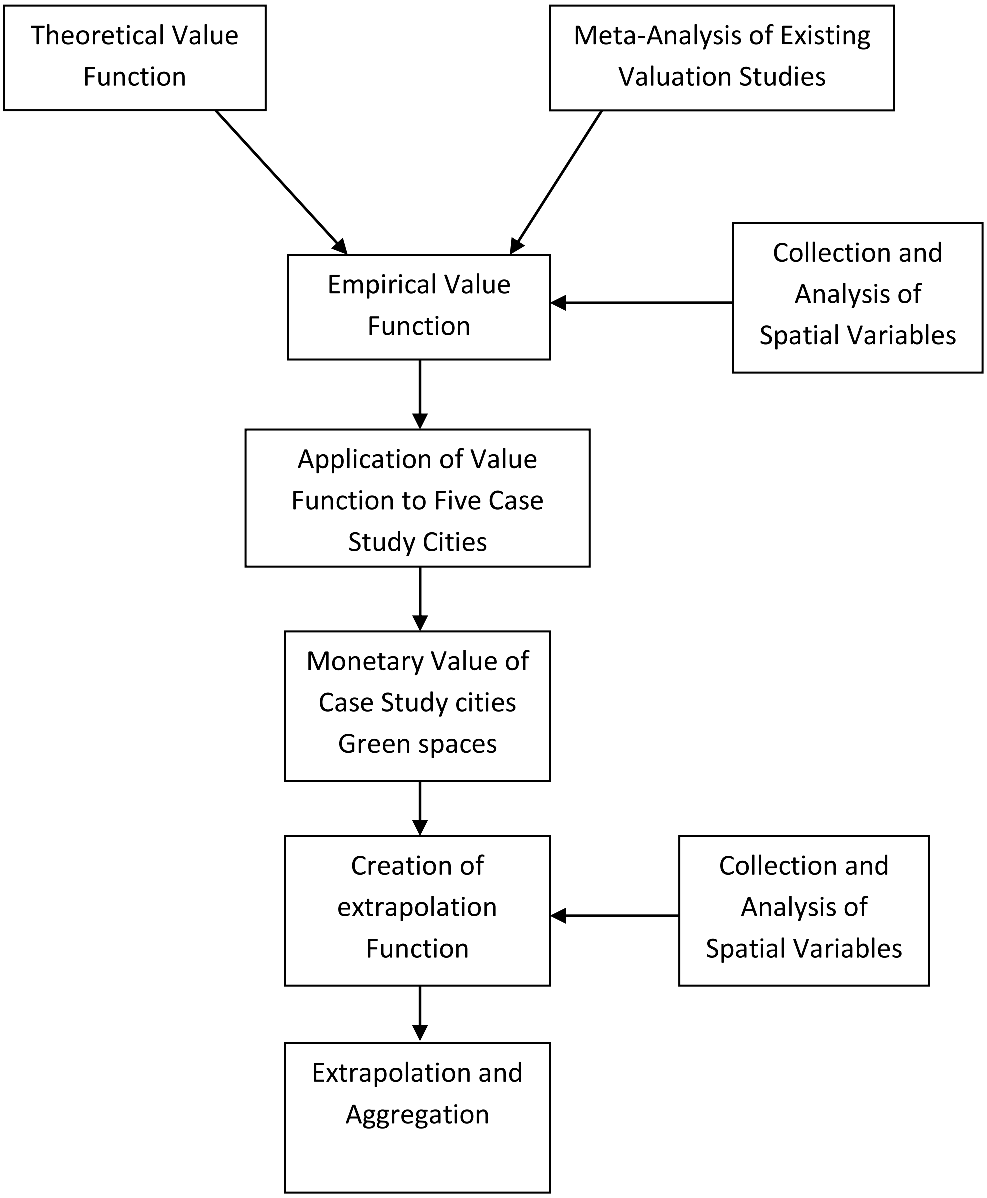


Figure 3.1 above outlines the main steps involved in our methodology. The marginal value functions used are based on a meta-analysis but also influenced by theory. This process is started by reviewing existing valuation studies. From these studies spatially sensitive value functions are derived using variables found to be significant determinants of the values reported in these studies. These value functions are then applied to five case study cities using the highest possible resolution spatial data available. Using the predicted values of the case study cities a model is estimated that uses nationally available data to extrapolate the valuation exercise to the whole country.

3.3.1. Meta-Analysis

Meta-Analysis is the statistical analysis of the findings of existing empirical studies for the purpose of integrating findings (Wolf, 1986) its most commonly employed in the fields of experimental medical treatments, psychotherapy and education. Typically it utilises studies with standardised designs and measurements. Indeed a lack of consistency between studies included in a meta-analysis will led to more suspect findings of cross analysis. Meta-analysis also faces a self-selection problem whereby available studies may be unrepresentative if studies with non-significant or negative findings have not been published. However meta-analysis studies can extract information from large masses of data which previously could only be achieved by a narrative or qualitative analysis (Hunter et al., 1982). As the authors are interested in quantifying the benefits of urban green-space a meta-analysis is used allowing us to utilise valuation studies of the same good (urban green-space) at multiple locations within GB. This frees us from the unfeasibly costly task of having to conduct valuation studies for all green-spaces in the UK. There is only one previous meta-analysis of urban green-space values that the authors are aware of. Brander and Koetse (2011), this included 20 Contingent Valuation Studies and 12 hedonic studies however only three of the studies used were UK based the majority being from the US. They found that there were large regional variations in preferences for urban green-spaces emphasising the need for us to use only UK based studies.

The first step of any meta-analysis is to survey the relevant literature to identify studies from which green-space valuations can be extracted. For our meta-analysis it was important that only UK studies that report relevant spatial variables were utilised. The next step was to analyse these studies and select variables to be included in the value functions. However a meta-analysis is only as good as the original studies it is based upon. This is particularly relevant in this context as most of the valuation studies in the literature were not designed with value transfer in mind and thus variations in value estimates may be due to methodological as well as site specific factors. In order to overcome some of these difficulties it was important that our value function while based on previous research was informed by theoretical considerations.

3.3.2. Developing a Spatially Sensitive Marginal Value Function

Basing a value function purely on a meta-analysis may result in unrealistic valuations and although this does introduce a certain amount of subjectivity into our study design it is unrealistic (considering the lack of suitable primary valuation studies) to base valuations on previous research alone. Due to the wide range of different benefits that urban green-spaces can provide their value can be a function of an infinite number of variables many of which relate to the characteristics of the green-space being valued and many of which relate to the households or individuals who hold these values. These include site characteristics relating to ecological quality, recreational affordances, household characteristics such as the presence of children in the household and the households recreational preferences. The value of an urban green-space may also be influenced by the presence of substitutes both in the form of other green-spaces and indeed other recreational affordances such as leisure centres and shopping malls. As it was not feasible for us to account for all potential influences on urban green space benefits this study focuses on accounting for spatial factors that are known to influence these benefits. Previous research shows that spatial referencing is vital for effective value transfer of spatial goods as location dictates values which typically decay over increasing distance from the good (Bateman et al., 2002, 2006).

3.3.3. The NEA Scenarios

As estimating the total value that urban green-spaces provide would involve extrapolating way beyond the range of observable values it is desirable to investigate their marginal value. Using marginal values allows us to examine the effects that changes from the current level of provisioning may have on green space benefits. As such it is necessary to define changes in the variables used in the above value functions. The NEA framework provides us with six policy scenarios that describe the UK in 2060 in terms of changes in key urban parameters such as the area covered by settlements, the population of these settlements and the amount of urban green space. Figure 3.2 shows an overview of the six NEA scenarios

Figure 3.2: Overview of the six NEA scenarios (from Haines-Young et al., 2011)

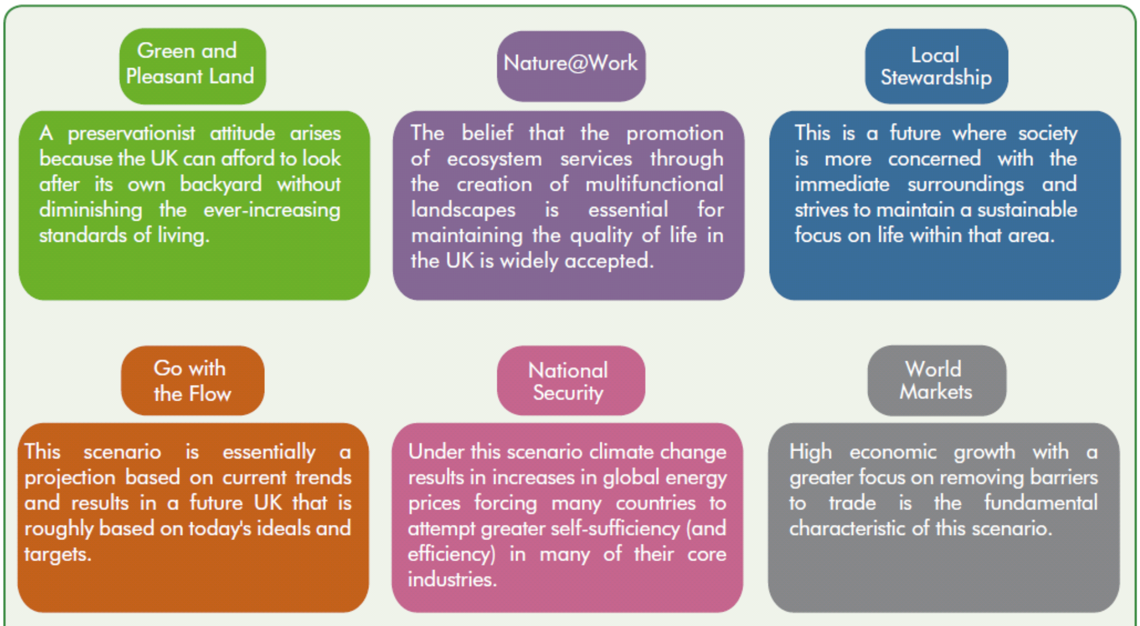


Figure 8 An overview of the six scenarios developed for the UK NEA. All share the common characteristics of a decline in global resource availability and an ageing UK population. They also include some level of technological innovation, although there are differences in the sectors involved.

These scenarios were developed to reflect how emerging socio-political and economic forces may create different futures in 2060. They were developed through the elicitation of focal questions from key stakeholders and through the review of existing scenario studies. These were brought together through a 'morphological analysis' in which a matrix was constructed that links key factors or issues to alternative future trajectories (for more information on the scenarios and how they were developed please see Haines-Young et al., 2011). A brief description of each of the scenarios is given below.

The *green and pleasant land* scenario reflects a future in which the protection maintenance and improvement of landscapes for their aesthetic appeal are driving forces of developments.

This leads to a reduction in farmland in favour of leisure and tourism which become more important in the UKs economy. The *nature at work* scenario envisages a future in which the maintenance and enhancement of ecosystem services in response to climate change become driving forces. A pragmatic view of ecosystem services is adopted with an acceptance of the need for trade-offs between conservation and other societal benefits. In contrast to these two scenarios the *world markets* scenario is driven by a desire for economic growth through trade liberalisation. Large scale industrial farming is prevalent and society continues to increase its consumption and resource use. Biodiversity suffers as a result of liberalisation and the private sector dominates. The *national security* scenario is driven primarily by increasing global energy prices that result in a greater interest in national self-sufficiency. Here the government creates a competition free environment for UK industry and increased trade barriers and tariffs to protect livelihoods. Unproductive land is put to agricultural production while resource consumption is curbed and society made more sustainable. The *local stewardship* scenario is driven by similar external pressures except society makes more of a conscious effort to reduce economic activity and consumption. People become stewards taking greater responsibility for their lifestyles in terms of consumption, energy use and food production. Political power is more localised and landscapes become more distinctive through increased local specialisation. Finally the go with the flow scenario describes a future in which the dominant socio-political and economic drivers of the UK at the end of 2010 continue. Environmental improvements are important but society and industry are reluctant to adopt policies that require radical changes, resulting in slow and inconsistent progress towards a low carbon economy. In order to operationalise these scenarios the NEA scenarios team provided us with a quantitative equivalent of these scenarios.

3.3.4. The Case Study Cities

While it would be possible to apply our meta-analysis based value function to all urban green spaces in GB this would require detailed spatial data on their location and size, data which could possibly be collated from the OS Master-map topographic layers but to do so would be a huge undertaking and is beyond the scope of this study. Instead five case study cities were chosen for which detailed spatial data was available for our value valuation functions to be applied to. Results from the case study cities were then used to create an aggregation function that allows for the value transfer to be applied nationally using available data to all urban areas with a population over 50,000.

3.4. Methods Implementation

3.4.1. A Typology of Urban Green Space

Initially it was necessary to divide the areas of urban and peri-urban green-space into three different categories so that marginal values associated with different types of green space can be accounted for (Table 3.1). After examining the range of available data and measures used in existing studies three urban and peri-urban green-space categories; Formal Recreation Sites (FRS) City-Edge Green-space and Informal Green-space were defined.

Table 3.1: A typology of green spaces.

Green space type	Definition	Spatial data source (Data set used)
Formal Recreational Sites	Accessible public green spaces (minimum of 1ha) mainly city parks but also include play parks, accessible recreation grounds and urban woodland areas	Urban woodlands were defined using the UK forestry commission woods for people dataset. Public park data was provided by city councils (apart from Norwich where no digitised information was available so park polygons were extracted from the Ordnance Survey Master-map datasets. Natural England CROW access layer (section 15) was also used
City-Edge Green-space	Areas of non-developed land directly adjacent to an urban fringe (i.e. land on the other side of the DLUA boundary).	This is any land not included in the DLUA (and not adjacent to any parks?)
Informal Green-space	Informal Green space is defined as any amount of land designated make natural in the OS Master-map data sets and measured as a percentage of 1km2 OS grid squares	OS Master-map topographic layer Make type natural

Using these categories spatially sensitive value functions were developed that attempt to account for the different benefits that they supply. These are based on the five studies shown in Table 3.2 below that all value FRS's and city-edge green-space in UK cities. Studies were selected that were considered to be of sufficient quality and provided information on the size of the green-space valued and the distance from the green-space. Studies were included that found positive marginal values of distance to green-space or not. In these studies the increase in property price arising from a reduction of one metre in the distance to the centre of the nearest green-space is used to produce a total of 61 marginal values were extracted. Regression analysis was then performed using data on the size of the green-space analysed, the distance from the green-space, median household income in the study area, population of the city and the elicitation method used to predict the marginal value of distance to green-space from each study. These marginal value functions were then applied to five case study cities in the UK using six policy scenarios (Haines-Young et al., 2011) using high resolution spatial data concerning the location and sizes of both green-spaces and the city's population. From these five case studies an extrapolation model that allowed this analysis to be extended to all the major urban areas in the UK was created.

3.4.2. Meta-Analysis Implementation

A review of the literature produced a set of five studies that value urban green-space in the UK Andrews (2009), CabeSpace (2005), Dehring and Dunse (2006), Dunse et al. (2007) and Hanley and Knight (1992) . Two of these studies used a hedonic pricing method (reporting thirty seven marginal values in total), two used contingent valuation (reporting six values in total) and one study using expert interviews (reporting eighteen values). The size of this dataset was limited somewhat by the lack of relevant UK valuation studies in the literature. As the point of the meta-analysis was to establish a spatially sensitive value function only studies that reported key spatial variables including the size and distance to the green space being valued could be included. This meant that several relevant studies could not be used as they did not include these variables (e.g. Bateman et al., 2004; Lake et al., 2000 and Powe et al., 1995).

Using the 61 marginal values of proximity to green-space (£s per metre) collected from the meta-analysis as dependent variables and data on the size of the green-spaces being valued, distance from the green-space to the location of the valuation, median household income in the study area, population of the city and characteristics of the valuation studies themselves as independent variables a regression model was fitted using a log log specification and a Heckman selection model. The log log specification was used to avoid the heteroskedasticity present in linear versions of the model and the Heckman model allowed us to keep observations with zero or negative marginal values (Heckman models are used to correct for selection bias in non-random samples). Table 3.2 presents the variables used in the regression with descriptions and summary statistics.

Table 3.2: Meta-Analysis Variable descriptions and summary statistics (N=61)

Variable	Description	Mean (std dev)	Median	Range
Marginal value of proximity to FRS (£ in 2009 prices per meter)	The value of moving one meter closer to the green space being valued. For hedonic studies this is implicit prices, for expert methods it is the experts estimate of implicit prices and for CV studies it is willingness to pay or willingness to preserve.	150.2 (473.2)	5.3	-40.4 to 3,347.6
Size of green-space (ha)	Size of the green-space valued in original study	34.5 (50.5)	18	0.5 to 180
Distance (in m)	Distance between the site and residence of the household.	406.1 (281)	300	35 to 1,500
Income (£/year)	Income of the study area calculated from averages of median annual household income at the LSOA level (using Experian Mosaic 2009 study set)	39,153 (8,119)	29,413	16,071 to 48,015
Population	Population of the study city (using 2009 ONS estimates)	471,141 (1,357,328)	213,800	4,505 to 7,753,600
No.Obs.	No. Obs. in original study	4,353 (10,292)	166	3 to 32,539
Peer Reviewed	Dummy variable 1 for peer reviewed studies	.525 (.506)	1	0 to 1
Year of Data Collection	Year of Data Collection	1992 (10.1)	1984	2009

Alternative regression specifications are reported in Perino et al., (2011). The regression results (Table 3.3) show that the marginal value of urban green-space can be seen to monotonically decrease with an increase in distance to the site being valued and with the size and income of the population. While intuitively the value of the site monotonically increases as the size of the site increases. The results for distance and size are intuitive and have been observed frequently while the decrease in the marginal value due to income is likely due to people with higher incomes being able to afford provision and access to substitute green-spaces (i.e. private gardens and trips to the countryside). This can be seen in some of the meta-analysis studies (Dehring & Dunse 2006, Dunse et al., 2007) where the price of flats is found to be more sensitive to the proximity of green-space than it does for houses, presumably because flats typically have no gardens. The absence of a positive relationship between income and the value of green space is common for environmental goods (see Brander & Koetse, 2011). For all but one of the studies median household income had to be extracted from the Experian Mosaic data set for the corresponding LSOA, this is not an ideal situation as the participant's income may not reflect that of the wider area (and year). The decreasing relationship between marginal value and city population size may be caused by the effects of overcrowding whereby the higher population is likely to result in more overcrowding and thus make the parks less attractive to residents, however in the absence of any housing density measures this is impossible to infer.

The lambda parameter for the selection equation is not significantly different from zero suggesting that no selection bias is present. However within the selection stage of the Heckman regression two of the three variables that have a significant effect on the probability that a zero or negative marginal value is reported are related to the study design used. While neither the elicitation method nor the number of observations in a study should influence participant's preferences for green spaces they can influence how accurately these preferences can be measured and as such the marginal values reported in such studies. The zero and negative marginal values included in the study design seem to be at least partially due to inappropriate study design. The valuation equation coefficients in Table 3.3 are used to specify the marginal value function for proximity to a green-space.

Table 3.3: Meta-analysis regression results for Formal Recreation Sites and City-Edge Green-space using a two stage Heckman procedure.

Valuation Equation	**lnMValue+**
lnDistance	-0.941*** (0.008)
lnSize	0.500** (0.032)
lnIncome	-2.945** (0.011)
lnPopulation	-0.554** (0.021)
Constant	44.53*** (0.001)
Selection Equation	
lnIncome	-1.196* (0.068)
Expert	2.685* (0.051)
No.Obs	0.000132** (0.016)
Peer Reviewed	1.916 (0.144)
Constant	10.27 (0.131)
Mills lambda	1.258 (0.137)
Observations	61

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.4.3. Marginal Value Functions

The results from the meta-analysis were used to create the following distance sensitive marginal value functions. As all the studies used in the meta-analysis report one-off payments the marginal value functions derived from them measure the discounted marginal benefit of green-space proximity over the planning horizon. As a log log specification was used our model function variable exponents indicate the percentage increase in marginal value if the level of the variable is increased by one percent. For example a one percent increase in distance to the centre of a green-space reduces the marginal value by 0.941 %. Thus from the regression results presented in Table 3.3 the marginal value function for FRS's and City-Edge Green-space is:

MValue(Distance, Size, Income, Population)

$$= \quad e^{44.53} \frac{Size^{0.5}}{Distance^{0.941} \cdot Income^{2.945} \cdot Population^{0.554}} \qquad \text{Eq. 1}$$

The Distance decay curve for this function is illustrated in Figure 3.3 below. Due to the fact that geometric centroids for postcode locations and for park locations were used this curve had to be adjusted to avoid postcode centroids falling within park boundaries. This is done using Equation 2 below:

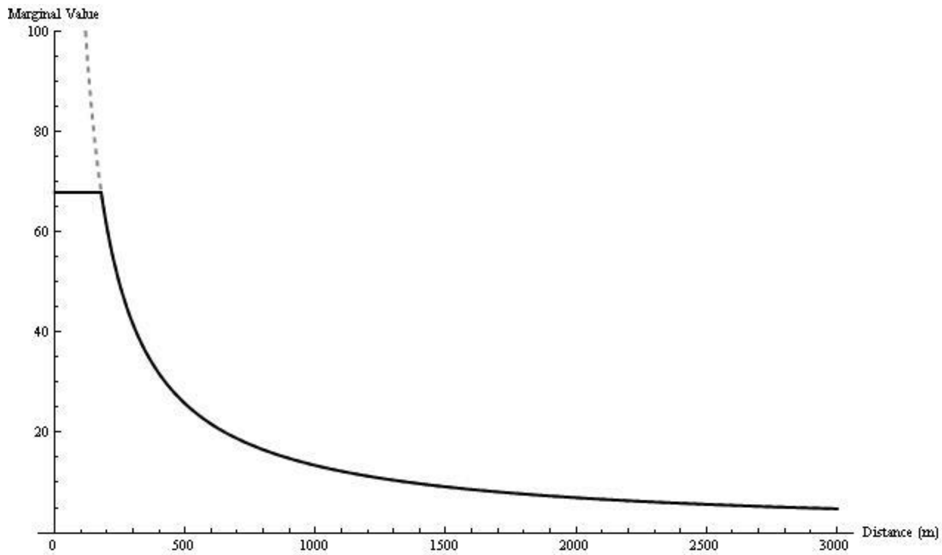
MValueFRS = MIN[

MValue(Distance, Size, Income, Population),

MValue(100(Size/3.14)^0.5, Size, Income, Population)]* Eq. 2

This effectively caps the value at a distance from the centre of the site that is equivalent to the radius of a circle with the same area as that of the park (represented by the bold line in Figure 3.3). Although most parks are far from being circular this represents an elegant way to avoid postcode centroids falling within park boundaries.

Figure 3.3: Distance decay function of marginal values for Formal Recreation Sites for a 10 ha park, population of 200,000 and income of 25,000)



Similar adjustments have to be made for City-Edge Green-space distance measures. This time though the city edge variable measures the Euclidean distance to the edge of the green-space instead of the centre (due to the potential size of city edge green space areas) in order to make this compatible with the centre-to centre measures used in the marginal value function (eq. 1) a standardised distance from the edge to the centre City-Edge Green-space is added. This distance is equal to the radius of a 10ha circle, thus deploying the assumption that city edge green-spaces are roughly equal to the average size of FRS's in the study.

MValueEdge =MValue(Distance + 178.5, 10ha, Income, Population) Eq. 3

These two adjustments have the effect of making the derived values more conservative as they are less prone to measurement errors. This is particularly so for FRS's where the distance variable already suffers from inaccuracy due to the use of park centroids rather than edges or access points and also because of the use of geometric postcode centroids.

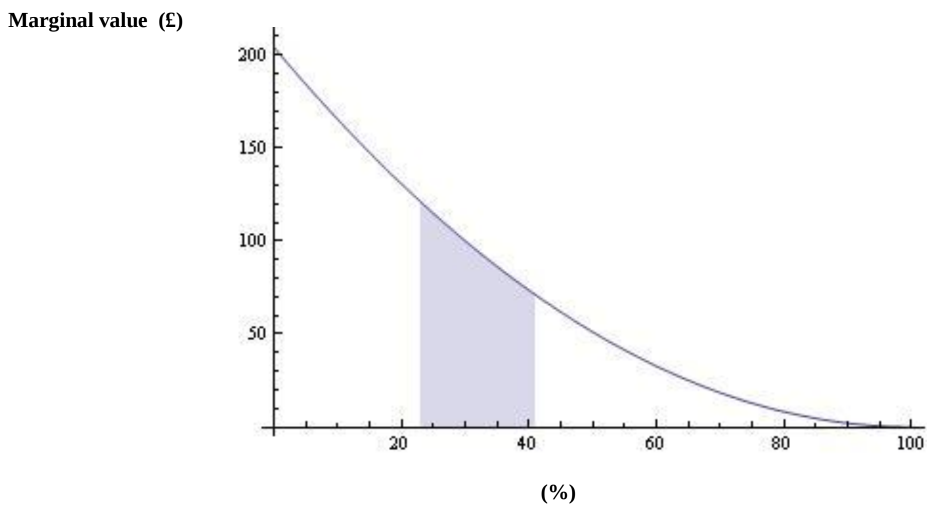
The distance decay functions assume that people living closer to a park typically derive more benefits from it than those living further away, this can be due to the number of people utilising the recreational affordances of a FRS decreases with distance (Bateman et al., 2006) and also because some of the passive benefits such as noise abatement and pollution reduction are greater the closer one lives to the site.

For the amount of informal green-space a marginal value function is derived from the results of Cheshire & Sheppard (1995). They report two marginal values for Reading (18% green-space with marginal value of £120) and for Darlington (8% value of £192) a quadratic function is fitted through these two points assuming that the marginal value is zero at 100% cover and non-negative for smaller percentages.

$$MarginalVvalue = 0.02268\, p^2 - 4.53686\, p + 226.843 \qquad \text{Eq. 4}$$

Here p measures the % of informal green space in a 1Km^2 square. To calculate the monetary value of changes in informal green space benefits in the 1Km^2 square surrounding a household this function is integrated over the interval given by the current and proposed future % of informal green-space cover. This gives us a monetary value of the change in discounted benefits of informal green space (Figure 3.4).

Figure 3.4: Marginal value of % of Informal Green-space in a 1km² square



3.4.4. Function Variable Measurements

In order to apply our marginal value functions to the five case study cities it was necessary to collate the spatially referenced data on its predictive variables. This section describes the process of collecting and generating this data, all spatial processing was performed in ESRI's ArcGIS 9.3 (all data sources used can be found in Appendix 3.2).

3.4.4.1. Define Study Areas and City Variables for the Five Case Study Cities

For each case study city it was necessary to define a study area to facilitate data collection and subsequent analysis. The OS Meridian Developed Land Use Area (DLUA) polygons were used alongside the 2001 English Census District boundaries (for Scotland the 2001 Council Areas were used) to define study areas. The DLUA are continuous tracks of land with populations over 10,000. All DLUA's that intersect the District boundary of the case study city were selected and a shape file created from these. Any small towns and villages were removed so that only large urban areas within the district remained. For areas such as Bristol and Sheffield which merge into neighbouring urban areas such as Rotherham (so that they form one continuous DLUA) it was necessary to create a mask layer polygon using a symmetrical difference function on the district polygon and DLUA. This negative image was then used to erase the connecting urban areas. Finally any donut polygons were removed from within the study areas so that they form discrete polygons.

For each case study city postcode polygons were obtained from Edina's Digimap service these were converted to geographic centroids (this allowed us a greater amount of flexibility than population weighted centroids) and all postcode points (centroids) that fell within the cities study area were exported to be used in subsequent calculations. For every full postcode in each city selected for inclusion the number of residential households was obtained from the 2010 UK National Statistics Postcode Directory[8]. Income data was not available at the postcode level so a spatial join function was used to extract the median gross annual household income from the 2008 Experian Mosaic Public Sector Data (at the LSOA level).

3.4.4.2. Define FRS Layer and Calculate Size and Distance

Formal Recreational Sites (FRS's) were defined as accessible formal parks, gardens (including play parks and playgrounds), accessible recreation grounds and accessible woodlands with an area of one hectare or more that intersected the study area. Using this definition, FRS polygons were extracted from data sets compiled and supplied by the respective city councils relating to locations of parks and gardens (including play parks and play areas) and accessible recreation grounds (not including school grounds) that intersect the study areas. These were supplemented with Accessible woodlands (from the Forestry Commission Woods for People data, or just all woodlands for Scottish cities) and CROW S15 and CROW open access spaces

[8] The number of residential households in each postcode were obtained from the UK Data Service Census Support Geoconvert website (http://geoconvert.mimas.ac.uk/).

that intersect the study areas. This rather narrow definition of formal recreational sites was used in an attempt to maintain consistency between the various different council data sets, which due to differences in the scope of their green space audits covered a range of different green spaces. FRS polygons were then merged into one layer and the polygons aggregate to avoid each green-space having multiple polygons. A threshold of 50 metres was used for the aggregation; however for cities traversed by many rivers such as Aberdeen it was necessary to reduce this threshold to 10m to avoid aggregating green-spaces across rivers. FRS areas were recalculated for the aggregated polygons and any that were below one hectare were removed. Finally centroids were calculated for each of the Formal Recreational Spaces and exported for use as points in the distance calculations.

For each of the case study cities distance to the centroid of each FRS from each postcode centroid was calculated using Euclidean distances. Originally these distances were calculated using the Ordnance Survey Integrated Transport Network and the Network analyst extensions of ArcGIS however the data demands this method implied meant that Euclidean distances were used instead. Distances to City-Edge were calculated using a similar method of Euclidean distances from postcode centroids to city exit points. The exit points were created at the intersection of the study area boundary and the road network. Any points that fell within existing FRS's on the city boundary were deleted. For both set of distance variables a 3km cut-off was applied thus presuming that any green-spaces beyond 3km have zero value.

As typically each postcode has more than one FRS located within the 3km cut-off the issue of substitution effects had to be considered. While the original studies did not address this issue and thus provide no basis for our treatment of substitution it was decided to compute an upper and lower bound value change for each postcode and scenario. The upper bound assumes no substitution and thus sums the value changes for all sites within 3km. This may result in overestimation by not taking substitution into account. The lower bound thus uses a single FRS and specifically the FRS that has the largest change in value for each scenario and each postcode. Through valuing just one FRS the lower bound estimate rules out overestimation due to substitution effects but ignores any benefits that other sites may have.

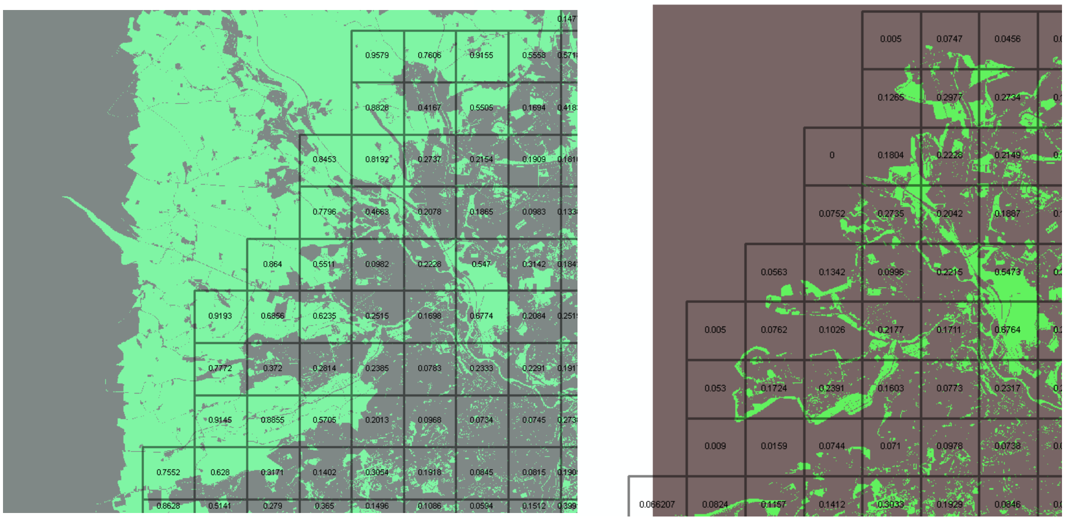
3.4.4.3. Define City Edge Green Space

City edge green-space was defined simply as the land outside of the boundary of the study area (effectively the DLUA). As point data is required to create distance measurements it was necessary to create exit points that represent the point of entry into these green-spaces. This was done by creating points at the intersection of the cities boundary and the road network (OS Master-map Integrated Transport Layer).

3.4.4.4. Define Informal Green Space

To take account of the benefits provided by other green spaces not included as FRS's a layer was created that represents all other natural surfaces in the study area. The OS Master-map topographic area layer was used to extract all polygons which have a Make attribute "natural" for the study area. In order to avoid double counting of the FRS's these areas were removed from the layer of natural land cover polygons. These "natural" surfaces were converted into a raster grid (from a vector resolution of 0.25m to a raster 1m resolution) and reclassified so that all natural areas were assigned a value of one and all other areas were given a value of 0. To measure the amount of informal green-space in each case study city a 1km^2 grid was draped over the study area (using Hawths Tools) and any squares that do not intersect the study area were removed. A Boolean variable was created for each grid square indicating whether that square contained an urban exit point or not. Using these grid squares and the natural raster layer the mean is calculated for the raster values contained in each grid square, when multiplied by 100 this mean gives the percentage of land in that grid square that is a natural surface. To avoid the double counting of values already accounted for by the distance to the urban edge, the percentage of natural land cover for grid squares that contain an exit point were recalculated using a raster grid with natural surfaces outside of the study boundary removed. Every postcode centroid was assigned the mean for its respective square and these values were exported. The resulting table contains a mean attribute that is the percentage of 1's i.e. the percentage of natural land covered in that 1km^2. This percentage calculation is performed again however this time the natural area polygons are clipped to the study area so that the percentages reflect the amount of natural land cover within the study area (see Figure 3.5). In addition it was also necessary to remove from the informal green-space raster any areas that were already being valued (i.e. FRS's) this was done prior to the conversion to a raster in order to minimise generalisation caused by the loss of resolution in conversion process.

Figure 3.5: Left, the percentage of natural land in 1km by 1km grid squares. Right, the percentage of natural land in 1km by 1km grid squares inside the study area.



(Derived from OS Mastermap Topographic Mapping, Crown Copyright, Ordnance Survey Ltd.)

3.5. NEA Scenario Data

In order to examine the effects that changes in the urban environment have on the value of urban green space the NEA scenarios team provided us with changes for four key urban variables for each of six future scenarios. These key variables include the size of green-spaces (both FRS and informal green-space) the size of the urban area and the size of the urban population, these are presented in Table 3.4 below.

Table 3.4: Changes in key urban parameters implied by NEA scenarios 2010-2060 (source: NEA scenarios team)

Scenario	Change in Urban Area in %	Change in Urban Population in %	Change of FRS Area in %	Change of Informal Green-space Area in %
Green & Pleasant Land	0.0	21.7	38.9	5.4
Nature@Work	-3.0	13.8	39.0	-4.9
World Market	79.0	52.6	73.0	20.7
National Security	-3.0	17.2	-34.3	4.8
Local Stewardship	-3.0	0.0	4.5	2.8
Go with the Flow	3.0	32.2	36.2	0.0

As can be seen in Table 3.4 most of the scenarios involve a change in the size of urban areas. This presented a major practical issue as it was beyond the scope of this study to model urban growth for the five case study cities. Instead changes in the extent of urban areas were represented in terms of changes in the distances from households to FRS's and City-Edge Green spaces. This was done by multiplying the distances from the geographical centroid of each postcode to the centroid of each FRS or City Edge by a factor equal to the square root of 1 plus the proportional change in the urban area, this is done so that a change in urban extent translates into a change in distance. Effectively inflating or deflating a city and thus having the desirable property of maintaining the location and number of postcodes in the study area but just adjusting their relative position. Changes in urban population were achieved by increasing the number of individuals in each postcode by the percentage specified in each scenario. Changes in green-space availability were achieved by expanding the size of existing FRS's using the same method applied to urban extents, it should be noted that although it may be more realistic to create new FRS's than to expand existing ones this was not practically possible. It is presumed that this method is more likely to underestimate rather than overestimate changes in values as a new park would generate more benefits than adding the same area to an existing site. While this introduces a potential bias as houses are not moved and thus certain households could now be located within the boundary of existing FRS's. The adjustments made to the marginal value function in eq.2 to avoid postcode centroids falling within park boundaries encompass the size of FRS’s and as such circumvent such problems. Changes in informal green-space are achieved using the same expansion technique and then dividing the % of informal green-space by 1+ the change in urban area to allow for the new urban extent. The effect of income is mainly driven by relative differences and as scenarios did not include changes in relative income this is maintained within this analysis.

3.6. The Five Case Study Cities

Five UK cities were chosen, Aberdeen, Bristol, Norwich Sheffield and Glasgow. These cities were selected as representative based on their size and population, however due to issues with the availability of green-space data the choice of case study cities was partially driven by data availability.

Table 3.5: Descriptives of the Five Case Study Cities

	Population in study area	Households in study area	Number of FRS's	Total area of FRS's (ha)	Area of FRS per household (m2)	Informal Green-space (ha)	Informal Green-space per household (m2)
Aberdeen	210,400	91,616	77	738	80.5	1,443	157.5
Bristol	402,358	169,080	67	1,318	77.9	2,174	128.6
Glasgow	588,470	272,847	223	2,225	81.6	6,026	220.9
Norwich	181,340	84,576	33	401	47.4	3,531	417.5
Sheffield	473,746	204,025	134	1,772	86.8	2,866	140.5

3.7. Analysis and Results[9]

3.7.1. Applying the Scenarios to the Case Study Cities

For each of the green-space categories per household values were multiplied by the number of households living in that postcode. These were then summed across all postcodes in the respective study area. These totals are then divided by the total number of households to yield the average per household values presented in Table 3.6 below (for Norwich). Mean per-household changes in benefits from all green space categories for each scenario across all five cities are presented in Table 3.7. The Green & Pleasant land, Nature@Work, and Local Stewardship scenarios all result in an increase in benefits while the others result in a reduction in green space benefits in 2060 compared to current levels.

[9] This study was conducted in October 2010.

Table 3.6: Average Per Household benefit changes for Norwich 2010-2060 (undiscounted capital values)

Scenario	Formal Recreation Sites	City-Edge Green-space	Informal Green-space	Sum
Green & Pleasant Land	£7,970	n.a.	£389	£8,358
Nature@Work	£18,000	£-2,020	£258	£16,238
World Market	£-71,900	£-10,800	£-780	£-83,480
National Security	£-33,900	£-2,520	£195	£-36,225
Local Stewardship	£7,070	£249	£305	£7,624
Go with the Flow	£-3,980	£-4,880	£192	£-8,668

Table 3.7: Benefit changes for all Green-space Categories (2010-2060 undiscounted capital values)

Scenario	Aberdeen	Bristol	Glasgow	Norwich	Sheffield
Green & Pleasant Land	£7,992	£6,614	£1,078	£8,358	£11,315
Nature@Work	£16,377	£13,781	£1,750	£16,238	£24,229
World Market	£-83,695	£-69,587	£-14,753	£-83,480	£-110,877
National Security	£-34,584	£-28,252	£-4,228	£-36,225	£-47,667
Local Stewardship	£7,442	£6,290	£1,182	£7,624	£10,372
Go with the Flow	£-7,623	£-5,927	£-1,835	£-8,668	£-8,089

3.7.2. Extrapolating and Aggregating Benefits

Extrapolation is restricted to Great Britain as comparable data for Northern Ireland was not available at the time. While this creates some issues for the generalisation of our findings these are thought to be negligible due to the small percentage of urban land area in Northern Ireland compared to the rest of the UK (only 3% Davies et al., 2011). Also only cities with a population of 50,000 or more were included as our methods are less suitable for smaller settlements due to the nature of the studies used in the meta-analysis. Median per household benefit changes at the LSOA (for England) or data zone (for Scottish cities) level were computed from the postcode level values calculated for each of the five cities. These values were then regressed (using the median household benefit change at the LSOA level as the dependent variable) as a function of local characteristics for which spatial data was available at the same spatial scale (LSOA). These included the total number of households, median gross household income in 2008, population density and the population of the city, results are presented in Table 3.8 below.

Table 3.8: Regression of median per household benefit changes at LSOA/Datazone level

	Green & Pleasant Land	Nature@Work	World Market	National Security	Local Stewardship	Go With the Flow
	(1) **lnGaP**	**(2)** **lnNaW**	**(3)** **Ln(-WM)**	**(4)** **Ln(-NS)**	**(5)** **lnLS**	**(6)** **Ln(-BAU)**
lnCityPopulation	0.704*** (15.00)	0.709*** (10.97)	0.688*** (16.69)	0.728*** (15.99)	0.692*** (16.15)	0.706*** (15.35)
lnLSOA-HH	0.240 *** (5.14)	0.295*** (4.29)	0.316*** (7.69)	0.250*** (5.52)	0.286*** (6.70)	0.263*** (4.12)
lnLSOA-Income	-3.000 *** (-72.44)	-3.131*** (-74.85)	-3.020*** (-82.96)	-3.212*** (-79.91)	-2.988*** (78.92)	-3.225*** (-57.51)
lnLSOA-Pop-Density	0.108*** (7.32)	0.136*** (7.05)	0.0969*** (7.49)	0.0846*** (5.93)	0.113*** (8.39)	
Glasgow	-0.865*** (-16.96)	-0.810*** (-12.04)	-0.906*** (-20.25)	-0.944*** (-19.10)	-0.855*** (18.38)	-1.253*** (-27.09)
Norwich	0.933*** (15.00)	0.830*** (10.58)	0.889*** (16.22)	0.998*** (16.50)	0.899*** (15.78)	1.145*** (19.97)
Sheffield	0.140* (3.11)	0.179** (3.87)	0.112* (2.85)	0.146* (3.35)	0.132* (3.22)	
Constant	28.36*** (50.93)	30.08*** (42.70)	30.57*** (62.53)	31.38*** (58.13)	28.06*** (55.19)	29.69*** (44.07)
Observations	1635	1636	1639	1639	1639	1633
Adjusted R2	0.782	0.778	0.822	0.810	0.809	0.809
df_r	1627	1628	1631	1631	1631	1627
F	836.5	917.8	1083.8	999.3	995.3	943.0

The natural log of city population has a significant and positive effect on the size of benefit changes caused by scenarios however it had a negative effect in the marginal value functions (eq1 -3) suggesting that here it picks up effects that are correlated with city size but which cannot be explicitly controlled for in the above regressions (such as the number and size of parks and other green spaces). The number of households in each LSOA also has the expected positive and significant influence on the size of benefit changes. The natural log of median income has a significant negative effect across all scenarios. This can be partly explained by income being one of the variables used to compute the values for FRS and City Edge green-space in the original value functions (eq. 2 and 3). As such the coefficients for income across scenarios are very similar to the coefficients used in the marginal value functions. For all but one scenario (go with the flow) the log of population density at the LSOA level has a significant positive influence on changes in urban ecosystem benefits that result from the scenarios. This result requires further consideration. Consider the city centre, these areas typically have the highest population density of a city, residents of these areas may also be more reliant upon urban green spaces due to their increased distance from green spaces at the edge of the city. At the same time FRS's are typically located in city centres (close to these areas of high population density) thus changes in their size can be expected to affect these households more than households at the cities edge. Inverse relationships between population density and green-space provision have been reported previously by Davies et al 2011. Combined with the fact that marginal benefits are typically higher for scarcer goods it seems that a positive relationship between population density and changes in the benefits of urban green spaces is feasible.

Dummy variables were used to represent each of the case study cities (Aberdeen being the base case), all of which are significant. Interestingly the coefficients for Glasgow are consistently negative showing us that there is some omitted variables which for Glasgow results in less changes relative to Aberdeen. While there is clearly some omitted variables the R^2 values show that all models explain a large proportion of the variation in the change of green space benefits. The Nature@Work and Go with the Flow scenarios suffer from heteroskedasticity and thus all t-values for these scenarios were computed using robust standard errors.

The results of the above regression analysis were used to extrapolate the per household changes in urban green-space benefits to all urban areas with a population of 50,000 or more in Great Britain at the LSOA/Datazone scale. This was done for each of the five scenarios using the corresponding coefficients. The extrapolation was restricted to LSOAs with populations greater than 50,000 for two reasons. Firstly the importance of urban green-spaces decreases rapidly for small towns due to the increased proximity to non-urban green-space on the outskirts of these towns. Secondly the smallest urban area used in the case studies is Norwich (with a population of 180,000) it was thus deemed unrealistic to extrapolate from these to settlements smaller than 50,000. As it stands the extrapolation uses more than 25,000 LSOA/data zones which cover approximately two thirds of the population of Great Britain (nearly 40 million people). The cities were selected using 2001 census data (DCLG, 2008) for England and Wales and using mid 2008 population estimates (GROS, 2008) for Scotland. LSOAs and data zones were then selected using look up tables provided by UKBORDERS (these match city codes to output areas). Median household income was extracted again from the Experian Mosaic dataset (2008). The most extreme (0.5%) of LSOAs were truncated to the value at that truncation point to avoid extreme values distorting the mean results.

Table 3.9 presents average changes in green space benefits for urban households in Great Britain and also the aggregate value of these changes for the entire aggregation sample of Great Britain. These are expressed as both changes in income p.a. from 2060 onwards and as net present values based on the H.M. Treasury's hyperbolic discounting rule. While these numbers should be viewed as rough estimates they do show us that the scenarios and thus future policy decisions can have a substantial impact on the benefits provided by urban green-spaces. This is especially true for the more extreme World Market scenario.

Table 3.9: Benefit changes of scenarios per urban household* and aggregated for all cities with a population of 50,000 or more in Great Britain 2010-2060 (in 2010 pounds).

	Green & Pleasant Land	**Nature@Work**	**World Market**	**National Security**	**Local Stewardship**	**Go with the Flow**
			Aggregate Values in Billion £			
Undiscounted Value Change (2010 – 2060)	66.3	149	-574	-217	54.8	-35.0
Change in p.a. income from 2060 onwards (used in Bateman et al., 2012)	2.12	4.76	-18.4	-6.94	1.75	-1.12
Change in income p.a. from 2060 onwards – no substitution between parks	4.43	9.00	-44.2	-18.7	4.10	-3.11
Net Present Value (H.M. Treasury standard discounting)	31.1	69.9	-270	-102	25.7	-16.4
			Per Household* Values in £			
Undiscounted Value Change (2010 – 2060)	4,370	9,790	-37,800	-14,300	3,610	-2,300
Change in income p.a. from 2060 onwards	140	313	-1,210	-457	115	-73.8
Change in income p.a. from 2060 onwards – no substitution	292	593	-2,900	-1,230	270	-205

between parks						
Net Present Value (H.M. Treasury standard discounting)	2,050	4,600	-17,800	-6,710	1,700	-1,080

* Based on the 15.2 million urban households living in the areas included in the extrapolation.

The first row in Table 3.9 presents the undiscounted change in value from 2010 to 2060 this is analogous to a one off gain or loss like that expressed in the change in the price of a house. In order to convert this into a change in a household's income stream the corresponding annuity is calculated using a constant discount rate of 3.2% equivalent to the constant declining discount rate schedule used by the H.M. Treasury for an annuity with an infinite horizon.

Although the difference in absolute value of changes between the beneficial scenarios (Green & Pleasant Land, Nature@Work and Local Stewardship) is substantial their relative spatial distribution is very similar. It is thus possible to visualise the three beneficial scenarios and the three negative scenarios on the same map just using different keys to represent the different scenarios these can be seen in Figures 3.6 and 3.7 below. As can be seen from both of these figures the largest positive and negative values are concentrated within the biggest cities (supporting are decision to exclude smaller towns from the analysis).

Figure 3.6: Spatial distribution of benefit changes under the scenarios which yield net gains for all cities with a population of 50,000 or more in Great Britain (change in income p.a. from 2060 onwards in 2010 pounds)

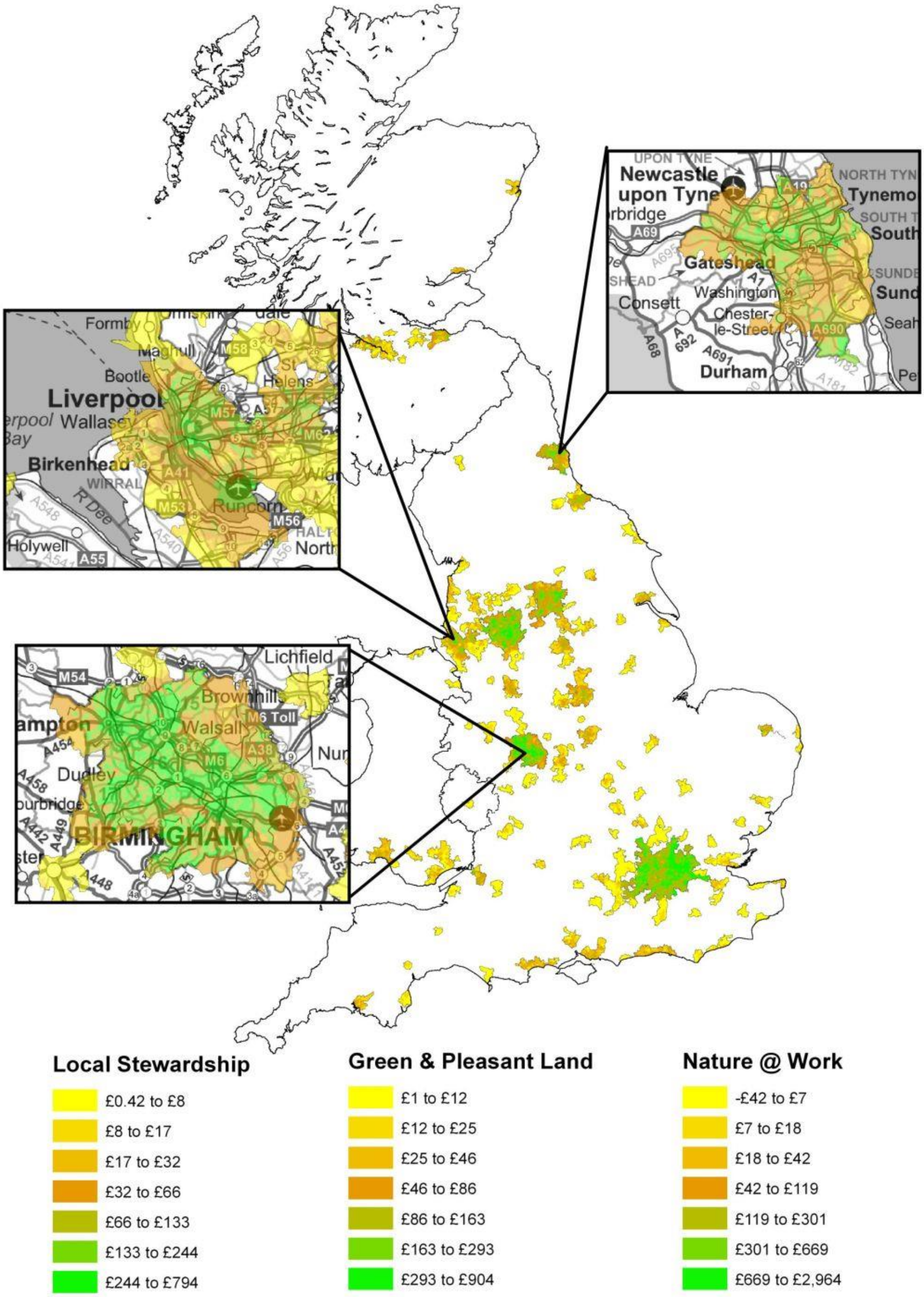
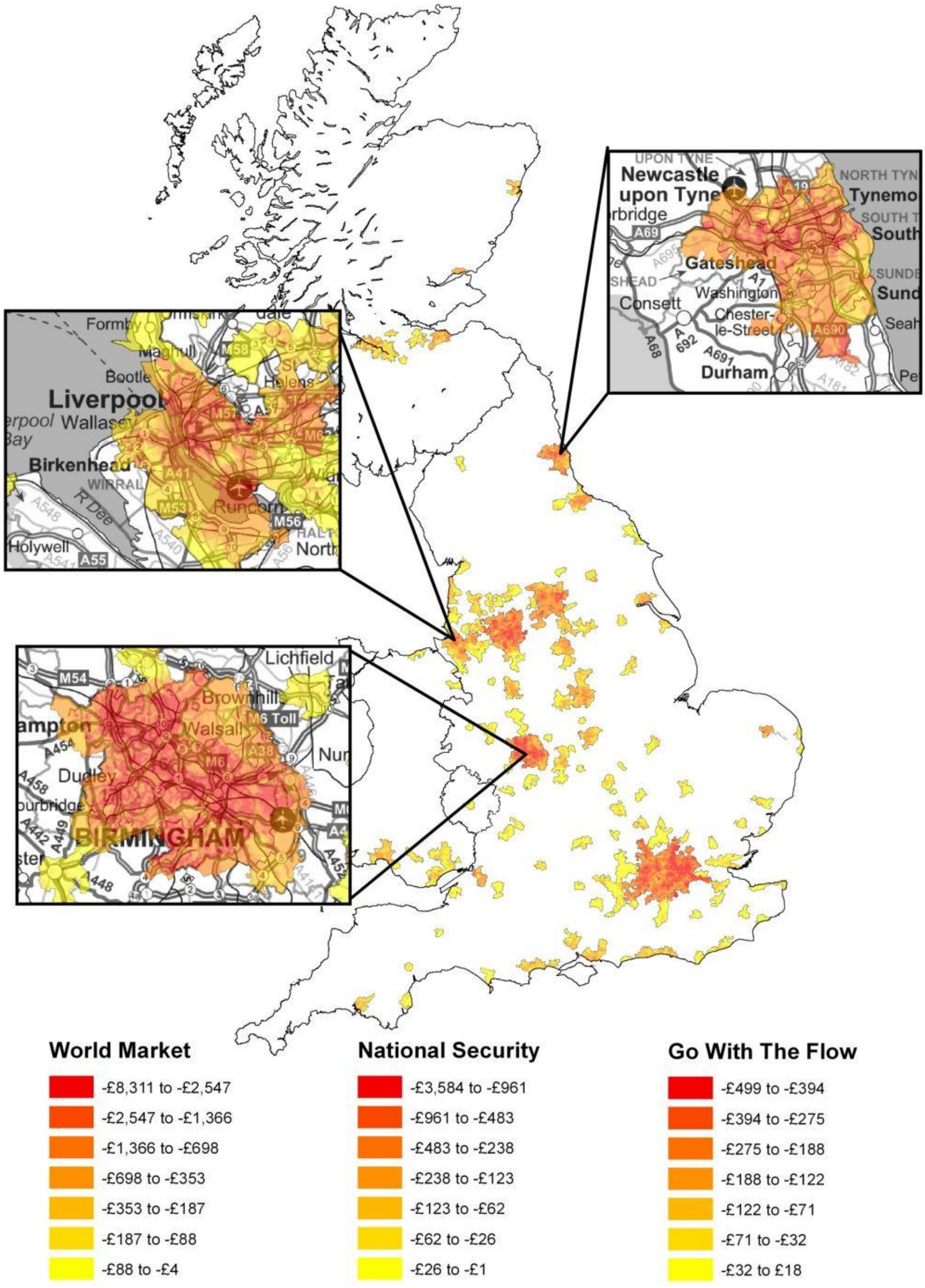


Figure 3.7: Spatial distribution of benefit changes under the scenarios which yield net losses for all cities with a population of 50,000 or more in Great Britain (change in income p.a. from 2060 onwards in 2010 pounds)



3.7.3. Distributional Weights

The H.M. Treasury (2003, Annex 5) recommendations for aggregating benefits are used by applying distributional weights to correct for the fact that the marginal utility of consumption is likely to vary according to the individual. The distributional weights are calculated for each LSOA by dividing the median household income for the UK by the median household income of each LSOA. Median household income for the UK is calculated by ordering all LSOAs by income and calculating the cumulative number of households and then selecting the median. This results in a median urban household income of £25,275 (2008 values). The impact of distributional weights can be seen in Table 3.10 below. Accounting for distributional factors increases benefit changes by up to 30% indicating that changes in the amount of urban green-space would have a greater effect on the poor.

Table 3.10: Benefit changes calculated with distributional weights of scenarios per urban household* and aggregated for all cities with a population of 50,000 or more in Great Britain 2010-2060 (in 2010 pounds).

	Green & Pleasant Land	**Nature@Work**	**World Market**	**National Security**	**Local Stewardship**	**Go with the Flow**
Aggregate Values in Billion £ (using distributional weights)						
Undiscounted Value Change (2010 – 2060)	77.8	167	-672	-268	62.8	-45.4
Change in income p.a. from 2060 onwards	2.49	5.33	-21.5	-8.58	2.01	-1.45
Net Present Value (H.M. Treasury standard discounting)	36.6	78.3	-316	-126	29.5	-21.3
Per Household* Values in £ (using distributional weights)						
Undiscounted Value Change (2010 – 2060)	5,130	11,000	-44,300	-17,700	4,130	-2,990
Change in income p.a. from 2060 onwards	164	351	-1,420	-565	132	-95.7
Net Present Value (H.M. Treasury standard discounting)	2,410	5,160	-20,800	-8,300	1,940	-1,410

* Based on the 15.2 million urban households living in the areas included in the extrapolation.

3.8. Conclusions

Previous research has shown that urban green spaces generates substantial benefits to urban residents (Whitford et al., 2000; Bolund & Hunhammar, 1999; Sanders, 1986; Ulrich, 1984; Kuo and Sullivan, 2001). Using a meta-analysis combined with benefit transfer methods the benefits of urban green space have been quantified in monetary terms for a large proportion of the UK. This analysis shows that changes in the provision of urban green space can create or destroy billions of pounds worth of value. Besides demonstrating the high value of urban green space the methods employed in this study present an important tool for the analysis of policies concerning changes in the amount location and accessibility of urban green space.
While this is a major achievement some caveats of this study need to be acknowledged. Firstly this study could not account for all of the potential benefits that urban green spaces provide for human well-being. Simply living in a green city may provide significant benefits irrespective of whether your home is close to a park (FRS) or not. Likewise living in a green neighbourhood could also provide benefits through simply viewing natural features. These benefits are not captured by the methods applied here (and if they are they form a bundle of goods which cannot be separated). Future work should try and separate out this bundle of goods for example the effects of parks from the effects of street trees. The second major limitation of this study is that the value functions used are only as good as the original studies they are based on and while every effort was made to select only studies that meet certain standards this was hampered by a limited pool of primary studies which was further reduced by our need for studies reporting key spatial variables. Methods employed in the original studies did not allow for the separation of different categories of value created by urban green-space or to what extent sites are substitutes. This makes the transfer of values from one site to another more tenuous as the composition of services and the availability of substitutes might differ between sites. While the original studies as a group were quite representative the absence of data on green-space characteristics (apart from size) and other city characteristics is a major problem. Conducting more primary valuation studies with this in mind could facilitate the disaggregation of benefit categories and improve the robustness of future value transfers.

A further source of problem in this study was the application of the NEA scenarios. Credibly modelling the impact of scenarios (particularly extreme changes such as those implied by the World Market scenario) requires more complex methods than those employed here and raises important questions for decision makers regarding changes in urban land use and populations (which are research topics in their own right). It is also important to note that some of these scenarios (like the World Market scenario) are rather extreme and should thus be thought of as representing worse case scenarios.

While this analysis is clearly useful in terms of asserting the high value of UK urban green-spaces and creating such valuations over a large spatial scale it fails to shed light on the mechanisms underlying these benefits. While it can clearly be seen that individuals value a property more if it is closer to a park it is not known whether they value it more because they want to use the park now (use values), in the future (choice values) or if they just like to know it’s there (so other people can use it).

In conclusion this study has demonstrated how GIS techniques can be used to take secondary data and tease out spatial relationships between green space and economic values. By assembling information on these relationships and then applying them to a representative sub sample of cities it has been possible to transfer these values across the whole country. This process results in nationwide valuation estimates that are far superior to a 1st order approximation as they explicitly account for spatial heterogeneity in both the distribution of urban green spaces and there beneficiaries. This translation of the relationship between green space and well-being into spatial functions which can be applied to areas for which valuation data is not available (and would be highly costly to create) demonstrates the value that analysis of secondary data sets can provide. The widespread coverage of our valuations promises to inform decision making at a scale never previously achieved as well as demonstrating a methodology that can be applied to future valuations at various scales as well as being updated if and when more detailed data become available. Future research will benefit from the increased availability of open source spatial data sets such as those provided by the Open Street Map initiative.

4. Good Parks – Bad Parks: The Influence of Location on WTP and Preference Motives for Urban Parks

4.1. Introduction

Urban parks generate substantial public benefits yet explicit economic assessments of such values remain relatively rare. Surveys of willingness to pay (WTP) were undertaken to assess such values for proposed new parks. The analysis assessed how preference motives and values varied according to the location of parks. Results revealed greater altruistic motivation and higher overall values for the creation of inner city as opposed to suburban parks. Spatial decomposition revealed that, after controlling for other determinants such as incomes, values generally increase for households closer to proposed park sites, but that a significant downturn in values is evident for households located very close to a proposed inner city park; a finding which echoes concerns regarding the potential for such sites to provide a focus for antisocial behaviour. While these findings provide strong overall support for provision of public parks they highlight the importance of location and the potential for localised dis-benefits. This Chapter explores the use of economic methods for quantifying the benefits of urban green spaces through the use of a stated preference study designed to test spatial determinants of WTP. As such this Chapter considers both of the research questions outlined in Chapter 1.

4.2. Background

Urban parks and other green spaces provide a wealth of benefits to urban residents. These include cultural services such as the provision of unique recreation and leisure affordances as well as an array of ecosystem services including noise and pollution abatement (Whitford et al, 2001), climate and hazard regulation (see Davies et al., 2010 for a thorough review). This wide range of benefits combined with an ever increasing demand for natural landscapes within increasingly populous urban areas of the UK results in public parks and green spaces being some of the most valuable land in the British landscape (Bateman, Abson et al. 2011). Despite awareness of the value of urban parks within the UK government (Natural England, 2011) the absence of prices for these benefits makes it difficult to justify both maintenance costs of existing parks and costs related to the creation of new parks. In England local authorities are not legally obliged to provide public parks, and as a result they are rarely prioritised over other revenue generating leisure activities and other statutory services (CABE, 2006).

In the current climate of resource cuts it is vital to ensure that available funds are targeted as efficiently as possible. This may mean that any future provision (or indeed a reduction and refocusing of existing resources) needs to provide the highest possible value of money (VFM). Assessment of such VFM is problematic if the major benefits of public parks remain as unvalued public goods. Given this the number of primary valuation studies of UK urban parks is surprising low (CabeSpace, 2005; Dehring & Dunse, 2006; Dunse et al, 2007; Hanley & Knight, 1992). The present study sets out in part to address this research gap by providing such values using a contingent valuation (CV) survey (Mitchell and Carson 1989) to estimate consumer surplus directly by asking people what they would be willing to pay (WTP) for the creation of two new public parks in the city of Norwich, UK[10]. In addition to providing values the determinants of WTP for the two new parks are explored through testing a parsimonious model of the determinants of WTP that includes both traditionally considered economic and spatial, as well as less commonly considered, attitudinal determinants of WTP.

4.2.1. Determinants of WTP

Previous stated preference studies have found that WTP for new urban parks decreases with increasing distance from the park (Salazar & Menendez, 2005). Here it is presumed that as distance to the good increases, the costs of access rise and so does the ratio of users to non-users. As users are considered to hold higher values than non-users the overall result is that average WTP declines with increasing distance (Bateman, Day et al. 2006). This relationship between WTP and distance to the good has usefully permitted the construction of spatially sensitive value functions for the aggregation and transfer of values (e.g. (Bateman and Langford 1997; Pate and Loomis 1997; Bateman, Day et al. 2006). While in the stated preference literature distance decay for open access public goods is presumed to be linear and non-decreasing numerous hedonic pricing studies have found quadratic or inverted U shape relationships with proximity and resources have been observed for a range of goods such as schools, transport hubs and shops (Day et al 2007). Here it is presumed that people want to be close to reduce travel costs, but far enough away to avoid potential local disammenities such as, noise and traffic. Indeed the value of proximity has been shown to vary for different property types (Dunse et al., 2007) neighbourhood characteristics (Anderson & West, 2006) and park types (Espey & Owusu-Edusei, 2001). In the case of urban parks, perceptions of crime and anti-social behaviour[11] may result in local disammenities and thus inverted U shaped distance decay relationships. The existence of such distance decay relationships would have implications for both park management and planning, as well as the use of value transfer methods for valuing urban parks. Value transfer (or benefit transfer) is the practice of using existing valuation studies to create valuations of sites for no such assessment has been made. As there is an increasing desire to assess the total economic costs or benefits of policies and projects by regulatory agencies and financial institutions so value transfer techniques have become more popular. While value transfer may only ever be a poor substitute for primary site specific valuations the savings made when compared to the costs associated with conducting primary valuations have resulted in it becoming common practice for recreational and natural sites (Rosenberger & Loomis, 2001; NRC, 2005). Crucial to an effective value transfer methodology is the incorporation of spatial relationships such as the distance decay of WTP values. Coefficients of distance are often used in value function transfers (Bateman et al.,

[10] The proposed new parks are entirely theoretical.

[11] A UK based poll showed that whilst 91% of people agreed that public parks and open spaces improve their quality of life, one in five respondents felt that investing money in park maintenance was not justified as they will just get vandalised (CABE, 2004).

2006) and as such any derivations from the expected linear decreases in WTP values at increasing distance will have significant implications for value transfer practices.

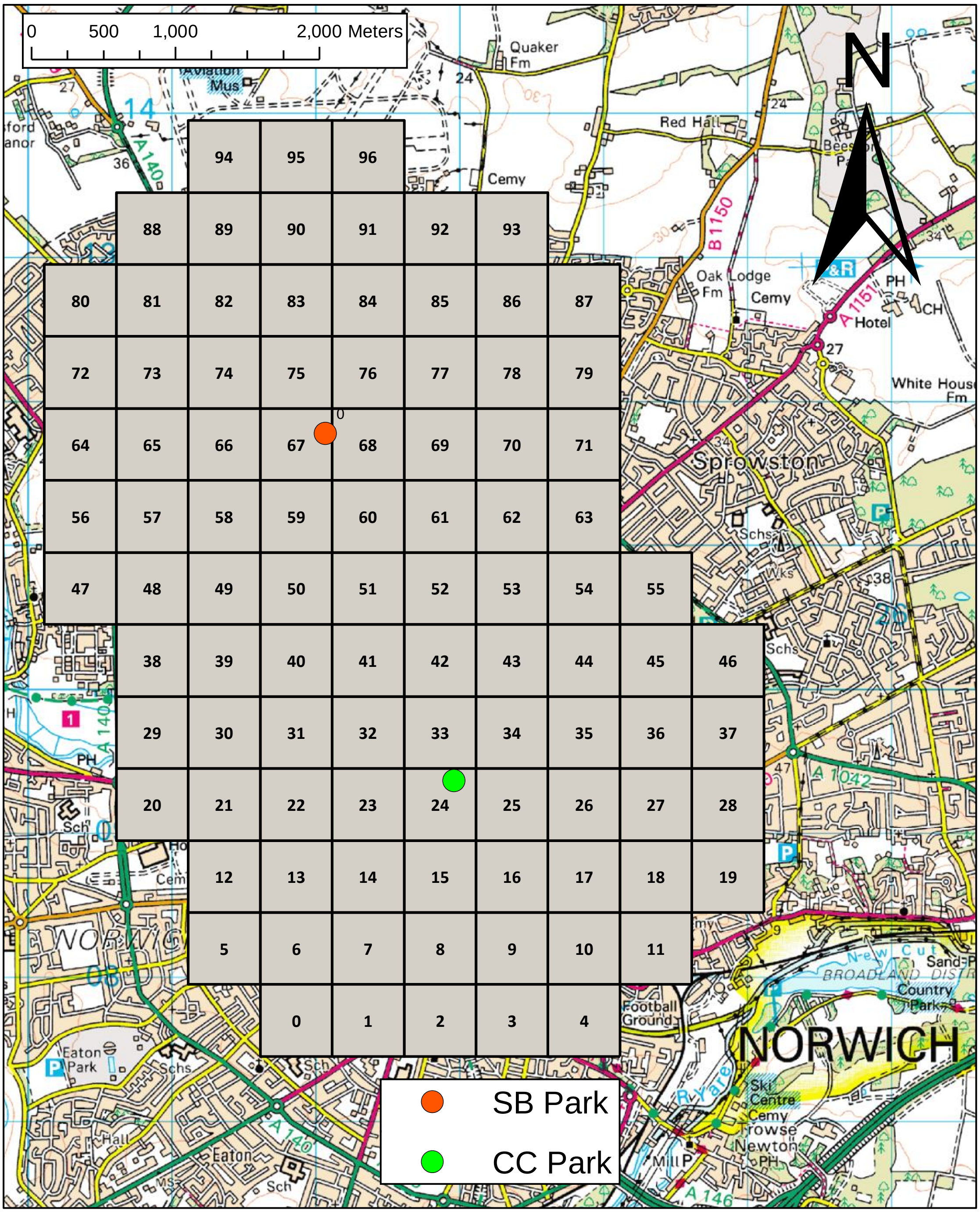
To account for potentially complex distance decay relationships in our model flexible semi-parametric approaches are employed (Ferrini and Fezzi 2012) to the modelling of WTP bids which through the use of smoothing functions avoid the imposition of specific functional forms to the modelling of consumer preferences.

While urban parks provide obvious use values they also provide significant non-use values in terms of the value they provide for other potential users and the environment. Such values may be motivated by other regarding behaviour whereby an individual includes the utility others gain from usage or potential usage of a good in their own utility function. Previous studies have demonstrated that attitudes can be a significant predictor of WTP for non-use values such as the protection of endangered species (Kotchen & Reiling, 2000). Indeed the presence of altruistic values may compensate for decreasing use values at increasing distance to the good and thus act as a moderator variable in the distance WTP relationship. Hanley et al. (2003) found that use values decreased more rapidly with distance than non-use values and suggests that distance decay will vary both spatially within a resource type and across different resource types. As stated preference methods measure both use and non-use values, a proxy measure of environmental concern is used to account for the potential influence of other regarding attitudes on WTP. While attitudes are object specific, values are general and abstract and often exhibit weak relationships with behaviour. As such the General Awareness of Consequences (GAC) scale is employed to measure a general attitude towards environmental behaviour, developed within the context of Sterns socio-psychological theory of environmental concern. It is a condensed version of the awareness of consequences scale (Stern et al., 1993 and has been shown to be very similar to the NEP scale (Stern et al., 1995) but with a greater focus on detecting underlying values such as altruism and self-transcendence. Studies have shown that individuals with self-transcendent and collective values are more willing to engage in different forms of altruistic, cooperative, or pro-environmental behaviour than those with individualistic or self-enhancement values (Nordlund and Garvill: Karp, 1996; Schwartz, 1992; Stern & Dietz 1994; Stern, Dietz & Black 1985-1986; Stern, Dietz & Guagnano, 1998). By accounting for the heterogeneous nature of participants other regarding attitudes the influence that such attitudes have on WTP can be observed in addition to any differences in the influence of attitudes on WTP between the two locations. This proxy measure of other regarding attitudes can also be used to test for a moderating effect of attitudes on the distance decay relationship whereby the value of distance is dependent upon the participants attitudes.

By proposing two identical parks that vary only in their location differences in both WTP values and motivations can be attributed to differences in the proposed locations. As such two locations which were both plausible whilst differing in their potential to be perceived as generating local disammenities and other regarding values were chosen. The first park, located in the city centre (CC) represents a highly accessible location however the area is visibly run down being home to an unfinished shopping complex (Anglia Square). While the CC location promises greater social benefits in terms of its accessible and deprived location this is a double edged sword as this run-down area is known to be frequented by drug addicts. It is possible that if distance decay in values is detectable then it will be non-monotonic due to the presence of local disammenities for the CC location. The second park (SB) was located near the cities outer ring road in a suburban location, representing an un-controversial location, the strength of participant's preferences is likely to be based on traditional economic motives i.e. budgetary constraints and use values as proxied by distance. The locations of the proposed parks can be seen in Figure 4.1 below. Although neither site is intended to be the best site for a new park, the two sites are for the most comparable, being next to large roads and shopping facilities; in addition, both imply redevelopment of disused buildings.

While the creation of both parks would involve urban re-development, the creation of the city centre park would involve highly visible changes in a clearly run-down area including the removal of a well-known abandoned building. It is hypothesised that both of these factors will contribute to the relative "other regarding" value perceived to be created by the two locations by residents and thus make the CC location more appealing to those with altruistic type attitudes.

Figure 4.1: Study area showing 96 sampling squares and sites of proposed Parks.



(Crown Copyright, Ordnance Survey Ltd.)

4.2.2. Aims and Research Questions

In this study the potential for CVM methods to measure the benefits of urban parks in Norwich, UK is explored. Due to the innate spatial nature of these goods particular attention is paid to the role that spatial relationships have in the modelling of WTP for urban parks. These spatial relationships have broader implications for environmental valuation as they are used extensively in both stated and revealed preference valuations. Spatial variables such as distance are used both in the construction of value functions and in determining aggregation areas without having to rely on political jurisdictions as well as increasingly being found in value transfer techniques. As such this study considers 3 research questions the first two of these can be considered sub-questions of the first research question outlined in Chapter 1 while the third, spatial question can be considered a sub question of the second research question of Chapter 1:

i) To provide economic values for the creation of two new parks in Norwich.
ii) To explore the influence that environmental attitudes on WTP for two new parks in Norwich.
iii) To explore spatial relationships that influence WTP for new parks in Norwich.

4.3. Methods

In accordance with the recommendations of the NOAA panel (Arrow et al., 1993) surveys were administered face to face at participant's homes. This enabled us to remind respondents of their budgetary constraints as well as the existence of potential substitute sites. Participants were informed that "we are researching the value of parks to the people of Norwich" and wished to interview people about their experiences and views. Interviewers were recruited internally from the university student population and were selected to facilitate testing of interviewer biases. All interviewers had a smart professional appearance and carried university ID cards so that participants could confirm their identity. Strict ethical guidelines were followed by the interviewers who made it clear to participants that their participation was entirely voluntary, that their data could be removed from the study at any point upon their request and importantly that the parks they were valuing were entirely theoretical and the results would only be used for research purposes. Initial piloting of the WTP questions using a small student sample resulted in refinement of the WTP question wording and payment vehicle used. Further piloting of the full survey instrument allowed for further refinements mostly targeted at reducing the overall time it would take to complete the survey.

The study area was defined by drawing a 1.5 mile circular buffer around each proposed park location. These two circles were joined together and a grid of 96, 500 m^2 sampling squares (shown in Figure 4.1) draped over this area. The resulting study area has the advantage of covering the majority of the Norwich city local authority area whilst also extending to the edge of the greater Norwich area (see Figure 4.1). Sample squares were selected from this grid using average values of the 2007 English index of multiple deprivation scores (IMD 2007) for all postcodes within each study square, postcode centroids were used to identify postcodes within each study square and thus avoid the problem of postcode polygons crossing sample squares. These values were plotted against the average straight line distance of all postcode centroids within each square to each of the proposed parks. Squares were then sampled from the resulting plot to provide a representative set both in terms of deprivation and distance to each of the parks.

4.3.1. Park Choice and WTP Questions

In order to establish the direction of participant's preferences and ensure participants had understood our proposal participants were asked which of the two parks they would prefer to be created if only one could be created. Participants were asked in an open ended format to explain their choice and to categorise their expected usage of the park into one of four categories. Assuming participants were familiar with the goods in question and that sufficient information had been provided for them to understand our proposal, interviewers explained that the significant costs of creating the new parks would be met through an increase in their annual council tax bill. This was chosen over an entry fee due to its compatibility with the public provisioning of urban parks in the UK. A compulsory payment vehicle such as a tax increase also has the added advantage of reducing free riding behaviour. It thus makes fairness implicit in the valuation increasing the weight of other regarding motives. In order to compare the effect of the park locations, each participant was asked three valuation questions, their maximum WTP for the creation of: i) the CC park alone; (ii) the SB park alone; (iii) the creation of both Parks[12]. A payment ladder flashcard was presented to participants to select values from (the interview wording and flashcards used can be found in Appendix 4.1). In order to rule out potential ordering effects (Halvorsen, 1996) the order in which the park valuation questions were presented on alternate sampling days.

4.3.2. Protest Bids

The presence of protest bids can introduce significant bias into WTP results, a problem confounded by the lack of any consensus on how they should be treated (Boyle and Bergstrom, 1999, Meyerhoff and Liebe, 2006). Their inclusion can lead to a downward bias in predicted values (driven by non-economic motives) while there removal can lead to a self-selection bias in the sample. This is particular important given our interest in non-economic motives. Protest bids are defined as a response which does not reflect the respondents genuine WTP but instead a zero or an unrealistically high or low value (Bateman et al., 2002). While true zeroes are the reservation price for individuals who are indifferent to the proposed change (Strazzera et al., 2003). To distinguish between the two, an open ended question asking participants to explain the reasons for a zero bid was used. An optional don't know response was offered to accommodate participants who did not have sufficient information to complete the valuation.

4.3.3. Participant Characteristics

Key socio-demographic variables were collected from each participant including age and household characteristics. Budgetary constraint was measured using both the number of dependents (under 18) and the total annual household income (facilitated by means of a flash card showing income categories see Appendix 4.1). Altruistic attitudes were proxied by measuring participant's environmental concern with the general awareness of consequences

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[12] Collecting values for the creation of both parks allows as us to observe any diminishment in values when compared against the value of a single park.

scale. The GAC was administered in its original self-complete format towards the end of the survey. To minimize potential bias in the GAC participants were re-assured that interviewers would not see their responses and were given an envelope in which to seal there completed scale.

The distance from each participant's geographic postcode centroid to the geographic centroid of the two parks was calculated using ArcGIS network analysis and the Ordnance Survey Integrated Transport Network (TM). Norwich postcodes can contain anything from 1 to 100 addresses and as such the use of postcode centroids introduces a significant amount of spatial error in distance calculations and significantly reduces the variability in the distance variable as many participants shared the same postcode. The average size of the postcode polygons used in this study was 14639 m^2 (with a range of 456 m^2 to 102255 m^2, std dev = 15708 m^2). (November 2007 version of the NSPD used).

4.4. Results

4.4.1. The Sample

Three interviewers collected 386 completed surveys[13]. 64 participants refused to value the CC park and 61 the SB park Follow up questions revealed that the majority of these responses were attributable to the payment vehicle. These participants felt that council tax was already too high and refused to pay any more on this basis. A further 13 participants gave don't know responses for the value of park A (14 for park B) and 4 participants gave bids over £150 for the CC park (5 for the SB park). Out of the original sample of 386 participants, 37 failed to provide their household income. Removal of these participants and the above outliers gives a final sample of 270 participants with 270 bids for the CC park and 268 for the SB park.

No significant differences were found between the means of the study variables between the two ordering treatments ruling out any potential ordering effects. Comparison of socio demographic characteristics of our sample with the study area reveals no significant differences in the distributions of age in our sample and those calculated from the 2001 census[14] for every postcode in the study area (z=-0.399, 0.69). Comparison of income values[15] reveals that the distribution of incomes is significantly higher in the study area. While there was a significantly higher number of dependents per household than the average for the study

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[13] Two male (22 and 26 years) and one female (51 years) interviewers were recruited, no significant differences were found between the estimated age of refusals and respondents (t = -0.111, p = 0.912). 568 individuals declined to be interviewed giving a 40% response rate. Of those who declined 53% were female and 46% male. This study was conducted in September 2009.

[14] Mean ages were calculated from mid points of census frequency data for all over 18s.

[15] Study area median household incomes were extracted from the Experian Mosaic data set at the LSOA level.

area. These test results and descriptive statistics for both our sample and the study area can be found in Appendix 4.2.

4.4.2. Environmental Attitudes

The GAC scale measures individual's environmental concern by asking participants how much they agree with statements regarding environmental degradation and protection. While the GAC scale is designed to measure 3 value orientations (biospheric, egoistic and altruistic) based on if the action occurs to avoid consequences for nature, the self or others respectively. Factor analysis of the GAC item scores revealed a lack of clear dimensionality in terms of the three value orientations, confirming the results of (Ryan & Spash, 2008) who found that the GAC scale cannot be relied on to describe three value orientations. As a result all subsequent analysis utilises the mean of all GAC item scores (percentage responses for the 9 item GAC scale and factor analysis results can be found in Appendix 4.3).

4.4.3. Park Choice Results

246 Participants stated that they would prefer the CC park to be created over the SB park leaving 133 choosing CC and seven giving a don't know response (Table 4.1). Showing a clear preference for the creation of the CC park. Roughly 47% of those who chose CC referenced the city centre location, a need for regeneration or altruistic reasons in their qualitative responses to why they chose each park. Indicating that a significant number of people expressed a preference for the CC park based on its location. In contrast, the reasons given for choosing the SB location where dominated by distance, access and a dislike of the Anglia square area (CC park site). The percentage of park choice reasons for both parks can be seen in Appendix 4.4. 70% of the sample chose the park closest to them, however of the 118 not choosing their closest park, some 81 (nearly 70%) chose the CC park. Indeed only 55% of those living closer to Park SB actually chose the latter as their preference. Taken together these results show a strong overall preference for the CC location[16].

Table 4.1: Cross-tabulation of park choice preferences.

		Choose CC Park	Choose SB Park	Total
Closer to CC	Count	165	37	202
	% of total sample	45	10	53
Closer to SB	Count	81	96	177
	% of total sample	21	25	47
Total	Count	246	133	379
	% of total sample	65	35	100

[16] Comparison of the incomes of those who choose park B with those who choose park A shows no significance difference (Mann-Whitney N = 280 z = 0.554 p = 0.5798). Comparison of the gender split of the two park choice categories also shows no significant difference with 43.84% of those choosing A being male compared to 45.54% of those who choose B.

A Probit model was fitted to participant's park choice responses using a Boolean variable coded so that one represents a choice of the SB location and zero the CC. Results of this model are shown in Table 4.2. The natural log of distance to the CC location has a significant and positive effect on park choice showing that the further away from the cc location participants are, the more likely they were to choose SB *ceteris paribus*. The coefficient for the natural log of distance to the SB location is negative indicating that the further away from Park B the less likely you are to choose the SB location *ceteris paribus*. The mean total GAC score also shows a significant negative relationship with the likelihood of choosing SB indicating that participants who express greater environmental concern are less likely to choose the SB location. This provides clear evidence that participant's preferences over the two locations are significantly influenced by their environmental concern. The categorical park use variable was converted into a single dummy variable with one equal to a participant intending to use a park at the SB location. Increasing intended usage has a significant positive effect on participant's choice of SB. The inclusion of use variables and distance is potentially problematic due to expected confounding; however the strongest correlation was found between the distance to SB and use of SB variable was relatively low (-0.3824).

Table 4.2: Probit park choice model, (1=choose park SB), N=374.

Variable	Coefficient (s.e.)	Z	P > Z
Log Distance to CC Park	0.95 (0.22)	4.42	0.000***
Log Distance to SB Park	-0.41 (0.13)	-3.10	0.000***
Use SB Park	0.89 (0.16)	5.62	0.000***
Mean of all GAC items	-0.31 (0.13)	-2.35	0.019**
Intercept	-4.04 (2.22)	-1.82	0.069*
Pseudo R^2	0.24		
P	0.000***		

Significance levels: ***=0.01;**=0.05; *0.10

4.4.4. WTP Results

Comparing the WTP bids for the two locations using a t-test confirms a significant difference (t = 3.411, p < 0.001) with the CC park location having higher mean WTP. Participants were classified as users and non-users based on their response to the park usage questions. Users have higher mean WTP than non-users while also living closer to the park being valued (Table 4.3). Kurtosis tests confirm that the distance, income and GAC measures are non-normally and thus non-parametric (Wilcoxon rank sum) tests of difference were performed between user and non-user groups. Significant differences were found between the distance of users and non-users of both the CC park (Z = -4.890, p = 0.000) and the SB park (Z = -5.930, p = 0.000).

While no significant differences were found in the distribution of income values for both the CC park (z = 2.145 p = 0.0320) and the SB park (z = 1.947 p = 0.0515). Mean GAC scores for the CC park are higher for non-users than users while for the SB park they are higher for users than non-users. Mann Whitney tests on the difference between the GAC scores of users and non-users show a significant difference for the CC park (z = 2.815 p = 0.0049 N = 319) and the SB park (z = -2.306, p = 0.0211, N = 317).

Table 4.3: Mean WTP (£) Missing income, protest and bids >£150 removed and Breakdown of bids (N's in parenthesis). Mean WTP for both parks = £31.71 (N = 270).

<table>
<tr><th></th><th>Protest Zeros</th><th>Genuine Zeros</th><th>Mean WTP</th><th></th><th>N</th><th>Mean Distance</th><th>Mean WTP (£) (s.d.)</th><th>Mean GAC</th></tr>
<tr><td rowspan="2">CC Park</td><td rowspan="2">64</td><td rowspan="2">90</td><td rowspan="2">£23.14 (270)</td><td>Users</td><td>191</td><td>2598 (972)**</td><td>30.06 (35.18)</td><td>4.04 (.57)</td></tr>
<tr><td>Non-Users</td><td>129</td><td>3195 (1101)**</td><td>12.60 (25.02)</td><td>3.85 (.55)</td></tr>
<tr><td rowspan="2">SB Park</td><td rowspan="2">61</td><td rowspan="2">104</td><td rowspan="2">£19.11 (268)</td><td>Users</td><td>141</td><td>2487 (1316)**</td><td>27.10 (35.12)</td><td>3.88 (.56)</td></tr>
<tr><td>Non-Users</td><td>177</td><td>3524 (1365)**</td><td>12.27 (20.26)</td><td>4.03 (.56)</td></tr>
</table>

4.4.5. Marginal Effects

To test whether WTP values are diminished when valuing multiple parks the sum of WTP values for parks A and B is compared with the WTP values given for the creation of both parks. A t-test confirms a significant difference between the means of WTP for both parks and the sum of WTP for both parks (t = 8.0202 p = 0.0000). This implies that there is a diminishment of WTP values when valuing the creation of more than one park.

4.4.6. Testing for Preference Reversals

Our study design permits us to examine the preference reversal phenomenon first reported by Slovic & Lichtenstein (1983). This occurs where a respondent faces the choice between two options and can expresses values for each option. Slovic & Lichtenstein note that in their experiment in a significant minority of cases the chosen option did not receive the highest valuation. It can be seen from Table 4.4 that of those who choose the CC park some 97 participants were willing to pay more for CC while 3 were willing to pay more for SB, and of those who chose SB just 4 were willing to pay more for CC while 42 people were willing to pay more for SB. This preference anomaly is quite clearly not present in our own experiment. This finding affords an interesting perspective on the original Slovic & Lichtenstein study, which concerned choices between and valuations of casino gambles. Bateman et al., 2008 provide evidence to suggest that the occurrence of such preference anomalies may be positively linked to the degree of uncertainty experienced by respondents. The lack of preference reversal in our study suggests that a high familiarity with the goods in question engendered low levels of uncertainty. This finding tends to reinforce the credibility of our overall valuation and choice results.

Table 4.4: Frequency of choices to test for reversal of preferences

	Choose CC	Choose SB
Frequency of WTP CC > WTP SB	97	4
Frequency of WTP CC < WTP SB	3	42

4.4.7. WTP Models

Initially Tobit models were fitted for each park, testing linear, log and quadratic forms of distance. Here the strongest (quadratic distance) models are reported in Table 4.5 (see Appendix 4.5 for all Tobit models). A positive effect of median household income on WTP was found but this was only significant for the SB park. The number of dependents (under 18s) in the household had a significant negative effect on WTP for both parks. These results are consistent with the effects of a budgetary constraint on WTP which appears to be more pronounced for the SB park.

The mean of all GAC scale items showed a significant and positive effect on WTP ceteris paribus for the CC park but no significant effect on WTP for the SB park. This confirms that non-economic motives can have a significant effect on WTP but that the significance of attitudes to WTP bids is dependent on the location of the park. The absence of a significant effect of GAC on WTP for the SB park suggests that participants WTP is based on use based motives. This is further emphasised by the significance of distance for all functional forms of distance for the SB park (Appendix 4.5). WTP for the CC park appears more sensitive to the functional form of distance with only the quadratic form achieving statistical significance. To test for a moderating effect of attitudes on distance decay an interaction term between GAC and distance was included in each Tobit model. No evidence was found for an interaction effect for either park (see Appendix 4.6). By testing the Tobit specification against the alternative model that is non-linear in its regressors and contains a heteroskedastic and non-normally distributed error term[17] both Tobit models were found to be miss-specified (CC park lm = 43.69, critical lm at a 10% significance = 2.83, SB park lm = 36.74, critical lm @ 10% = 3.58). As a result the coefficients produced from these models are unreliable.

Based on Ferrini & Fezzi (2012) Generalised Additive Models (GAMs) were used in an attempt to incorporate non-linear relationships through the use of smoothing functions and achieve a correctly specified model (Table 4.5). Given the theoretical importance of distance in WTP for spatial goods (e.g. Bateman et al., 2006) and the apparent sensitivity of our prior models to the functional form of distance, the GAM model were used to apply a non-parametric smoothing function to the distance measures within a Poisson log link regression model. This avoids the need to impose a priori assumptions concerning the shape of the distance decay. It also has the advantage of allowing us to further explore potential interaction effects between distance and attitudes without the confounding that would result from including both a quadratic and GAC*distance interaction. The number of dependents and median household income remain as standard parametric variables as in the prior Tobit models.

[17] Using Stata's bctobit command

Table 4.5: WTP regression models (standard errors in parenthesis).

Predictors	Tobit		GAM	
	CC Park	SB Park	CC Park	SB Park
Distance	0.034** (0.014)	-0.023 (0.009)***	Smoothed Distance: Edf = 2.28 Ref.df = 2.849 P = 0.047**	Smoothed Distance: Edf = 1.859 Ref.df = 2.341 P = 0.0007***
Distance (sqrd)	-0.000006*** (0.000002)	0.000003** (0.000001)		
GAC	11.423** (4.828)	2.707 (4.451)	0.29 (0.14)**	0.08 (0.14)**
Income	.0002 (.0001)	.0003** (.0001)	-0.20 (0.09)*	-0.22 (0.08)**
No. of Dependents	-5.670** (2.430)	-4.533** (2.284)	0.000006 (0.000003)**	0.000008 (0.000004)**
Constant	-72.913*** (27.029)	31.378 (21.286)	1.86 (0.58)***	2.49 (0.59)***
R^2	.060	0.066	R^2 = 0.05 (8.68% Var. Explained)	R^2 = 0.06 (7.97% Var. Explained)
N	270 (79 left censored)	268 (88 left censored)	270	268

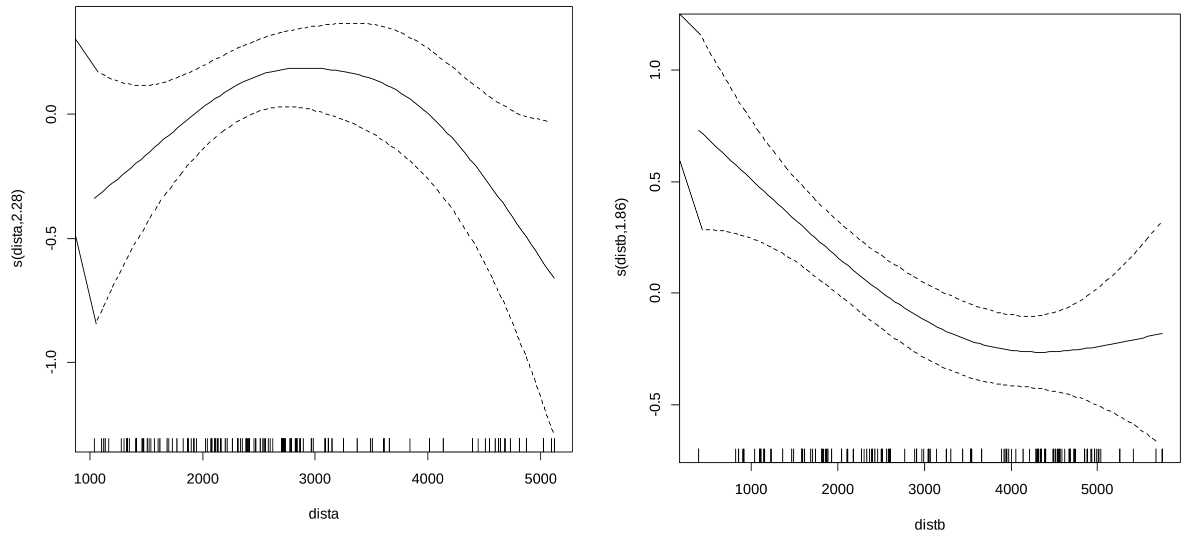
Significance Levels: * = p < 0.1, ** = p < 0.05, *** = p < 0.01

The GAM models show a similar pattern of results to the Tobit models, again the GAC score has a significant positive effect only on WTP for the CC location, confirming our initial suspicions that this location is perceived to offer more altruistic value. The effects of income and the number of dependents in the GAM models are reassuringly consistent with the Tobit models. The EDF (effective degrees of freedom) of the distance smoothing functions (Table 4.5) indicates the estimated degree of "wiggliness", an EDF of one would indicate that the best approximation of the smoothing function would be linear. Again no evidence for an interaction between GAC and the smoothed distance function was found (see Appendix 4.6 for interaction models).

4.4.8. Evidence for the localised dis-amenity of city centre parks

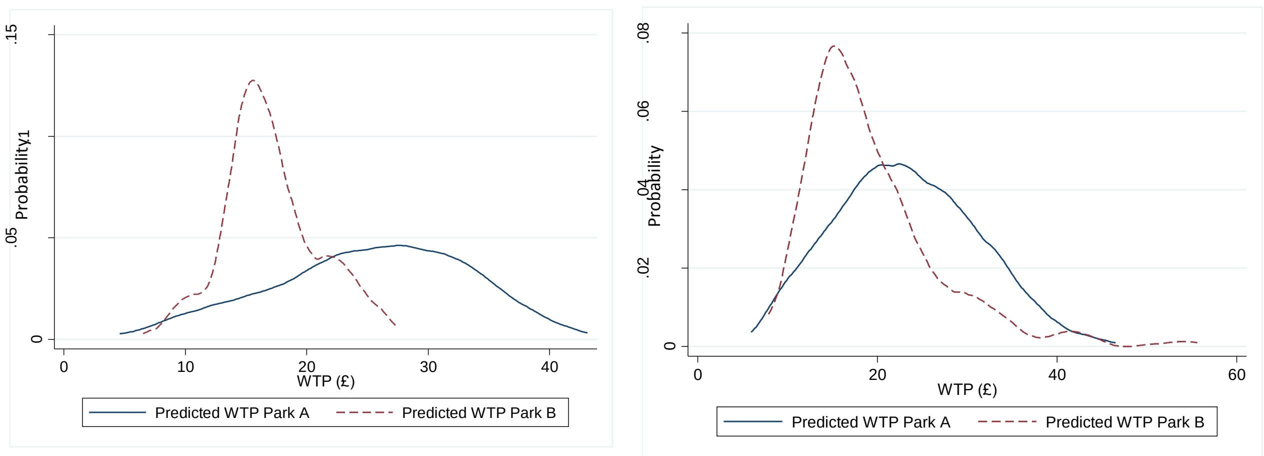
Figure 4.2 shows canonical plots of our smoothed distance parameters both distance variables are clearly nonlinear (with the SB model closer to linearity than the CC park) and both coefficients are significant. By not implying rigid assumptions concerning the functional form of distance decay relationships distinct differences in the shape and statistical significance of distance WTP relationships can be observed. For the CC park, WTP increases with distance until approximately 3000 metres at which point it starts to decrease with distance. This is contrasted by the slope of the smoothing function for distance to park B which shows decreasing WTP with distance up to approximately 4000 metres at which point it plateaus and then turns slightly positive likely due to the reduced number of observations at these high distances. This n shaped curve confirms our suspicions that despite the overall preference shown by participants for the CC park it appears to produce local disammenities.

Figure 4.2: Estimated canonical parameters distance decay functions (equal to the linear predictor) for distance to park A (left) and distance to park B (right).



There is a consistent difference in the distribution of predicted WTP values for the two parks (Figure 4.3) with median WTP for the CC park being consistently higher and with a broader distribution of WTP values (descriptives of predicted values for all models can be found in Appendix 4.7).

Figure 4.3: Predicted WTP values (in sample) distributions for parks A and B (left Tobit model, right GAM).



To demonstrate the difference between the GAM and Tobit models reported above, Figure 4.4 and 4.5 below show mean household WTP for the CC park predicted for all postcodes in the study area (details of data sources used for out of sample predictions can be viewed in Appendix 4.8). The Tobit map on the left shows the expected monotonic decay with values decreasing with increasing road distances from the CC park. While the GAM map shows a large local disammenities with lower mean WTP in the immediate vicinity of the CC park which steadily increases before decreasing.

Figure 4.4: Predicted WTP by Tobit model (quadratic distance) £ per household (no protestors) for the study area (2740 postcodes).

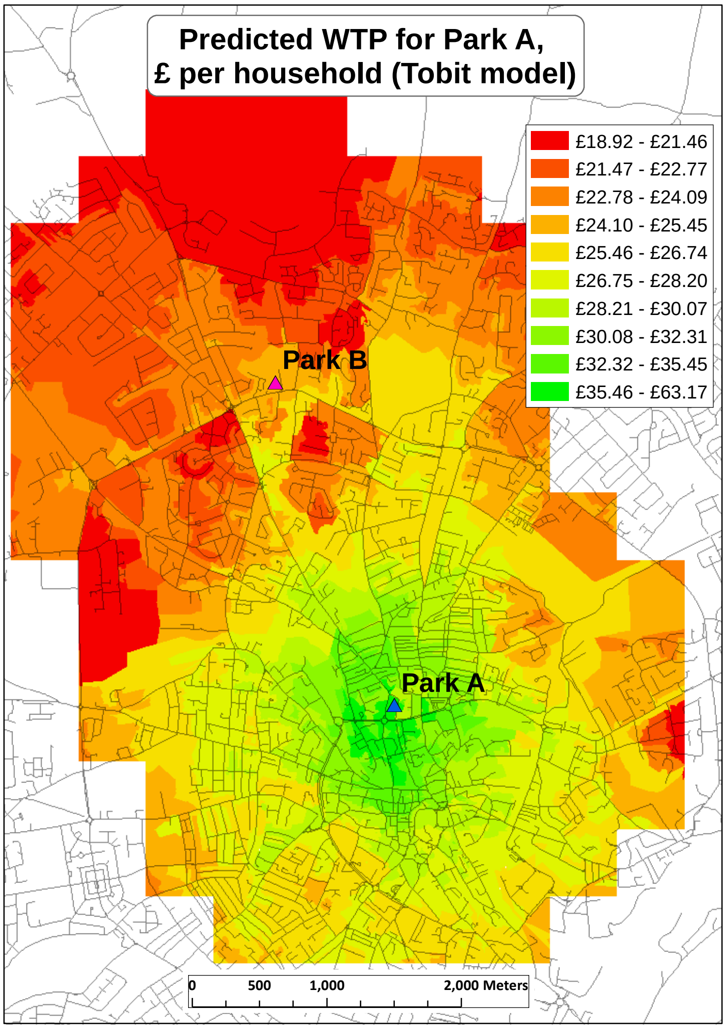


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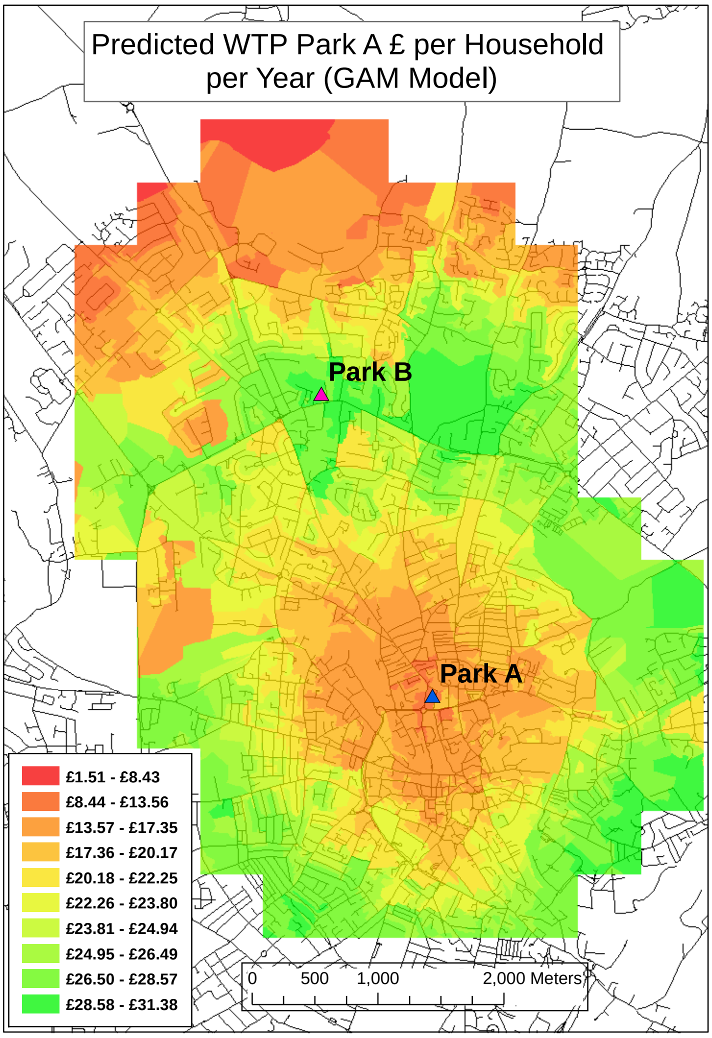
Figure 4.5: Predicted WTP (GAM model) £ per household for the study area (2740 postcodes)



(Crown Copyright, Ordnance Survey Ltd.)

4.4.9. Aggregation

In a decision making context the total annual benefit that a new park could bring is more useful to policymakers than mean WTP values. Whilst it is possible to simply estimate the total annual benefits by multiplying the average WTP for each park by the number of households in the aggregation area required this would not allow for the fact that the population of households may exhibit different distances and incomes than our sample. If it is presumed that the sample is representative of the wider population then the relationships with WTP should hold for the population (i.e. coefficients for the sample will be the same as for the population). Similarly relationships between WTP and distance should hold, allowing a value function transfer to be made. Here the WTP model is used to predict the WTP for areas without WTP responses.

Aggregated values of the two parks for the study area and a larger 10 mile buffer of the city center are presented in Table 4.6 below. The first row shows a simple aggregation based on the mean WTP of each park. For the Tobit and GAM based aggregations two sets of aggregations are presented. The first treats the preferences of protestors as if they are the same as non-protestors (i.e. by excluding them). This method may well over estimate aggregate WTP as a result of ignoring the preferences of protestors. The second method presumes that protest zeros are genuine economic preferences and thus uses the protest rate of the sample to set 6.5% of households in each aggregation population to a WTP of zero. If these aggregations are compared for the study area it can be seen that the Tobit models produce very similar aggregate values for park A (Mean based = £1,130,674, Tobit based = £1,297,970) when protestors are ignored. The inclusion of a lower bound to account for protestors in the Tobit model also resulted in similar values to the equivalent mean based aggregation (mean based = £933,302 Tobit based = 1,140,256). The study area aggregations based on the GAM model were relatively similar but lower than those based on the Tobit models and thus even closer to the mean based aggregations.

Table 4.6: Tobit and GAM Model based aggregations for the study area and a ten mile buffer of Norwich. Simple aggregations are based on a mean WTP of £23.14 for the CC park and £19.11 for the SB.

	Study Area = 49,591 households in 2,743 postcodes		Ten Mile Aggregation = 106,576 households in 6,442 postcodes	
	CC Park	SB Park	CC Park	SB Park
Aggregation based on mean WTP (bids >150 protest zeros and missing incomes removed)	£1,147,536	£947,684	£2,466,169	£2,036,667
Tobit aggregation Model (protests removed)	£1,297,971	£1,005,133	£2,484,897	£1,846,733
Tobit aggregation Model (6.5% of households zero)	£1,140,256	£886,763	£2,323,379	£1,726,695
Aggregation based on GAM model with (protests removed)	£1,114,849	£905,259	£1,863,520	£1,909,985
Aggregation based on GAM model (6.5% households zero)	£1,042,384	£846,417	£1,742,392	£1,785,836

The expansion of the aggregations to a ten-mile circular buffer of Norwich results in a significant difference between the Tobit and GAM based aggregations. The GAM models produce significantly lower aggregate values than the Tobit and the gap between the two parks begins to decrease. This is to be expected as the GAM models are trained on a set of distances with a much lower range than those used in the ten-mile aggregation. While these models are theoretically more accurate in their ability to estimate the functional form of non-linear variables they represent a trade-off in terms of a loss of predictive power for out of sample data.

4.5. Discussion and Conclusions

Results of our CV survey have shown that the creation of new parks in the city of Norwich has the potential to generate substantial value to residents. A low protest bid rate in our sample seems to confirm that not only do people value urban parks but that at least in principle they are willing to pay for increased provisioning through a familiar and realistic payment vehicle. Using an ex ante valuation allowed us to compare values and preference motives for two locations revealing significant differences in both mean WTP and its determinants. Results of a simple choice experiment of which park should be created revealed that 65% of the sample would prefer a park to be created at the CC location. While participants were more likely to choose the park closest to them variations in levels of participant's environmental concern also had a significant effect on their park choice.

This preference for the CC location was also evident in WTP bids with significantly higher mean WTP for the CC location than the SB. Examination of the determinants of WTP for each park reveal consistent differences in the effects of distance. Both the concave quadratic specification of the Tobit and smoothed distance curve of the GAM model indicate that participants prefer to live close to this park but not too close. In contrast WTP for the SB park decreases steadily to a distance of approximately 4000m at which point a slight upturn in values occurs. These differences in both the shape and magnitude of distance decay can only be attributed to differences in participant's perceptions of the two locations. This has implications for the practice of value transfer in which spatial value functions are used to transfer values from one site to another. These results indicate that if such methods are to be effective then they must be sufficiently complex to account for variations in participants perceptions of place in relation to the spatially good being valued.

While the author speculates that it is an increased fear of crime and anti-social behaviour at this site that drives this disamenity further research is needed to qualify what exactly it is about the locations that cause these differences. While it has been seen that distance decay relationships are influenced by location this study has also observed different effects of attitudes on WTP values with increased levels of environmental concern causing a greater increase in WTP for the city centre park. While much debate surrounds the inclusion of such non-use values in cost benefit analysis attitudes such as environmental concern do have an effect on preferences which to a policy maker is important whether these values are included or not. Even if these values are not included in a final cost benefit analysis understanding peoples preference motives can help us to increase the value available to the public through both provisioning and information campaigns targeted at changing people's attitudes.

While environmental concern had a significant effect on participants preference as to which park should be created it was initially found to only be a significant predictor of WTP for the CC park thus supporting previous empirical findings that non-economic motives can be relevant to individuals WTP for goods with non-use values (Ojea and Loureiro 2007; Cooper, Poe et al. 2004).. While higher levels of environmental concern were associated with increased WTP for the CC park (consistent with their negative affect on participant's probability of choosing the SB park) Tobit models failed to detect any significant effect of environmental attitudes on WTP for the SB park. The introduction of a smoothed distance term in the GAM models allowed it to reach significance suggesting potential cofounding between distance and environmental concern; however no significant interaction effects between distance and GAC could be found.

As spatially referenced data is increasingly used to improve the cost effectiveness and validity of environmental valuations (through value transfer techniques etc.) one should be aware of the effects of the goods location on its perceived benefits. Value functions must not only account for variations in observable park characteristics but also locational characteristics that determine individual's perceptions of place. While the use of distance decay functions in the measurement and aggregation of WTP values is a huge improvement over aggregating mean values. The use of such functions to transfer values to new sites needs to account for the potential influence that location can have on both distance decay relationships and the effects of attitudes on WTP. Also the importance of considering the marginal nature of park valuations is emphasised as if ignored may well result in overestimation of aggregate values over many sites.

In conclusion this study has shown that due to the implicitly spatial nature of public goods such as urban parks no two parks are created equal. Even when the two parks offer the same facilities the value they create will depend on other spatial factors determined by the interaction of individual's attitudes with their perceptions of that specific location. This is an important finding for decision makers as it shows that the value of a park is not just determined by its attributes but by its location. By locating parks where they will provide the most altruistic value it may be possible to increase total benefits. Future research should investigate how the spatial nature of public goods such as parks influences their value beyond the traditionally considered measures of distance (and indeed how measures of distance interact with other motivations of value). These spatial factors are as likely to be social in nature as they are physical and may include place attachments perceptions of crime and cultural factors relating to the story of particular places. This is particularly relevant in the light of increasing use of value transfer methods to value ecosystem services.

5. Experienced Well Being and Everyday Activities in the Urban Environment: The Influence of Visual Exposure to Natural Features

Abstract

A quasi-real time approach is used to investigate the relative influence of urban green space on individual's experienced well-being. Using a diary-style survey instrument (the Day Reconstruction Method; Kahneman et al., 2004) combined with personal GPS trackers, the influence that visual exposure to natural and urban features has on the emotional experiences of everyday trips and activities is explored. Controlling for a number of coincident effects, such as activities, interaction with others and time of day, it is found that exposure to green space has a positive influence upon experienced wellbeing. This study is concluded by considering the implications for planning of urban environments and the use of experienced well-being measures within policy formulation and decision making.

5.1. Introduction

Natural features in the urban environment provide many benefits to the health and well-being of the ever increasing urban population. Urban environments are characterised by high levels of environmental stressors (such as poor air quality and excess noise) and an absence of natural features (plants and animals). Urban green space, (parks, forests, playing fields, river corridors, road side verges and areas of open water) have the potential to mitigate against some of the adverse effects of modern urban life. Urban blue spaces (inland and coastal waterways) have been shown to have a particularly strong effect on well-being. Living closer to the coast has been associated with good health (Wheeler et al., 2012) while viewing scenes containing water have been shown to be associated with greater positive affect and higher perceived restorativeness and urban scenes containing water have been rated as positively as natural scenes containing water (White et al., 2010). While parks, woodlands and other expansive natural and semi natural areas provide unique leisure and recreational opportunities independently promoting physical activity (Kaczynski et al., 2007; Humpel et al., 2002) there is also evidence that simple visual exposure to natural features can have a direct effect on human physiology. These benefits including reducing blood pressure, stress levels (Hartig et al., 2003, Pretty et al., 2005) and faster healing in patients who have undergone surgery (Ulrich, 1984). Ulrich et al., (1991) proposed a psycho-evolutionary theory to explain the apparent innate affiliation of humans with nature. It is theorised that our evolutionary past has left us with a hard wired restorative response to certain nature settings but no such disposition for the more recent built environments (Ulrich, 1999). These restorative responses evoke interest and positive affect having the effect of reducing stress, blood pressure and heart rate (Hartig et al., 2010).

Previous studies into the well-being benefits of visual exposure to natural environmental features have generally suffered from two problems. Firstly experimental and quasi-experimental studies lack ecological validity; typically participants are shown photos or videos of different scenes with varying amounts of natural and man-made features (e.g. Ryan et al., 2010; van den Berg et al., 2003; Ulrich, 1979). Such experiences have little relevance to the everyday experiences of urban residents and may suffer from focusing illusions. Similar problems with real world applicability are encountered in studies which use real nature based exposures either through interventions (such as outdoors programs, R.Kaplan & S.Kaplan, 1989 and green exercise programs, Pretty et al., 2007) or natural experiments using prisons (Moore, 1981), hospitals (Ulrich, 1984) or public housing (Kuo & Sullivan,2001). A second problem, commonly encountered in observational studies in which exposure to natural features is measured indirectly either through some measure of access (typically distance to a site, e.g. Bjork et al., 2008; Kaplan, 2001) or by aggregated measures of green space in an individual's neighbourhood or country (e.g. Mitchell & Popham, 2007). While such studies offer improved ecological validity over experimental studies the use of indirect measures of exposure fails to account for actual experiences. Likewise the use of reflective measures of well-being such as life satisfaction scores suffer from recall bias and peak end bias (Kahneman & Riis, 2005).

An alternative method to exploring the potential benefits of exposure to natural features is to use experiential study designs such as ecological momentary assessment (EMA) (Shiffman et al., 2008), experience sampling method (Hektner et al., 2007) and the day reconstruction method (DRM) (Kahneman et al., 2004). All of these methods attempt to capture real time (or in the case of the DRM quasi real-time) measurements of participants experience thus minimising recall and reflective bias. While they have been used to investigate influences on well-being including diurnal patterns (Stone et al, 2006) companionship and activities (Csíkszentmihályi & Hunter, 2003) to date only one example of the application of experience level data collection methods to the relationship between urban green space and well-being is Mackerron (2012) who used a mobile phone app to relate experiential measures of well-being to environmental quality measured through the use of the phones built in GPS.

In this study an attempt is made to overcome these problems through the use of ecological methods. Specifically the use of a quasi-real time diary instrument (the DRM) to collect data on everyday activities and experienced well-being. The DRM has the advantage of collecting a wide range of data based on a personal diary that participants construct for the previous day's activities. This includes how individuals felt in terms of positive and negative emotions what they were doing (activities) and if they were interacting with anyone. The DRM thus offers many of the benefits of real time EMA methods whilst requiring considerably less resources than traditional EMA techniques. In order to relate people's emotional experiences to exposure to natural features in the urban environment the DRM is combined with personal GPS trackers. Through combining participant's locational data with high resolution spatial data within a geographical information system it is possible to create direct measures of participant's visual exposure to natural features in everyday activities. With the aid of high resolution digital surface models the area of land that can be seen from a series of observation points can be calculated, these "isovist fields" (Benedikt, 1979) promise more realistic measures of visual exposure to natural features than the course resolution point based measures used to date (i.e. Mackerron, 2012).

In addition the use of well-being measures offers an attractive alternative to traditional economic measures that equate progress and welfare with levels of consumption (Gowdy, 2005). Increasingly evidence shows that the link between well-being and income is relatively weak and that growth can even reduce welfare in the presence of government optimisation (Nf, 2000). This coincides with international initiatives to progress the measurement of societal progress by the EU (Beyond GDP) and the OECD (Measuring the Progress of Societies). While traditional economic theory derives values from individuals preferences expressed through the observable choices they make, such a view is increasingly being questioned in the light of observations that people do not always make decisions that maximise their well-being and behavioural research that shows that economic agents are at best only boundedly rational (Kahneman, 2003). As a result economists and psychologists are returning to Bentham to address the question of what makes people happy and how this can be quantified (Easterlin, 2001; Kahneman et al., 1997; Layard 2003).

As such directly quantifying the well-being benefits of urban green spaces offers a new method through which the influence of features in the urban environment can be quantified. Such measures can be used to evaluate the costs and benefits of specific projects or policies, either complementing existing cost benefit assessments through the derivation of monetary values from the substitutability of well-being and income or offering an alternative to monetary valuation through the direct assessment of their influence on well-being.

5.1.1. Study Aims and Hypothesis

This study intends to examine whether visual exposure to urban green space has an influence on positive and negative feelings experienced in everyday activities. In so doing it is first necessary to test methods of measuring exposure to physical environments. To this end a second aim of this study is to compare objective measures of exposure to the physical environment (through use of GPS trackers) to self-reported perceived measures of exposure to urban and natural features in the urban environment. In addition to the challenge of measuring exposure to the physical environment a further hurdle to investigating the relationship between the environment and SWB is in the temporal operationalisation of experienced SWB through episodes defined within the diary based structure of the DRM. These episodes form the primary unit of analysis in this study and it is thus crucially important that exposure measures use the same temporal metric as the experienced well-being measures, i.e. episodes (as defined by each individuals DRM). However while the GPS exposure measures are objective the DRM requires participants to recall what they did the previous day and are thus prone to the usual array of retrospective biases. There thus exists a risk of misinterpreting the GPS data if the episode level exposure measures on the subjective episode start and end times of the DRM are relied upon. The objective nature of the GPS data however allows us to check for such problems and due to the endogenous relationship between activities and the environments in which they occur, it is possible to derive episode start and end times from the GPS data itself. This study thus has two aims the first to compare self-reported (perceived) measures of exposure to urban green space with GPS measured exposures. The second aim is to explore the potential effect that exposure to different urban environmental features has on the experienced well-being of everyday activities. From these two aims a series of one and two tailed hypothesis are derived.

1) To compare the subjective episode level environmental exposure measures to the objective GPS episode level measures.

    H1.1: There is a significant and positive relationship between subjective and objective measures of environmental exposure.

2) To explore relationships between environmental exposure measures and experienced well-being measures.

    H2.1: There is a positive relationship between subjective exposure to natural environmental features and experienced well-being at the episode level.

    H2.2: There is a positive relationship between objective exposure to natural environmental features and experienced well-being at the episode level.

    H2.3: There is a negative relationship between subjective exposure to urban environmental features and experienced well-being at the episode level.

    H2.4: There is a negative relationship between objective exposure to urban environmental features and experienced well-being at the episode level.

5.2. Methods

5.2.1. The Day Reconstruction Method

The Day Reconstruction Method (Kahneman et al., 2004) is a survey instrument designed to collect data describing the experiences that an individual has on a given day. Based on the strengths of experience sampling (Stone et al., 1999) and developments in the measurement of well-being, both activities and their subjective experiences are documented through a systematic reconstruction of the previous day. The DRM is split into four sections; firstly the participant completes a series of standard socio-demographic questions. In the second section participants recall the experiences of the previous day by completing a short diary in which the previous day's activities are reported as a sequence of personally meaningful episodes. Participants are reassured that the diary entries are confidential and that the diary will not be collected from them. They are encouraged to make idiosyncratic notes in the diary including details they may not want to share, thus aiding their recollection of the previous day's experiences. This episodic diary is intended to facilitate recollection as well as providing temporal units for which experienced well-being (as well as environmental exposures) can be assessed. Following the diary, part three requires participants to answer a series of questions concerning each of the episodes reported in their confidential diary. Questions included the episodes start and end times, where they were, the activities they were engaged in, whom they were interacting with and how they felt in that episode. As in the original DRM experienced well-being was measured by asking participants to indicate their agreement with a series of affect adjectives on a 7 point Likert scale (see Figure 5.1). Four of these adjectives relate to positive affect (happy, warm, enjoying myself and competent) five to negative affect (frustrated, sad, angry, worried and impatient) and three other adjectives that measure stress (stressed), tiredness (tired) and impatience (impatient for it to end).

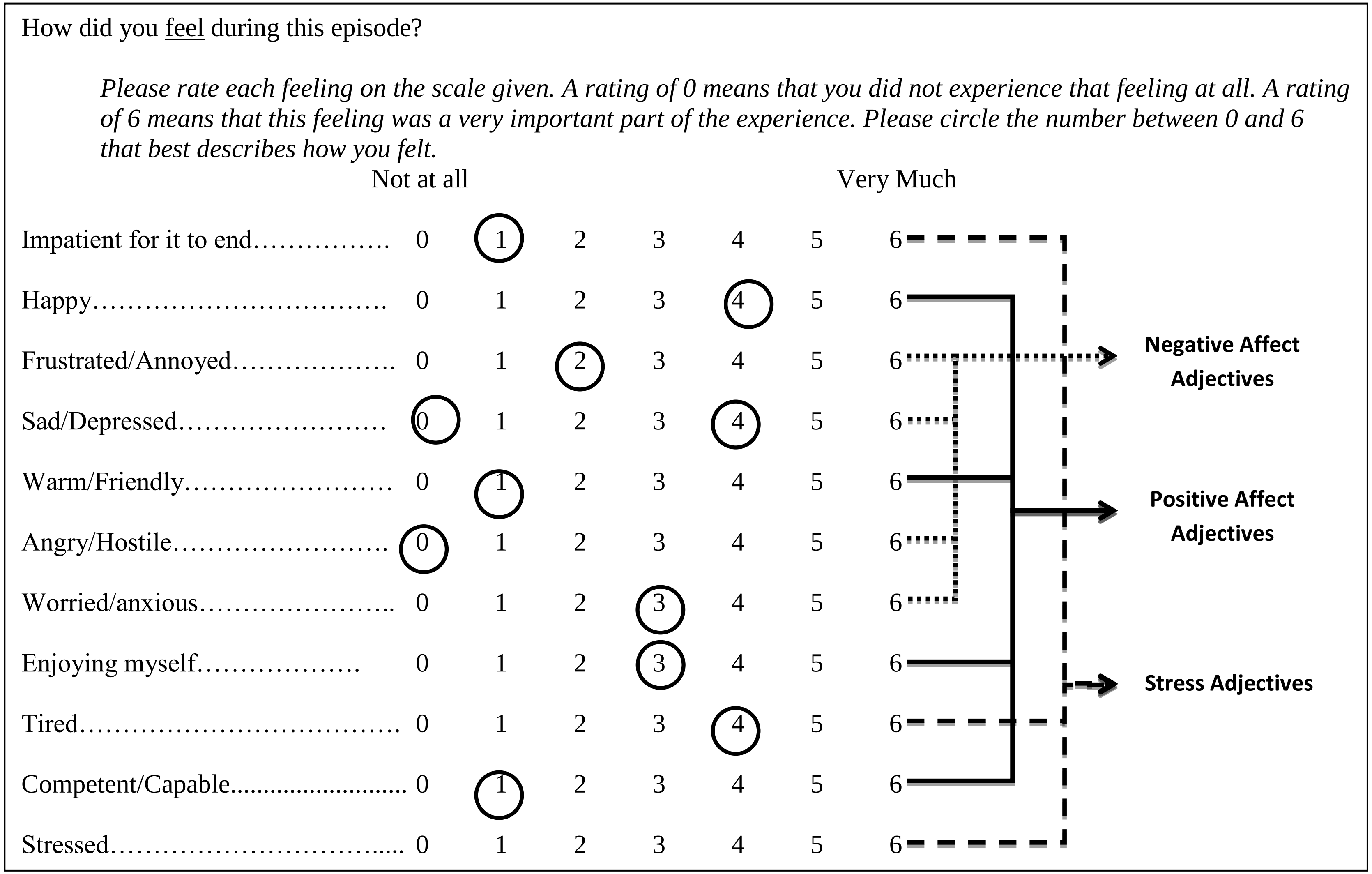
A pilot study was conducted using 20 participants and the original DRM questionnaire as reported in Kahneman et al., (2004), results of this pilot pointed towards numerous changes to the layout and working of the DRM questionnaire in order to make it more suitable for an English audience. While for the most part[18] the original DRM form is used, as reported in Kahneman et al., (2004), this study is unique as participants were furnished with an iGotu GT600e GPS tracker that logged their location every 5 seconds. Participants were recruited opportunistically from the staff and student population of the University of East Anglia. Willing participants were met the day before data collection was to commence to discuss what would be required of them. Participants completed informed consent forms and were assured that the data collected from them (especially location data from the GPS) would be fully anonymised so that they could not be identified as individuals, would only be used for the purpose of this study and would be stored securely. It was made clear to participants that their participation was entirely voluntary and that they could with-draw at any time. A hard copy of all details required for participation in this study together with the informed consent declaration were given to participants together with a GPS tracker which they were instructed

[18] Activity categories and several affect adjectives were changed to make the survey more suitable for an English audience.

to switch on the next day. Participants carried a GPS for a full day (either a Wednesday or Sunday) and returned the following day to complete the DRM questionnaire. Participants were instructed to switch on and wear the units (either around the ankle or if that was not comfortable around the wrist or on a belt loop) as soon as they woke up and to keep them on until they went to bed when they could take the unit off and switch it off. Participants GPS tracks were then exported from the GPS trackers as .csv files and imported as tables into ArcGIS. From here the GPS tracks were converted into points and projected from their native WGS 1986 geographic coordinate system into the UK National grid projected system. Once all tracks had been projected they were cleaned and sorted into indoor and outdoor activities. Attempts to fully automate the process of GPS data cleaning and sorting failed due to the complex nature of this task. Although cleaning of GPS tracks for random and systematic errors was successfully achieved by removing GPS points with excessive velocity and through use of a Gauss Kernal smoothing algorithm, (see Appendix 5.1), matching DRM reported episodes to GPS trips and activities so that GPS and DRM data share the same episode metric proved to be very difficult due to errors in participants recollections of episode start and end times and errors in the GPS tracks themselves (including multipath errors created from urban obstructions and missing periods of GPS data due to loss of signal and prolonged cold start times)As a result GPS data had to be sorted into episodes manually within ArcMap using Google maps and the OS Mastermap topographic layers to confirm episode start and end times through examining the locations of participants reported activities.

Participants in each session returned to a quiet room in the university to complete the DRM. They were given each of the four parts of DRM in sealed envelopes and instructed to complete the questionnaire one part at a time and to not look or read through any of the other parts of the DRM.

Figure 5.1: Affect adjectives used in the DRM to assess experienced well-being



How did you feel during this episode?

Please rate each feeling on the scale given. A rating of 0 means that you did not experience that feeling at all. A rating of 6 means that this feeling was a very important part of the experience. Please circle the number between 0 and 6 that best describes how you felt.

	Not at all						Very Much
Impatient for it to end…………….	0	1	2	3	4	5	6
Happy…………………………….	0	1	2	3	4	5	6
Frustrated/Annoyed………………	0	1	2	3	4	5	6
Sad/Depressed……………………	0	1	2	3	4	5	6
Warm/Friendly……………………	0	1	2	3	4	5	6
Angry/Hostile……………………	0	1	2	3	4	5	6
Worried/anxious…………………..	0	1	2	3	4	5	6
Enjoying myself………………	0	1	2	3	4	5	6
Tired………………………………	0	1	2	3	4	5	6
Competent/Capable.........................	0	1	2	3	4	5	6
Stressed…………………………....	0	1	2	3	4	5	6

5.2.2. Measuring Visual Exposure to Urban Features

5.2.2.1. Subjective Exposure Measures

Two approaches to measuring exposure to environmental features were used in this study. First participants were asked to report how often they could see animals, trees, vegetation, roads, traffic and people (using a 0-5 Likert scale) for each episode they reported in their diary (see Figure 5.2). While these subjective measures of exposure may suffer from recollection errors, the DRM is essentially a retrospective survey so that recollection errors should at least be operating in both the exposure and well-being measures as both self-reported measures use the same episode metric.

Figure 5.2: Self-reported perceived visual exposure questions.

How often could you see or were you aware of the following things around you:

	Didn't see					Saw frequently
Birds/Squirrels/Other Animals…….	0	1	2	3	4	5
Trees……………………………….	0	1	2	3	4	5
Vegetation (green plants)………….	0	1	2	3	4	5
Roads……………………………....	0	1	2	3	4	5
Traffic……….……………………	0	1	2	3	4	5
People……….…………………….	0	1	2	3	4	5

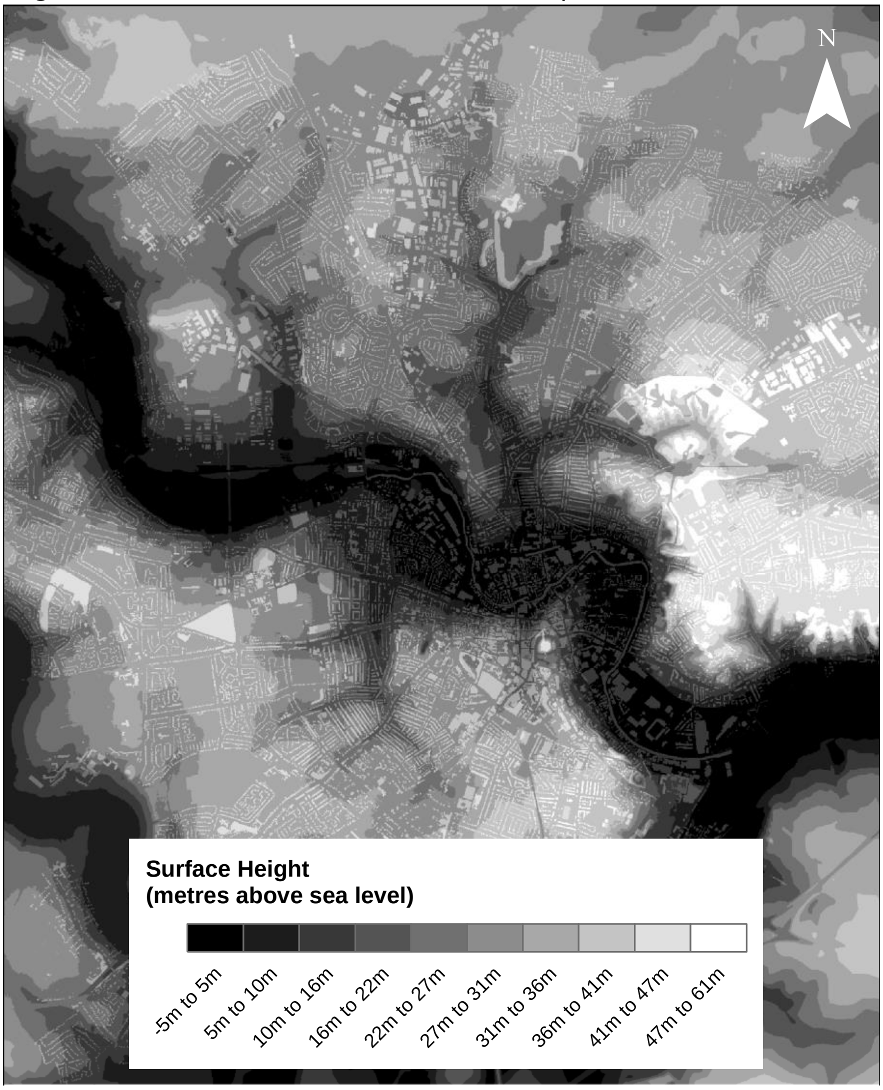
5.2.2.2. Objective Exposure Measures

The subjective measures were supplemented with 'objective' exposure measures created from the participants GPS tracks. Whilst the simplest way to measure exposure from GPS tracks would be to extract the land use that each GPS point falls within, or to use buffers around the GPS points, here a novel approach is taken to measuring exposure. As visual exposure is the main concern a method from spatial syntax studies is borrowed (Benedikt, 1979) and calculate 2-D isovists for each of the GPS points within each of the participants reported outdoor episodes. An isovist (*ibid.*) is the volume of space visible from a given point in space and by calculating unique isovists for each of the points that make up a participants outdoor episode and merging them together to create an isovist field. The isovist field represents the total area that could be seen for the entire duration of any outdoor episode. By combining isovist fields with maps of natural and urban features it is possible to calculate exposure measures that reflect the actual land use encountered in any outdoor episode.

To calculate isovist fields for participant's outdoor episodes, a custom VBA script was written for ArcGIS to produce two dimensional isovists from the participants GPS tracks (Appendix 5.2). The script uses a rather simplistic approach to generating isovists. Using each point in the participants GPS track as an observation point the script traces 50 radial lines (lines of sight) to a distance of 100 metres in all directions from the observation point. Every time one of these lines is obstructed by an object higher than the GPS observation point it returns the coordinates of that obstruction point. These obstruction points are used to create polygons for every point on the track, which are then dissolved to form the visual isovist field for that track.

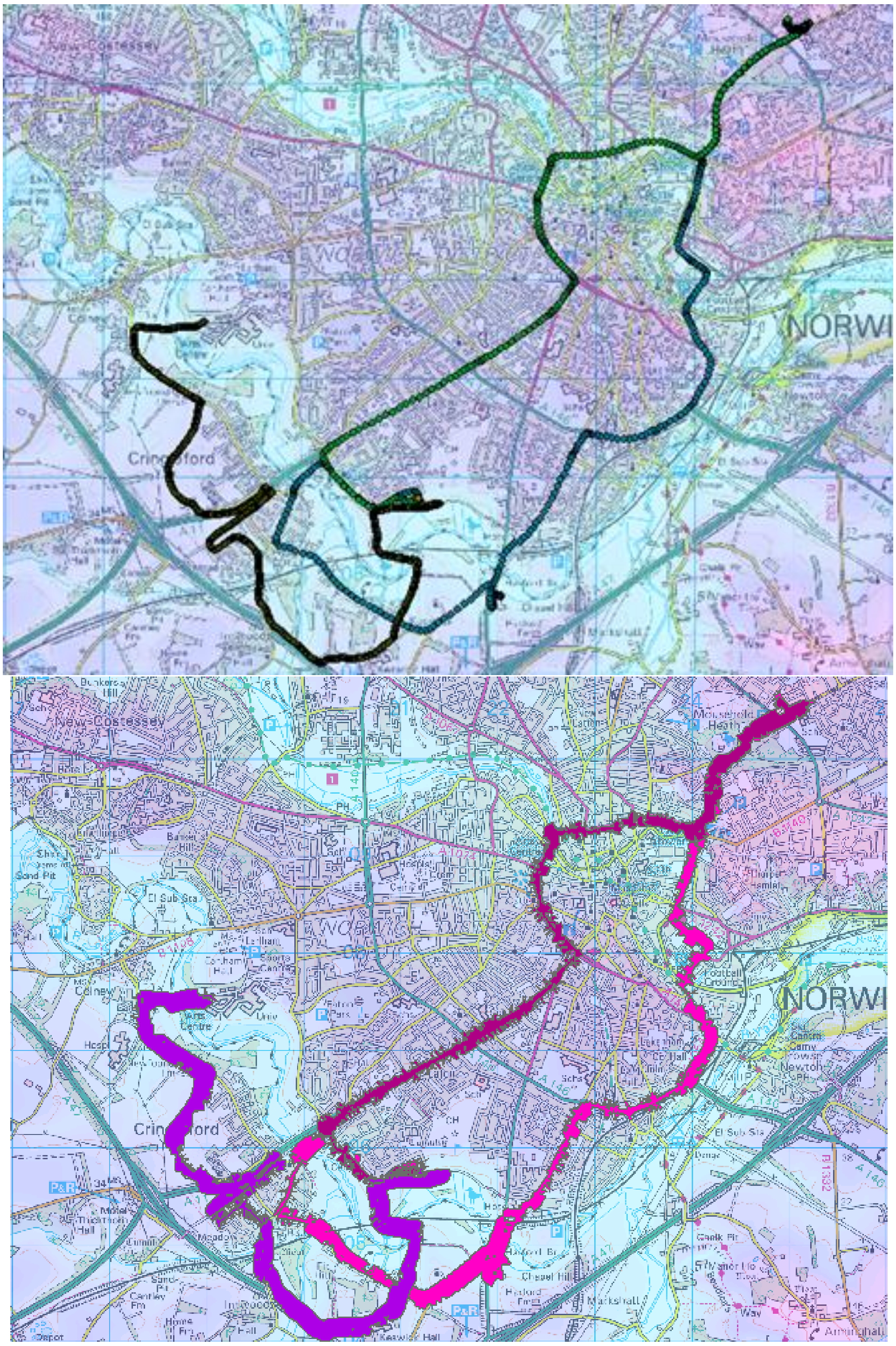
Observation points are assigned heights from the Bluesky 5 metre resolution Digital Terrain model (DTM) while obstruction points for radial lines from each observation point were calculated from a Digital Surface Model (DSM). This was constructed by adding surface features to the Bluesky 5 metre DEM. These included building heights which were obtained from Landmap and converted to point data to facilitate them being joined to building polygon extracted from the latest OS Mastermap topographic layers for the study area. Every building polygon from the MasterMap layer that had a point from the Land height layer was assigned that height, however a significant number of buildings in the OS Mastermap dataset layer did not have building heights due to the land map building height data being relatively dated. To assign building heights to the remaining polygons a nearest join was performed so that any buildings that did not have a height were assigned the height of the nearest building which does have heights. This layer was then converted to a raster with a resolution of 0.25 metres so that it could be added to the Bluesky Digital terrain model using the raster calculator. In addition areas of trees where extracted from the OS Mastermap layer and assigned a conservative height of 10 metres, these were added to the surface model. It should be noted that this surface model is by no means perfect as individual trees and other obstructions for which data was not available are not modelled. LIDAR data would be much better however to date no such data is available for the city of Norwich. Figure 5.3 shows the final surface model for the North of Norwich it lighter areas in the image are higher than darker areas. Figure 5.4 shows an example of a participants GPS track and the resulting isovist fields calculated from these tracks. .

Figure 5.3: Digital surface model constructed for the Study Area.



(Crown Copyright, Ordnance Survey Ltd.)

Figure 5.4: Example participant GPS tracks (top) and corresponding isovist fields created from the same GPS tracks (bottom).



(Crown Copyright, Ordnance Survey Ltd.)

Once the isovist fields were calculated for all outdoor episodes with complete GPS data ArcGIS was used to calculate zonal statistics regarding the proportion of different land uses that were contained in each isovist field. High resolution land cover data was extracted and converted into 1 metre raster layers from the OS Mastermap topographic layer. These raster layers were reclassified into Boolean values so that mean values could be calculated for all cells within each isovist field to derive the percentage of natural land cover, road cover and multiple use cover.

5.2.3. Controlling for Additional Person and Episode Level Confounders

There are a large range of factors that could potentially confound our analysis of the influence of the environment on experienced well-being. It was necessary to identify possible confounding factors at both the episode and person level. As such information collected from an amateur weather station set up by the author to record wind, temperature and rainfall data at 15 minute intervals to control for variations at the episode and day level[19]. Although fixed effects models can help control for between participant variations for example differences in personality type, measures of Neuroticism and Extraversion were added to the final part of the DRM questionnaire (see Appendix 5.3). It has been found in previous studies that extraverts are more susceptible to feelings of positive affect and those with high neuroticism scores are more susceptible to negative affect (Rusting & Larsen, 1996).

[19] The weather data collected was not used in the final analysis presented here.

5.3. Results

5.3.1. Descriptives

Participants were recruited from the university populace through a recruitment email sent out to staff and students in a variety of schools at the University of East Anglia, this study was conducted in July 2011. Participants who expressed an interest in participating were sent further details of the requirements and on confirming that they could meet these requirements they were allocated to one of 10 sessions (either Sunday or Wednesday). The sample consisted of 61% females, aged 18 to 68 years with a mean age of 25 years. 85% of participants were in full time education, 39% were in full time employment and the majority (78%) reported their marital status as single.

5.3.1.1. Person Level Descriptives

In total 201 participants were given GPS units and returned the following day to complete the DRM questionnaire in a quiet room. Two participants did not return the following day, however the GPS units were later recovered (this data was not included in the study). Of these 198 participants a total of 2520 episodes were reported with an average of 12.7 episodes reported per participant (range 4 to 24). Person level descriptives for this sample can be seen in Table 5.1 below.

Table 5.1: Person level descriptive statistics.

Variable Name	N	Mean	Std Dev.	Median
Income (£/year)	174	9414.03	9711.09	3000
Age in years	194	25	8.73	22
Number of people in household	199	3.97	2.63	4
Extraversion score	168	26.81	6.10	27
Neuroticism score	168	21.99	6.21	22
Overall mood yesterday	199	2.7	0.77	3
Global life satisfaction score	197	3.18	0.60	3
Home life satisfaction score	197	3.24	0.68	3
Work life satisfaction score	197	3.11	0.68	3
Psychological well-being score	199	41.95	9.05	42
Percentage female	197	61%	0.49	
Percentage in paid employment	197	39%	0.49	
Percentage in full time education	198	85%	0.36	
Percentage single marital status	199	78%	0.41	
Percentage who have children	199	10.2%	0.31	
Percentage ethnic group white	199	82%	0.39	
Percentage disabled	199	8.54%	0.09	

5.3.1.2. Episode Level Descriptives

While participants were asked to record discrete activity episodes (i.e. one episode per activity), a number of individuals reported multiple activities per episode. In addition, on examination of the GPS data, it was clear that many people reported multimode episodes, for example a trip to the local grocery store involves both an outdoor component (i.e. walking to the store) and then an indoor part (i.e. the actual shopping). As the primary unit of analysis in this study is the participant defined episode, all multimode and multi activity episodes had to be controlled for. In the event, the simplest option was to remove such multiple mode/activity episodes. Table 5.2 shows a breakdown of indoor, outdoor and episodes reported which involved both indoor/outdoor activities. 1213 episodes reported by participants had more than one activity associated with them.

Table 5.2: Indoor, outdoor and mixed mode episodes.

No of Participants	No. of episodes[1]	Reported Indoors	Reported Outdoor	Reported As Both In/Out	Episodes with >1 activities	Outdoor Single Activity Episodes
198	2520	2021	603	83	1213	405

Note: 1. mean = 12.7 (+/- 3.4); Min = 4; Max = 24

A large number of participants used the open "Other" category when reporting episode activities (n=739). Such episodes were then described using open ended text responses. To reduce the number of activity variables, these were re-classified for incorporation within subsequent analyses. Many open-ended responses were compatible with existing standard categories. However, five additional categories had to be created: waking & personal maintenance; eating and cooking; other-hobby, other-chore; prayer/church activities; and listening to music, radio, etc. Studying was reclassified as work as were meetings, lectures and revision. Watching TV, movies and playing computer games were amalgamated into the 'screen time' category. The frequency duration and mean affect ratings of participant's re-classed activities can be seen in Table 5.3 below.

Figure 5.5: Number of Activities reported per episode by participants (n=2520)

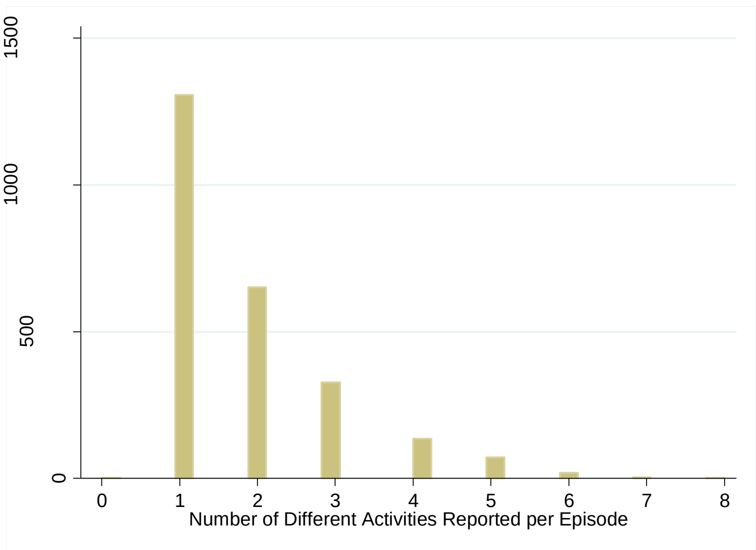


Table 5.3: Re-classed Activity categories: Frequencies and Means of key variables N= 1307 (only single activity episodes reported).

Activity	N	Total Duration (Mins)	Episode Duration (Mins)		Mean of Positive Affect Adjectives[1]		Mean of Negative Affect Adjectives[2]		Net Affect[3]	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Transport	367	12425	34.32	45.40	2.84	1.36	1.34	1.13	1.51	2.06
Socialising	92	6660	73.19	157.50	3.87	1.32	1.05	1.04	2.87	2.03
Screen-Time	138	14535	105.33	133.04	3.42	1.25	0.95	0.83	2.47	1.73
Work	284	28704	101.43	77.41	2.69	1.29	1.76	1.22	0.93	2.18
Exercise/Outdoor Sports	31	2381	76.81	34.30	4.06	1.19	0.60	0.66	3.46	1.58
Looking after Own Children	18	1155	64.17	64.08	3.92	1.21	0.97	1.29	2.95	2.24
Shopping	23	1042	45.30	30.67	3.19	1.16	0.99	1.04	2.21	1.78
Housework	43	2995	69.65	45.54	3.03	1.40	1.34	0.88	1.70	1.74
Work-Break	28	815	29.11	17.11	3.90	1.35	0.77	0.72	3.13	1.81
Relaxing/Doing Nothing	78	4515	57.88	50.65	3.31	1.32	0.84	0.93	2.47	1.83
Intimate Relations	7	655	93.57	85.67	5.21	0.68	0.57	0.72	4.64	1.07
Reading	17	1685	105.31	64.23	3.54	1.09	0.45	0.58	3.10	1.30
Other-Hobbies	13	1000	76.92	50.85	3.83	1.44	0.63	0.68	3.20	1.84
Prey/Church	13	1335	102.69	67.35	3.73	0.95	1.28	0.92	2.45	1.82
Listening to Music/Radio	7	665	95.00	56.79	3.36	1.30	0.63	0.81	2.73	1.99
Waiting	11	555	50.45	43.50	2.25	1.29	2.07	1.13	0.18	2.16
WakingUp/Personal Maintenance	129	5334	42.33	106.32	2.90	1.41	0.89	1.03	2.01	2.03
Eating/Cooking	3	212	70.67	95.71	3.08	0.88	1.40	0.40	1.68	1.28
Other-Chores	18	515	28.61	17.97	2.44	1.27	1.64	0.96	0.81	1.89
Other	6	225	37.50	41.56	1.58	1.04	3.20	2.06	-1.62	2.98

Note: 1. Mean rating of happy, warm/friendly, enjoying myself, competent/capable.
2. Mean rating of frustrated/annoyed, sad/depressed, worried/anxious and impatient for it to end.
3. Net Affect = mean positive affect rating – mean negative affect rating.

5.3.1.2.1. Experienced Well Being Descriptives

The primary purpose of the DRM is to collect data on participants experienced well-being that is the positive and negative feelings an individual experiences in a particular time frame. For each episode reported in the DRM participants gave responses to four positive and five negative affect adjectives. A factor analysis to check that the affect adjectives yield two distinct factors. As the two factors are expected to be negatively correlated it is necessary to use an oblique rotation (Comrey, 1967). .

Table 5.4: Rotated Two Factor Solution N = 2501

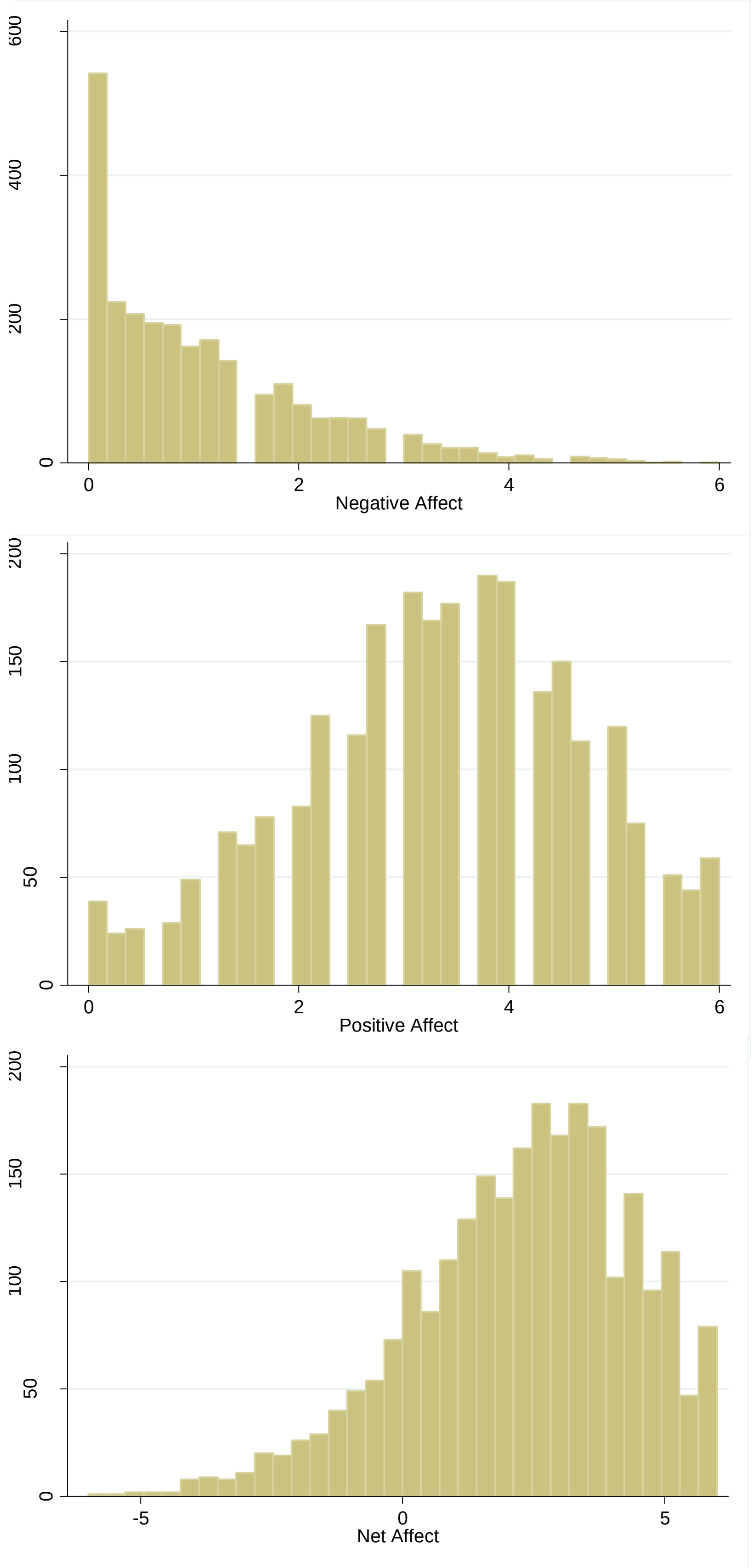
	Variable		Factor1	Factor2	Uniqueness
Positive Affect	competent		0.658	0.162	0.628
	happy		0.849	-0.088	0.211
	warm		0.888	0.069	0.257
	enjoying		0.861	-0.067	0.207
Negative Affect	frustrated		-0.105	0.774	0.323
	sad		-0.047	0.709	0.468
	angry		0.127	0.846	0.357
	worried		-0.010	0.749	0.433
	Impatient		-0.342	0.433	0.574

As expected Table 5.4 shows a two factor solution (eigenvalues = 4.021 and 1.523 respectively) which cumulatively explains 62% of the total variance (second factor only explains 17%). The rotated factor loadings (promax) reported in Table 5.4 indicate that the positive and negative affect adjectives are describing two dimensions. The four positive affect adjectives load highly on factor one and the four negative adjectives loading on factor 2. Knowing this, the affect adjectives can be confidently combined into positive and negative affect measures. This is done by simply averaging the positive and negative affect ratings. For example to calculate positive affect (PA) from the example response shown in Figure 5.1 the average value of the four positive affect ratings (i.e. (4+4+3+4)/4 = 3.75[20]) is calculated. Figure 5.6 below shows these aggregate measures including a net affect score calculated by subtracting the average of the four negative adjectives from the average of the four positive (mean = 2.28 sd = 2.10 range = -6 to 6). It can be seen from Figure 5.6 that the distribution of negative affect scores is heavily skewed towards the left while this may be due to social pressure to under-report negative emotions it is also worth entertaining the possibility that our sample experienced low

[20] In the case of missing affect adjective values i.e if a participant reported only 3 of the four positive affect adjectives then the average of the three available was used, if any more than one positive or negative adjective was missing per episode then it is reported as missing.

levels of negative emotions. In contrast the positive affect ratings are almost normal with a slight positive skew in their distribution again this could be a result of social pressure to over report positive emotions.

Figure 5.6: Histograms of composite affect measures, negative affect (top), positive affect (middle) and net affect (bottom).



5.3.1.2.2. Subjective Exposure Descriptives

Before an attempt was made to incorporate visual exposure measures into the affect models the distribution of both the subjective and objective exposure measures is examined. Table 5.5 shows the median of subjective exposure measures for each activity reported by participants. As expected, participants reported very low levels of exposure to animal's trees vegetation roads and traffic in all but outdoor based activities. In contrast, for all activities excluding reading and listening to music participants reported being able to see other people for the majority of the episode. In order to be able to test for an effect of subjective visual exposure to natural features on experienced well-being subsequent analysis will focus on single activity transport activities only.

Table 5.5: Median subjective exposure measures for all single activity episodes.

Activity (N's in parenthesis)	Animals	Trees	Vegetation	Roads	Traffic	People
Transport (367)	1	4	4	5	4	4
Workbreak (28)	0	1	1.5	0	0	5
Shopping (23)	0	0	0	1	0	5
Children (18)	0	0	0	0	0	5
Other/Hobby (13)	0	1	1	0	0	3
Intimate Relations (7)	0	0	0	0	0	5
Prey/Church (13)	0	0	0	0	0	5
Waiting (11)	0	0	0	0	0	5
Eating/Cooking (3)	0	0	0	0	0	4
Social (92)	0	0	0	0	0	4
Work (284)	0	0	0	0	0	4
Other Chores/ Appointments (18)	0	0	0	0	0	4
Exercise & Outdoor Sports (31)	0	0	0	0	0	3
Other (6)	0.5	0	0	0	0	1.5
Screentime (138)	0	0	0	0	0	1
Housework/chores (43)	0	0	0	0	0	1
Relaxing (78)	0	0	0	0	0	1
Reading (17)	0	0	0	0	0	0
Music/Listening (7)	0	0	0	0	0	0
Waking/Personal Maintenance (128)	0	0	0	0	0	0

5.3.1.2.3. Objective Exposure Descriptives

Of the 198 participants who returned GPS units and completed a questionnaire 15 of these had absent GPS tracks (several of these participants confessed to have forgotten to switch on or take the GPS units with them). GPS descriptives can be seen in Table 5.6 below.

Table 5.6: GPS Descriptives (N=185)

Mean GPS track length (hours/person/day)[1]	Total number of outdoor episodes for which there was some GPS track	Number of episodes with missing track data	Number of episodes with 80% or more GPS track duration
7.37	492	254	394

Notes: 1. SD = 4.46 (hours)

Due to large number of multipath errors in the GPS tracks, and numerous participants reporting multiple activities in the same episode, only 294 single activity episodes with complete GPS data could be used for creating the objective exposure measures. Percentages of various land uses for isovist fields created from participants outdoor GPS tracks can be seen in Table 5.7 below.

Table 5.7: Mean percentage cover of land use types in isovist fields for single activity outdoor episodes (N = 294).

Activity (N)	Mean % Natural	Mean % Multiple	Mean % Water	Mean % Trees	Mean % Rds
Transport (230)	0.45	0.18	0.01	0.09	0.27
Social (3)	0.45	0.14	0.00	0.05	0.21
Screentime (6)	0.49	0.11	0.00	0.07	0.22
Work (22)	0.63	0.03	0.01	0.09	0.20
Exercise/Sport (8)	0.72	0.05	0.08	0.08	0.15
Shopping (4)	0.37	0.18	0.00	0.09	0.29
Housework/chores (2)	0.45	0.19	0.00	0.04	0.22
Workbreak (3)	0.59	0.00	0.00	0.07	0.18
Relaxing (3)	0.12	0.17	0.00	0.01	0.46
Reading (2)	0.62	0.00	0.00	0.04	0.19
Other/Hobby (1)	0.93	0.00	0.03	0.15	0.05
Prayer/Church (1)	0.64	0.05	0.00	0.14	0.18
Music/Listening (1)	0.58	0.00	0.00	0.13	0.14
Waiting (3)	0.53	0.02	0.12	0.02	0.23
Appointment (4)	0.35	0.13	0.01	0.05	0.34
Other (1)	0.30	0.15	0.02	0.07	0.36

5.3.1.2.4. Relationship Between Subjective and Objective Exposure Measures

Previous research has shown that perceptions do not correlate well with objective measures in the case of access to green spaces (Macintyre et al., 2008) and thus one of the aims of this study is to examine the relationship between subjective and objectively measured exposure. Although it was not possible to create exact analogues to the subjective exposure measures it was possible to extract the % of trees and roads in participant's isovist fields. Table 5.8 below shows correlations between our perceived and isovist based exposure measures.

Table 5.8: Correlations between perceived and isovist based exposure measures for single activity transport episodes only (n=230)

	% Natural	% Multiple	% Water	% Trees	% Roads	Could see Animals	Could see Trees	Could see Vegetation	Could see Roads	Could see Traffic
% Multiple	-0.80									
% Water	0.03	-0.24								
% Trees	0.36	-0.27	-0.05							
% Roads	-0.85	0.58	0.09	-0.34						
Could see animals	0.06	0.00	-0.11	0.04	-0.10					
Could see trees	0.02	0.08	-0.18	0.07	-0.16	0.44				
Could see Vegetation	0.06	0.04	-0.11	0.07	-0.18	0.43	0.86			
Could see Roads	-0.19	0.27	-0.01	0.02	0.16	0.13	0.40	0.40		
Could see Traffic	-0.21	0.22	0.06	0.00	0.20	0.13	0.20	0.26	0.74	
Could see people	-0.07	-0.06	0.04	-0.05	0.04	0.19	0.18	0.21	0.16	0.33

Within the objective exposure measures strong negative correlation between the % multiple and % natural measures were observed, as the make multiple land cover is for the most part represents residential gardens this is no surprise and likely reflects the inverse relationship between the urban area and natural land use covers. A similar relationship between % natural and % roads was seen again reflecting a tendency for natural and roads to not occur together. Within the subjective measures positive correlations of increasing strength can be seen between animals and trees, traffic and roads, and trees and vegetation. While very low correlations between the subjective and objective exposure were observed measures which may be somewhat unsurprising given the potential recall bias involved in the perceived measures. This result shows support for the rejection of hypothesis 1.1, that there is not a positive relationship between perceived and isovist based measures of visual exposure.

5.3.2. Regression Analysis of Experienced Well-Being

In order to test whether exposure to natural features in everyday activities has an effect on experienced well-being regression analysis is used to construct a model of experienced well-being. Data from the DRM survey represents a hierarchical data set with episode level observations nested within participant level data. As such mixed effects (also known as hierarchical or multilevel) regression modelling is used which allows for both fixed and random effects. This allows both observed influences such as the different activities a participants may be engaged in and factors which can be thought of as being randomly selected from a larger set of values (such as the effects of a participants personality) to be accounted for. Not only do mixed models allows us to "partition" the variance explained by the model into that attributed to between participant and within participant variations, they are also more efficient than fixed effects estimators as they do not discard data on between individual variation[21]. Net-affect and positive affect are used as dependent variables in subsequent regression analysis. The composite negative affect score is not analysed here as it is far from normally distributed and is already accounted for in the net-affect variable.

5.3.2.1. Baseline Variance components model

In order to get an idea for how much variation in affect is driven by individual versus episode level factors empty models with only a random intercept (equivalent to a random-effects ANOVA) on both net-affect and positive affect were run. The intraclass correlation (ICC) describes how strongly measurements from the same group resemble each other, in our model it describes how much of the variation in net-affect is attributable to individual differences. Our empty model of net-affect (see Appendix 5.4) indicates that roughly 29% of the variation in net-affect is attributable to differences between individuals. While our empty model of positive affect (Appendix 5.5) indicates that 37% of the variation in positive affect is attributable to individual level differences.

5.3.2.2. Accounting for the effects of everyday activities

The activity categories reported in Table 5.3 were added as dummy variables to our mixed effects model of net and positive affect respectively (using transport as the base case). Through a stepwise process activity variables with p <= 0.1 were removed resulting in the two models shown in Table 5.9 below. The level one R-squared for Model (1) ($R_1^2 = 0.149$) indicates that 14.9% of the variation in net-affect is attributable to the level one activity variables[22]. This is equivalent to the R^2 value generated by an OLS regression (which is similar at 0.13). A similar

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[21] All models are fitted using Stata 11's xtmixed command. We specify an unstructured covariance matrix for the random effects where used allowing all variance and co-variances to be distinct thus avoiding assuming that random effect terms are independent. An unstructured covariance matrix allows for potential correlation between all variance co-covariance model components and level 1 correlates.

[22] The level one R^2 is calculated from the total variance of Model (1) and that of the empty model (reported in appendix 1.1). Variance of the new model = 3.955, Variance of the empty model = 4.65, R_1^2 = 1 – (VarNew/VarOld) = 0.149.

pattern of results can be seen in this model to those revealed by the activity level descriptives (reported in Table 5.3) with intimate relations appearing as the largest positive predictor of net-affect and the other activity category as the lowest. The intra-class correlation for Model (1) ICC = 0.32, indicating that 32% of the variation in net-affect is driven by differences between individuals. While a Wald test indicates that all the included activity variables were jointly significant (p = 0.000). Comparison of Model (1) to a model fitted with all activity variables (not reported here) with a likelihood ratio test (chi^2 (3 dof) = 3.28 p=0.350) shows that there is a statistically significant difference between the two models and it can be concluded that the reduced activity model is a better fit.

Model (2) shows the results of the same stepwise process using positive affect as the dependent variable. The use of positive affect results in fewer significant activity variables than the model fitted to net-affect indeed the activities which have to be dropped from the positive affect model can be thought of as those which have a negative effect on well-being it is thus unsurprising that they fail to reach significance when using an exclusive measure of positive emotion compared to net-affect which accounts for both negative and positive emotional states. The level one R-squared for Model (2) tells us that 10% of the variation in positive affect is attributable to the level one activity variables (R_1^2=0.099). The intra-class correlation of model (2) indicates that 41% of variation in positive affect is attributable to individual differences. A likelihood ratio test comparing model (2) to a model with all activities confirms a statistically significant difference between the two models (chi^2 (7 dof) = 9.39 p=0.226) confirming that the model reported in Table 5.9 is a statistically better fit.

Likelihood ratio tests for both Models (1) & (2) allow us to reject the hypothesis that the intercept is the same across individuals which justifies the inclusion of a random intercept for both models. Examination of the residuals relative to both the predicted values and independent variables for both models (1) and (2) in Table 5.9 reveals a normal distribution (confirmed with a kurtosis test).

Table 5.9: Mixed Effects model of activities on net-affect (1) and Positive Affect (2), (transport is the base case). Intraclass correlation for model (1) = 0.318, Model (2) = 0.408. Log restricted-likelihood model (1) = -2653.484, Model (2) = -2047.671, Wald test Model (1) chi^2 (16) = 249.67 p = 0.000, Wald test Model (2) chi^2 (16) = 208.03 p = 0.000

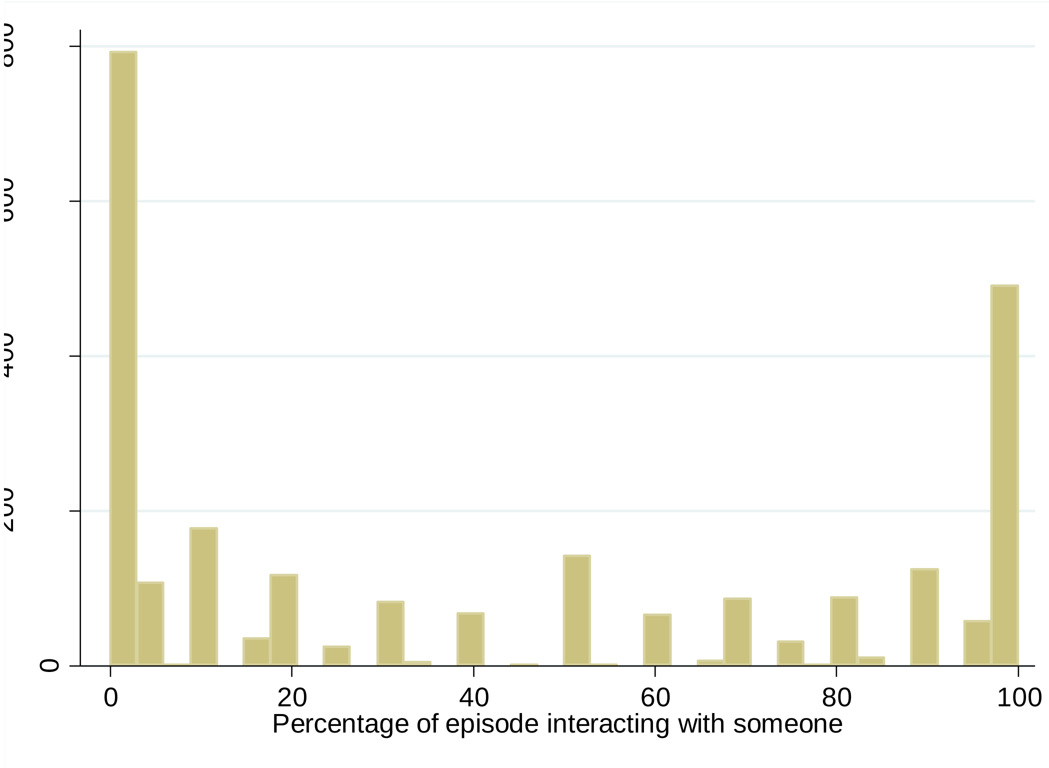
	(1) Net-Affect			(2) Positive Affect		
	N_1 = 1317 N_2= 195			N_1 = 1321 N_2= 195		
	Coef	Std Err	P	Coef	Std Err	P
Social	1.413	0.206	0.000	1.091	0.122	0.000
Screen Time	0.803	0.177	0.000	0.474	0.103	0.000
Work	-0.595	0.136	0.000			
Exercise/Sport	1.627	0.325	0.000	1.181	0.197	0.000
Children	0.813	0.449	0.071	0.761	0.279	0.006
Shopping						
Housework/Chores						
Workbreak	1.452	0.342	0.000	1.002	0.207	0.000
Relaxing	1.028	0.221	0.000	0.604	0.132	0.000
Intimate Relations	3.354	0.657	0.000	2.377	0.405	0.000
Reading	1.599	0.434	0.000	0.874	0.267	0.001
Other/Hobby	1.526	0.493	0.002	1.107	0.303	0.000
Prayer/Church	1.097	0.541	0.043	1.009	0.336	0.003
Music/Listening	1.088	0.655	0.097	0.708	0.404	0.079
Waiting	-1.169	0.523	0.025			
Waking/Personal Maintenance	0.301	0.176	0.088			
Eating/Cooking						
Appointment	-0.835	0.443	0.060			
Other	-3.075	0.706	0.000	-1.012	0.435	0.020
Constant	1.628	0.119	0.000	2.862	0.072	0.000
Random Effects	Estimate	Std. Err.		Estimate	Std. Err.	
Individual level variance (level 2)	1.265	0.178		0.706	0.091	
Episode level variance (level 1)	2.690	0.113		1.023	0.043	

Model (1) Likelihood ratio test vs Linear Regression p = 0.000
Model (2) Likelihood ratio test vs Linear Regression p = 0.000

5.3.2.3. Accounting for Interactions with Other People

Another factor known to increase mood is interacting with other people. For every episode the DRM asks participants to report what percentage of the episode they spent interacting with another person (see Figure 5.7 for the distribution of the interaction variable). This was added to the regression models of net and positive affect and the results reported in Table 5.10 below.

Figure 5.7: Histogram of the percentage of each episode spent interacting with another person.



Including the episode level interaction variable in the net-affect model reduces the significance of several activity variables indicating that confounding is occurring. Rather than complicating our model with numerous interaction terms in order to control for potential affect covariates, the activity variables which are no longer significant were dropped. Prayer and Church as well as listening to music are activities typically done without interacting with another and are subsequently removed. The addition of the interaction variable also causes the time with children activity variable to become insignificant likely as a result of the different effect of interacting with your own children compared to that of interacting with other adults. The resulting Model (3) has a $R_1^2 = 0.154$ indicating that together the significant activity variables and the percentage interaction variable account for 15.4% of the variation in net-affect. Comparing Model (3) to Model (1) with a likelihood ratio test confirms a statistically significant difference between the two models (LR chi^2 (2) = -58.39, p = 1.000). Model (3) yields an intraclass correlation of 34% a slight increase over the amount of variation in net-affect explained by individual differences in comparison to Model (1).

A similar effect of including the interaction variable in the positive affect (Model (4)) with listening to music/radio and time with children becoming insignificant can be seen, these are subsequently removed resulting in Model (4) below. This model explains 10.8% of the variation in positive affect a slight increase over that of Model (2) the improvement in fit of Model (4) over Model (2) is confirmed by a LR-test (LR chi^2(1) = -80.12 p = 1.000). An increase in the amount of positive affect explained by individual level differences as indicated by the increased intra-class correlation (44%) is also observed.

Wald tests of both models (3) and (4) show that the level 1 covariates reach combined statistical significance (p = 0.000 and p = 0.000 respectively). Again LR tests of both models (3) and (4) indicate that the intercepts in both models are different across individuals thus justifying the use of a random intercept.

Table 5.10: Mixed Effects model of activities and percentage interaction on net-affect, (transport is the base case). Intraclass correlation for model (3) = 0.343, Model (4) =0.444 Log restricted-likelihood model (3) = -2623.097, Model (4) = -2007.611. Model (3) Wald test chi^2 (16) = 249.67 p = 0.000, Model (4) Wald test chi^2 (11) = 295.54 p = 0.000.

	(3) Net-Affect			(4) Positive Affect		
	N_1 = 1314 N_2= 195			N_1 = 1318 N_2= 195		
	Coef	Std Err	P	Coef	Std Err	P
Percentage Interacting	0.010	0.001	0.000	0.007	0.001	0.000
Social	0.808	0.218	0.000	0.667	0.128	0.000
Screen-time	0.718	0.171	0.000	0.434	0.100	0.000
Work	-0.744	0.133	0.000			
Exercise/Sport	1.435	0.318	0.000	1.074	0.191	0.000
Work-break	1.076	0.337	0.001	0.770	0.202	0.000
Relaxing	1.042	0.215	0.000	0.646	0.128	0.000
Intimate Relations	2.776	0.646	0.000	1.971	0.393	0.000
Reading	1.673	0.425	0.000	0.948	0.258	0.000
Hobby	1.289	0.481	0.007	0.949	0.293	0.001
Prayer / Church				0.735	0.327	0.025
Waiting	-1.219	0.511	0.017			
Waking/Personal Maintenance	0.439	0.174	0.012			
Other Chore	-1.113	0.435	0.010			
Other	-3.075	0.690	0.000	-1.005	0.420	0.017
Constant	1.389	0.125	0.000	2.663	0.077	0.000
Random Effects	Estimate		Std. Err.	Estimate		Std. Err.
Individual level variance (level 2)	1.342		0.185	0.760		0.096
Episode level variance (level 1)	2.575		0.109	0.953		0.040

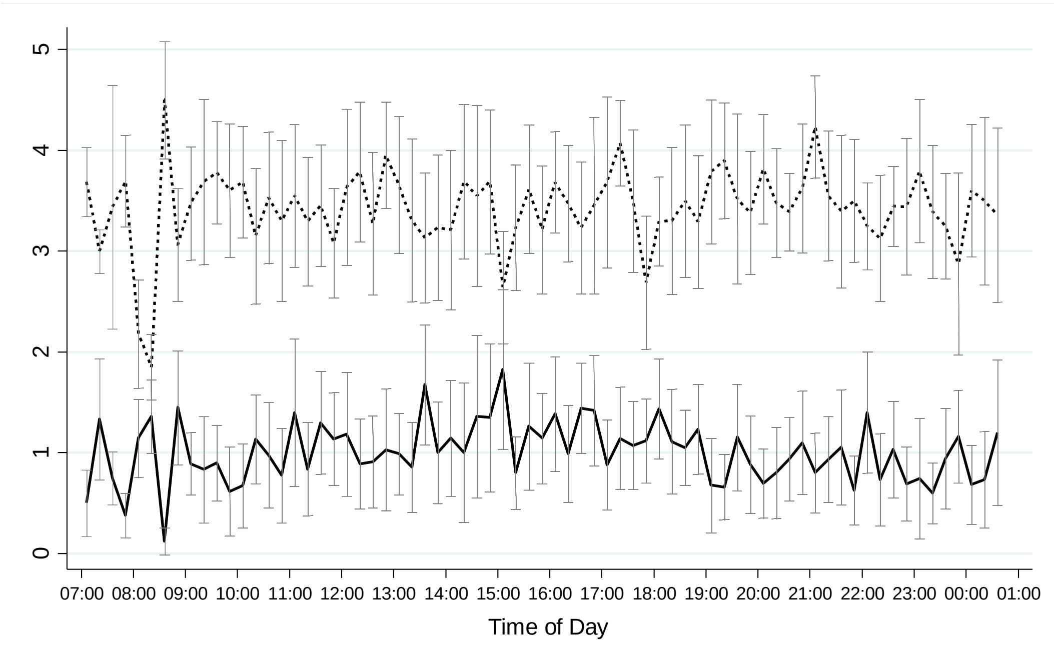
Model (3) Likelihood ratio test vs Linear Regression p = 0.000

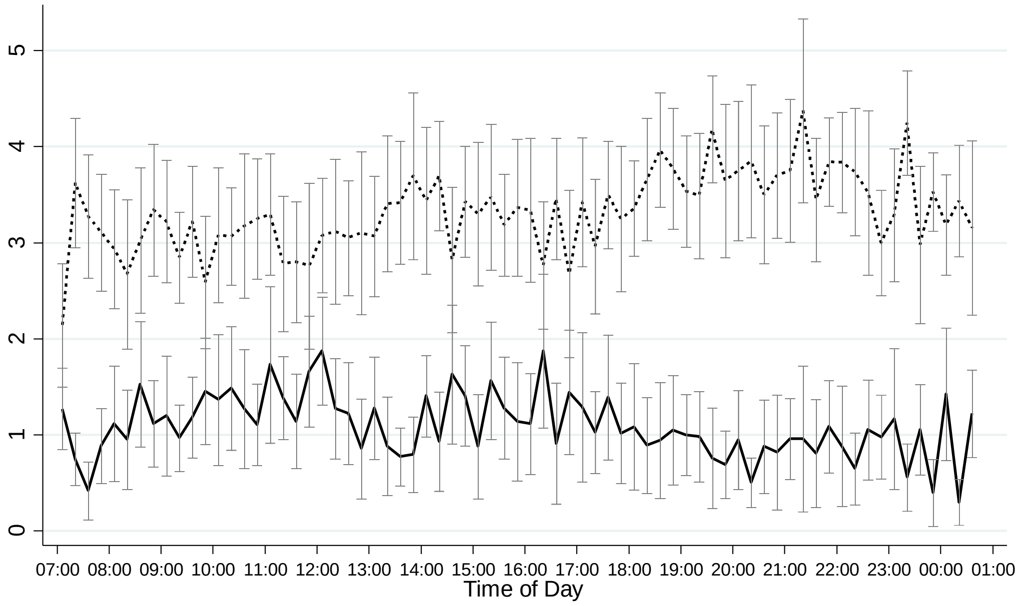
Model (4) Likelihood ratio test vs Linear Regression p = 0.000

5.3.2.4. Accounting for Time of Day (TOD) Effects

So far roughly 14% of episode level variance can be explained by the activities participants are engaged in and the percentage of the episode spent interacting with another. The influence of diurnal cycles is yet to be controlled for. Previous studies have used the DRM to investigate diurnal patterns of affect and found significant diurnal patterns. For example Stone et al., 2006 found bimodal patterns in both negative and positive affect. Such diurnal patterns are theorised to be a product of both physiological and environmental influences. Habitual behaviour patterns such as commuting and eating are expected to be associated with decreased positive and increased negative affect (Kahneman, Krueger, Schkade, Schwarz & Stone, 2004). In addition physiological influences such as cortisol and other stress hormones which are known to decline through the day and regenerate during sleep (Kirschbaum & Hellhammer, 1989) may have an independent effect on experienced well-being. The approach of Stone et al., 2006 was followed with the day divided into fifteen minute intervals Figure 5.8 plots the average net-affect for intervals with more than 10 observations for Sundays and weekdays.

Figure 5.8: Positive (dashed line) and negative (solid line) affect over 15 minute intervals: Upper graph is for Sunday and lower is for Wednesday.





As expected, weekdays show a more pronounced diurnal cycle of affect than Sundays. A clear increase in positive affect and decrease in negative affect around 18:00 corresponding with the end of the working day can be seen in Figure 5.8, this end of the day high lasts almost until bed time. To identify times of day that have a significant effect on experienced well-being, another panel model was run, this time using a categorical time of day variable[23], and net affect as the dependent variable. Again contrasting patterns of affect for different days of the week were observed (Table 5.11) with the Sunday model not passing the Wald test for overall significance. For weekdays a significant positive effect from the dummy variables was observed representing what are clearly non-work hours (from 17:00 to 21:00).

[23] The categorical TOD variable ranges from 1 to 25 representing episode mid points that fall into hourly time slots starting at 05:00am (1). The final categorical Tod variable was trimmed to remove categories with low Ns (1 = n 1/ 22 = n 1/ 23&24 = n 3).

Table 5.11: Two level model of categorical Tod variable on Net Affect for the Sunday and Weekday groups the base case for Tod is 06:00am. Sunday N = 1397 episodes for 106 participants with between 2 and 22 episodes per participant (avg = 13.2). LR test p = 0.000 and Wald p = 0.000 Log likelihood = -2901.7841. Weekday N = 1031 episodes for 89 participants with between 3 and 22 episodes (avg = 11.6) LR test p = 0.000 Wald p = 0.1348 Log likelihood = -2065.4308.

	Wednesday p = 0.000			Sunday p = 0.135		
Tod	Coef	Std Err	P	Coef	Std Err	P
07:00	-0.327	0.327	0.317	-0.964	0.545	0.077
08:00	-0.205	0.323	0.526	-0.068	0.491	0.890
09:00	-0.270	0.329	0.412	-0.314	0.488	0.520
10:00	-0.462	0.326	0.157	-0.724	0.476	0.128
11:00	-0.083	0.316	0.794	-0.346	0.469	0.461
12:00	0.622*	0.328	0.058	-0.696	0.478	0.146
13:00	-0.014	0.323	0.964	-0.594	0.473	0.209
14:00	0.218	0.328	0.507	-0.918*	0.471	0.051
15:00	-0.188	0.345	0.586	-0.756	0.495	0.127
16:00	0.186	0.318	0.557	-0.482	0.483	0.318
17:00	0.719**	0.318	0.023	-0.465	0.462	0.315
18:00	0.707**	0.346	0.041	-0.186	0.486	0.702
19:00	0.973***	0.327	0.003	-0.065	0.476	0.892
20:00	0.906***	0.336	0.007	-0.229	0.474	0.628
21:00	0.748**	0.377	0.047	-0.224	0.496	0.652
22:00	0.707	0.366	0.054	-0.521	0.501	0.299
23:00	0.030	0.384	0.938	-0.101	0.535	0.851
00:00	-0.685	0.678	0.312	-0.853	0.823	0.300
01:00	0.846	1.113	0.448	-0.464	0.683	0.497
Constant	1.999965	0.28149	0.000	2.884883	0.446	0.000
Random-effects	Estimate	Std. Err.	xtmrh	Estimate	Std.	Xtmrho
Individual level variance (level 2)	1.279	0.215	0.28	1.288	0.235	0.32
Episode level variance (level 1)	3.260	0.129		2.761	0.129	

It is possible that this afternoon effect will already be taken into account at the episode level by the reported activity. To test such a postulation a dummy variable was created to represent this afternoon period and added to our existing activity model, once activities were controlled for no significant effect for Tod was observed. This is understandable due to the endogeneity of activities and time of day.

Stone et al., (2006) found that diurnal cycles of affect adjectives associated with both positive and negative affect (enjoyment and frustration) were attenuated when activities were accounted for. This activity hypothesis was tested both the composite positive and net affect measures by including a dummy variable that represents the significant Sunday afternoon period in the mixed models (results shown in Table 5.12 below). As expected once activities are accounted for there is no significant effect of an episode occurring in this significant afternoon period on a week day.

Table 5.12: Mixed effects model of activities, percentage interaction and significant weekday afternoon periods on net-affect and positive affect (transport is the base case). Intraclass correlation for model (5) = 0.345, Model (6) =0.444 Log restricted-likelihood model (5) = -2622.476, Model (6) = -2007.304. Model (5) Wald test chi^2 (15) = 308.61, p = 0.000, Model (6) Wald test chi^2 (12) = 296.37, p = 0.000.

	(5) Net Affect			(6) Positive Affect		
	N = 1314 (195 participants)			N = 1318 (195 participants)		
	Coef	Std Err	P	Coef.	Std. Err.	P
Week-Day Afternoon	0.185	0.166	0.264	0.081	0.103	0.433
Percentage Interacting	0.010	0.001	0.000	0.007	0.001	0.000
Social	0.805	0.217	0.000	0.667	0.128	0.000
Screen-time	0.700	0.172	0.000	0.427	0.100	0.000
Work	-0.745	0.132	0.000			
Exercise/Sport	1.437	0.318	0.000	1.075	0.191	0.000
Work-break	1.082	0.337	0.001	0.773	0.202	0.000
Relaxing	1.048	0.215	0.000	0.649	0.128	0.000
Intimate Relations	2.807	0.646	0.000	1.985	0.394	0.000
Reading	1.642	0.425	0.000	0.935	0.259	0.000
Hobby	1.274	0.481	0.008	0.943	0.293	0.001
Prayer/Church				0.752	0.328	0.022
Waiting	-1.227	0.511	0.016			
Waking/Personal Maintenance	0.442	0.174	0.011			
Other Chore	-1.107	0.434	0.011			
Other	-3.050	0.690	0.000	-0.993	0.420	0.018
Constant	1.369	0.126	0.000	2.654	0.078	0.000
Random Effects	Estimat	Std. Err.		Estimat	Std. Err.	
Individual level variance (level 2)	1.352	0.186		0.761	0.096	
Episode level variance (level 1)	2.570	0.108		0.953	0.040	

Net affect model likelihood ratio test vs linear regression p = 0.000
Positive affect model likelihood ratio test vs linear regression p = 0.000

5.3.2.5. Accounting for person level covariates

In order to isolate the effects of exposure to environmental features it is essential to account for as many other determinants of experienced well-being as possible. So far only episode level determinants of experienced well-being have been considered however our mixed effects model specification allow us to include both inter and intra individual effects on well-being such as personality traits. Testing the affect measures against established psychological norms helps to build confidence in these values. To do so the sample was divided into participants with greater and less than the median extraversion and neuroticism scores of the sample and compare mean person level affect ratings with independent group t tests. Extraverts are expected to experience more positive affect and neurotics to report greater negative affect.

Table 5.13: Results of independent t test of PA, NA and U-Index scores for individuals reporting above and below the median extraversion and neuroticism scores.

	Neuroticism		Extraversion	
	Low	High	Low	High
Mean U-index[24] (part level)	2.337 (11.47)***	4.793 (14.09)***	3.715 (12.15)	3.651 (13.81)
Mean PA	3.466 (1.36)***	3.253 (1.36)***	3.321 (1.30)	3.377 (1.42)
Mean NA	0.638 (0.91)***	1.117 (1.09)***	0.984 (1.80)***	0.821 (0.77)***

Table 5.13 reveals that those with an above median Neuroticism score report higher person level mean negative affect and that the difference between the means is statistically different from zero. Likewise for Negative affect, extraverts (those reporting above median extraversion scores) reported slightly less negative affect. There is also a significant difference in mean reported positive affect between participants with high and low neuroticism scores with above median neuroticism scores producing slightly lower than average PA values. Curiously the average positive affect reported by those with high extraversion is not significantly different from those with low extraversion. This could be attributed to social pressures to over-report positive affect.

To test whether these differences are attributable to personality differences at the level of everyday activities the person level neuroticism and extraversion scores were added to the random intercept model of affect balance. The effect this has on the model is to effectively account for some of the variance accounted for by the random intercept. Of the two only the neuroticism score had a significant and, as expected, negative influence on affect balance.

[24] The U-index (unpleasantness index) after Kahneman et al., (2004) is a participant level measure as the percentage of the day spent in an unpleasant emotional state. Here an unpleasant emotional state is defined as any episode for which the highest reported affect adjective was a negative adjective.

Table 5.14: Mixed effects model of activities, percentage interaction and individual's neuroticism score on net-affect and positive affect (transport is the base case). Intraclass correlation for model (7) = 0.302, Model (8) =0.440 Log restricted-likelihood model (7) = -2428.087, Model (8) = -1861.001. Model (7) Wald test chi^2 (15) = 339.03, p = 0.000, Model (8) Wald test chi^2 (12) = 298.37, p = 0.000.

	Net Affect (7)			Positive Affect (8)		
	N = 1224 (185 participants)			N = 1228 (185 participants)		
	Coef.	Std. Err.	P	Coef.	Std. Err.	P
Neuroticism Score	-0.076	0.015	0.000	-0.030	0.011	0.008
Percentage Interacting	0.011	0.001	0.000	0.008	0.001	0.000
Social	0.821	0.222	0.000	0.687	0.131	0.000
Screen-time	0.691	0.175	0.000	0.444	0.102	0.000
Work	-0.810	0.136	0.000			
Exercise/Sport	1.399	0.322	0.000	1.069	0.193	0.000
Work-break	1.217	0.353	0.001	0.798	0.211	0.000
Relaxing	1.047	0.220	0.000	0.661	0.130	0.000
Intimate Relations	2.857	0.693	0.000	2.107	0.421	0.000
Reading	1.609	0.436	0.000	0.903	0.265	0.001
Hobby	1.154	0.500	0.021	0.853	0.303	0.005
Prayer/Church				0.736	0.325	0.023
Waiting	-1.179	0.534	0.027			
Waking/Personal Maintenance	0.421	0.179	0.019			
Other Chore	-0.936	0.464	0.044			
Other	-4.348	0.839	0.000	-1.330	0.509	0.009
Constant	3.048	0.358	0.000	3.308	0.265	0.000
Random Effects	Estimat	Std. Err.		Estimat	Std. Err.	
Individual level variance (level 2)	1.106	0.164		0.736	0.096	
Episode level variance (level 1)	2.558	0.112		0.938	0.041	

Net affect model likelihood ratio test vs linear regression p = 0.000
Positive affect model likelihood ratio test vs linear regression p = 0.000

The newly added participant level covariate is statistically significant with a negative coefficient indicating that those with higher neuroticism report lower net affect. Addition of the neuroticism score to the model has reduced the level 2 variance component from 1.404 to 1.106 indicating that it has accounted for some of the variation in the intercepts. Likewise for the positive affect model participant's neuroticism score has a small but significant effect, again accounting for some of the variation in the intercepts, (reducing the person level variance from 0.760 to 0.736).

The level 1 R^2 of model (7) = 0.209 and the level 2 R^2 = 0.176. This means that differences in participants self-reported neuroticism accounts for 18% of the variance in the intercepts. For the positive affect model the level 1 R^2 of model (8) = 0.128 and the level 2 R^2 = 0.032. The extremely low level 2 R2 for positive affect indicates supports previous findings (e.g. Rusting et al., 1997) that neuroticism has a greater effect on negative rather than positive affect.

So far only neuroticism has been included as a level 1 covariate assuming that the person level intercepts are random and thus that neuroticism has a common effect across all individuals. To test whether neuroticism has a differing effect across individuals a random slope specification of neuroticism was tested, this allows the effect of neuroticism to vary for each individual. Initially this model was run with an unstructured covariance matrix to allow for correlation between all variance covariance's and level 1 covariates, however an LR test shows that including the covariance for neuroticism does not significantly improve the fit of the model (LR $Chi^2(1) = 0.31$, $p = 0.575$) and an independent covariance matrix was specified for the random slope model. Results are presented in Table 5.15 below.

Table 5.15: Mixed effects model of activities, percentage interaction and individual's neuroticism score on net-affect and positive affect (transport is the base case). Intraclass correlation for net affect model = 0.302, Model (8) =0.440 Log restricted-likelihood model (7) = -2428.087, Model (8) = -1861.001. Model (7) Wald test chi^2 (15) = 339.03, p = 0.000, Model (8) Wald test chi^2 (12) = 298.37, p = 0.000.

	Net Affect (7)			Positive Affect (8)		
	N = 1224 (185 participants)			N = 1228 (185 participants)		
	Coef	Std Err	P	Coef.	Std. Err.	P
Neuroticism Score	-0.076	0.015	0.000	-0.030	0.011	0.008
Percentage Interacting	0.011	0.001	0.000	0.008	0.001	0.000
Social	0.821	0.222	0.000	0.687	0.131	0.000
Screen-time	0.691	0.175	0.000	0.444	0.102	0.000
Work	-0.810	0.136	0.000			
Exercise/Sport	1.399	0.322	0.000	1.069	0.193	0.000
Work-break	1.217	0.353	0.001	0.798	0.211	0.000
Relaxing	1.047	0.220	0.000	0.661	0.130	0.000
Intimate Relations	2.857	0.693	0.000	2.107	0.421	0.000
Reading	1.609	0.436	0.000	0.903	0.265	0.001
Hobby	1.154	0.500	0.021	0.853	0.303	0.005
Prayer/Church				0.736	0.325	0.023
Waiting	-1.179	0.534	0.027			
Waking/Personal Maintenance	0.421	0.179	0.019			
Other Chore	-0.936	0.464	0.044			
Other	-4.348	0.839	0.000	-1.330	0.509	0.009
Constant	3.048	0.358	0.000	3.308	0.265	0.000
Random Effects	Estimate	Std. Err.		Estimate	Std. Err.	
Neuroticism Variance component	1.63e-10	4.82e-10		2.01e-12	1.71e-09	
Individual level variance (level 2)	1.106	0.164		0.736	0.096	
Episode level variance (level 1)	2.558	0.112		0.938	0.041	

Net affect model likelihood ratio test vs linear regression p = 0.000
Positive affect model likelihood ratio test vs linear regression p = 0.000

The variance component on neuroticism is very small (Table 5.15) in both the net affect and positive affect models suggesting that the effect of neuroticism does not vary across individuals. This new model actually yielded the same log likelihood as the random intercept model and it was thus concluded that the new variance component was not improving model fit. In an attempt to account for more individual level variance in the model through person level covariates are tested in the model. No significant effect of gender, age, psychological well-being (SOS10 Blais et al., 1999), extraversion, marital status, income and whether or not the participant has children were found.

5.3.2.6. Accounting for Subjective Exposure Effects on Experienced Well-Being

The relationship between environmental exposure and experienced well-being is investigated using both the perceived and the measured exposure measures. First the relationship between subjective exposure and episode level affect measures were examined.

Table 5.16 indicates that there are significant but weak correlations between the experienced well-being measures and the subjective exposure measures. The strongest relationship appearing between the "could see people" and positive affect variables. To further explore these relationships the subjective exposure measures were added into the model of net affect (Table 5.17 below). Through a stepwise process it was found that reported visual exposure to animals is the only variable to significantly influence affect balance with the expected positive influence on net affect. Obvious collinearity between the percentage interacting with another and the "could see people" variable prevent this variable from reaching significance.

Table 5.16: Pearson correlations between perceived exposure measures and positive (PA) and negative Affect (NA).

	Animals	Trees	Vegetation	Roads	Traffic	People
Positive Affect	.092***	.005	.010	-.044**	-.044**	.204***
Negative Affect	-.012	-.005	-.016	.028	.032	.006
Net Affect	.067***	.009	.001	-.066***	-.068***	0.120***

Table 5.17: Mixed effects model of activities, percentage interaction, individual's neuroticism score and perceived exposure on net- and positive affect. Net affect model (9) intraclass correlation = 0.321, log restricted-likelihood = -2239.063, Wald test = chi^2 (16) = 346.27 p = 0.000. Positive affect model (10) intraclass correlation = 0.442 log restricted likelihood = -1852.221, Wald test = chi^2 (13) = 320.64 p = 0.000.

	Net-Affect (9)			Positive Affect (10)		
	N = 1126 (185 participants)			N = 1126 (185 participants)		
	Coef	Std Err	P	Coef	Std Err	P
Animals High**	0.593	0.214	0.006	0.405	0.096	0.000
Neuroticism Score	-0.077	0.016	0.000	-0.029	0.011	0.009
Percentage Interacting	0.011	0.001	0.000	0.008	0.001	0.000
Social	1.008	0.231	0.000	0.736	0.130	0.000
Screen-time	0.883	0.185	0.000	0.481	0.101	0.000
Work	-0.613	0.146	0.000			
Exercise/Sport	1.482	0.323	0.000	1.065	0.192	0.000
Work-break	1.367	0.355	0.000	0.812	0.210	0.000
Relaxing	1.221	0.229	0.000	0.687	0.130	0.000
Intimate Relations	3.102	0.696	0.000	2.208	0.418	0.000
Reading	1.747	0.440	0.000	0.948	0.263	0.000
Hobby	1.312	0.508	0.010	0.843	0.301	0.005
Prayer/Church	-1.018	0.532	0.056			
Waiting	0.585	0.186	0.002			
Waking/Personal Maintenance	-0.809	0.464	0.081			
Other Chore				0.771	0.322	0.017
Other	-4.177	0.843	0.000	-1.272	0.506	0.012
Constant	2.885	0.377	0.000	3.240	0.264	0.000
Random Effects	Estimate	Std. Err.		Estimate	Std. Err.	
Individual level variance (level 2)	1.192	0.178		0.732	0.095	
Episode level variance (level 1)	2.520	0.116		0.924	0.040	

Net affect model likelihood ratio test vs linear regression p = 0.000
Positive affect model likelihood ratio test vs linear regression p = 0.000

** For net affect model (9) Animals High = 4/5 (could see animals most or all the time) for positive affect model (10) Animals High = 3/4/5

As the random slope parameter was removed from the model the covariance matrix is no longer required. For the net affect model (9) only the highest two responses to the "could see animals" had a significant and positive effect on net affect. This is represented by the dummy variable Animals High in Table 5.17. This positive and significant relationship between reported visual exposure to animals and net affect provides some evidence in support of hypothesis 2.1 that natural features have a significant impact on experienced well-being (Wald test of combined significance = chi2(16) = 346.27 p =0.000). No significant effects of the remaining subjective exposure measures could see trees, vegetation, roads, traffic or people on net affect.

For both the net affect (9) and positive affect model (10) a significant positive effect of Animals High was found. Animals High represents the top three categories of could see animals. Again this shows support for hypothesis (2.1) that natural features have a significant and positive impact on experienced well-being. No evidence of a negative effect of perceived exposure to roads or traffic on net affect or positive affect was found. Before the influence of GPS isovist measures is considered, further episode level effects are investigated using single activity models.

5.3.2.6.1. Work only Model

So far a large amount of the variance in net affect has been attributable to the activities participants are engaged in. The dominance of activities in these models may confound the effects of environmental factors (particularly as environments and activities are likely to not be perfectly orthogonal) one way to avoid the endogeneity of activities and the environments they are performed in it is to analysis single activities independently. Table 5.3 shows us that the most commonly reported activities are transport (367), work (284), screen time (138), waking and personal maintenance (129) and social (92). Due to the relatively low n's here only single activity models for transport and work episodes are reported.

The random effects ANOVA (empty model) for work only single activity episodes and net affect (reported in Appendix 5.6) shows that 44% of the variation in net affect is attributable to individual differences. For positive affect this empty model attributes 49% the variation in positive affect to individual differences (Appendix 5.7).

No significant effects of any of the subjective exposure measures on net affect was observed. The net affect model (11) reported in Table 5.18 below show only the % interacting with others variable and the participant's neuroticism score have a significant effect on net affect. Level 1 R^2 for the work only model shown in Table 5.18 amounts to only 3% of the variation in net affect experienced in work activities. A Wald test of the joint significance of the level 1 covariates shows them to be jointly significant (chi^2 (3) = 9.44 p = 0.024). This shows no support for hypothesis 2.1 and it can be concluded that there is no evidence for a significant effect of perceived exposure to natural features for work activities.

The positive affect model (12) (Table 5.18) reveals that neuroticism has no significant influence on positive affect for work only episodes. Percentage interacting with others still has a significant positive effect. Participants who reported not seeing any vegetation in work episodes has a significant (at $p < 0.10$) and negative effect on the positive affect experienced in work episodes. As the majority of work episodes reported by participants were indoors this result does not directly support our hypothesis concerning urban green space and experienced well-being. However this does echo the findings Chang & Chen (2005) who's experimental study reports significant positive effects of office plants and window views of natural features on tension and anxiety.

Table 5.18: Mixed effects model of net affect and positive affect for work only episodes, N = 265 (108 individuals with between 1 and 7 episodes each). For net affect model (11) log-likelihood = -556.733, intraclass correlation = 0.403, Wald test Chi^2 (2) = 9.47, p = 0.009. For positive affect model (12) log-likelihood = -415.688, intraclass correlation = 0.472, Wald test Chi^2 (3) = 13.95 p = 0.003.

	Net Affect (11)			Positive Affect (12)		
	N = 265 (108 individuals)			N = 1126 (185 participants)		
	Coef	Std. Err	p	Coef	Std Err	P
Didn't See Vegetation				-0.323	0.167	0.054
Neuroticism score	-0.058	0.027	0.029			
% interaction with others	0.007	0.003	0.034	0.006	0.002	0.001
Constant	1.957	0.635	0.002	2.872	0.398	0.000
Random Effects	Estimate	Std. Err.		Estimate	Std. Err.	
Var(_cons)	1.732283	0.389		0.720	0.155	
Var(Residual)	2.564457	0.274		0.806	0.089	

Net affect model likelihood ratio test vs. linear regression p = 0.000

Positive affect model likelihood ratio test vs. linear regression p = 0.000

5.3.2.6.2. Transport only Model

The random effects ANOVA (empty model) for transport only single activity models shows that an even greater amount of the variance in net affect is attributable to individual differences with approximately 51% of the variation in net affect attributable to individual differences leaving only 49% left for differences between episodes (see Appendix 5.8). Likewise the empty model for transport only episodes on positive affect shows that 58% of the variation in positive affect is attributable to individual differences (see Appendix 5.9).

Again no significant effect of perceived exposure measures on net affect was found and significant negative effects of neuroticism and positive effect of interaction with others (Table 5.19). As all transport activities are outdoor episodes this result raises suspicions concerning the significance of animals in the multiple activity model reported in Table 5.17 and thus our initial support for hypothesis 2.1. Again no evidence for a negative influence of perceived exposure to roads and traffic on net affect was found. For the positive affect model (14) reported in Table 5.19, a significant positive effect of the three highest 'could see vegetation' categories which is represented by the animal's high variable can be seen. A Wald test confirms the significance of the animals high variable (Chi^2 (1) = 4.76, p = 0.029). Again showing support for hypothesis 2.1 that natural features have a significant positive influence on experienced well-being.

Table 5.19: Mixed effects model of net affect and positive affect for transport only episodes. For net affect model (13) level 1 n = 335, level 2 n = 124 individuals (with between 1 and 7 episodes per individual, mean = 2.7), log-likelihood = -663.056, intraclass correlation = 0.486, Wald test Chi^2 (2) =35.26, p = 0.000. For positive affect model (14) level 1 n = 366 episodes, level 2 = 133 individuals (with between 1 and 8 episodes per individual, mean = 2.8), log-likelihood = -559.176, intraclass correlation = 0.601, Wald test Chi^2 (2) =29.42 p = 0.000.

	Net Affect (13)			Positive Affect (14)		
	N = 335 (124 individuals)			N = 1126 (185 participants)		
	Coef	Std. Err	p	Coef	Std Err	P
Animals_High				0.288	0.132	0.029
Neuroticism score	-0.075	0.024	0.002			
% interaction with others	0.013	0.003	0.000	0.008	0.002	0.000
Constant	2.811	0.569	0.000	2.554	0.116	0.000
Random Effects	Estimate	Std. Err.		Estimate	Std. Err.	
Var(_cons)	1.779	0.340		1.029	0.167	
Var(Residual)	1.882	0.182		0.683	0.064	

Net affect model likelihood ratio test vs. linear regression p = 0.000

Positive affect model likelihood ratio test vs. linear regression p = 0.000

5.3.2.7. Accounting for Objective Exposure Effects on Experienced Well-Being

So far only the effects of participant's perceived exposure to natural and urban features have been examined, as these were reported for every episode in participant's diaries it was possible to include them for all activities. However as isovist measures were calculated from participants GPS tracks they can only be obtained for single activity outdoor episodes with sufficient GPS data. Due to the small number of observations in our measured data set for which the majority consist of transport activities the net and positive affect models are run using only single activity transport episodes. Table 5.20 shows correlations between the five objective isovist based measures of visual exposure and the positive, negative and net affect measures of experienced well-being. Low correlations between all objective exposure measures and affect measures are observed (Table 5.20).

Table 5.20 Correlations (Pearson's) between isovist exposure measures and composite affect measures.

	% Natural	% Multiple	% Water	% Trees	% Roads
Positive Affect	0.010	-0.029	0.075	0.010	0.004
Negative Affect	-0.118	0.113	-0.057	-0.035	0.067
Net Affect	0.069	-0.078	0.080	0.026	-0.033

A new random effects ANOVA was fitted to single activity transport episodes for which complete GPS data was available (see Appendix 5.10) this yielded an intraclass correlation of 55%. For positive affect the intraclass correlation of the empty model indicates that 62% of the variation in positive affect is attributable to individual differences. Table 5.21 again shows the model resulting from a stepwise process. Only the presence of water in participant's isovist field has a significant but large positive influence on net affect. This is confirmed with a Wald test (Chi2 (1) = 3.70 p = 0.054) again showing support for hypothesis 2.2 that there is a positive relationship between objective exposure measures and experienced well-being. Together these variables explain 17% of the variation in net affect (level 1 R^2 = 0.172). For positive affect again a significant influence of the percentage of water in a participant's isovist for transport only episodes is seen. This is confirmed with a Wald test Chi^2 (1) = 3.92, p = 0.048.

Table 5.21: Mixed effects model of net affect and positive affect for transport only episodes. For net affect model (15) level 1 n =202, level 2 n = 101 individuals (with between 1 and 7 episodes per individual, mean = 2.2), log-likelihood = -564.258, intraclass correlation = 0.414, Wald test Chi^2 (3) = 50.21, p = 0.000. For positive affect model (15) level 1 n = 202 episodes, level 2 n = 101 participants (with between 1 and 7 episodes per individual mean = 2.0), log-likelihood = -317.444, intraclass correlation = 0.602, Wald test Chi^2 (3) = 11.56 p = 0.009.

	Net Affect (15)			Positive Affect (16)		
	N = 202 (101 individuals)			N = 202 (101 participants)		
	Coef.	Std. Err.	p	Coef.	Std. Err.	P
% Water in Isovist	0.958	0.498	0.054	0.966	0.488	0.048
Neuroticism score	-0.103	0.024	0.000	-0.025	0.020	0.215
% interaction with others	0.014	0.003	0.000	0.005	0.002	0.027
Constant	3.674	0.565	0.000	3.228	0.482	0.000
Random Effects	Estimate	Std. Err.		Estimate	Std. Err.	
Var(_cons)	1.486	0.333		1.000	0.201	
Var(Residual)	2.103	0.234		0.661	0.090	

Net affect model likelihood ratio test vs. linear regression p = 0.000
Positive affect model likelihood ratio test vs. linear regression p = 0.000

5.4. Conclusions

While several studies have shown that visual exposure to natural features can have a beneficial influence on well-being (Hartig et al., 2003, Pretty et al., 2005) such lab based studies have suffered from a lack of ecological validity as they fail to replicate the context of everyday life. Similarly, while observational studies have demonstrated a positive effect of urban green spaces on well-being (Bjork et al., 2008; Kaplan, 2001), such analyses have struggled to develop and incorporate realistic measures of exposure to environmental features. In this study I have tried to overcome some of these problems. Through the use of momentary assessment of individual's emotional experience alongside simultaneous real time objective measures of visual exposure to environmental features the effects of visual exposure to various environmental features on experienced well-being have been tested and found to be significant.

Both individual and contextual effects were found to have a substantial influence on participants' experienced well-being. At the episode level, the activities participants are engaged in, and how much of any episode was spent interacting with another person, have a significant influence on experienced well-being. While activities have a range of positive and negative effects on participants' experienced well-being, as would be expected, interacting with another has a small but consistently positive influence on both net and positive affect. This suggests that interacting with others not only reduces negative affect but also increases positive affect.

While clear diurnal variations in well-being were observable these did not have a significant influence on well-being when the effects of activities were held constant.

While significant differences in experienced well-being for those categorised as exhibiting either above or below median neuroticism and extraversion scores (Table 5.13) has been observed only neuroticism proves to have a significant effect when significant activities and interacting with others are held constant (Table 5.14). This effect is approximately twice the size for net than it is positive affect suggesting that neuroticism has a greater influence on negative emotions (which are included in the net affect measure). While person level neuroticism has a significant effect on experienced well-being no evidence was found that the effect of neuroticism varies between individuals (by the inclusion of a random slope). This suggests that the effect of neuroticism is approximately the same across individuals in the sample. While the significance of activities in all the models fitted in this study may be unsurprising it is problematic for an analysis of the influence of environmental features as it is likely that certain activities can only be performed in particular environments. As such, our analysis of the influence of visual exposure on experienced well-being was restricted to single activities; while this resulted in a substantially reduced sample size, it does circumvent the problem of environments being endogenous to activities. This is one of the major contributions of our analysis, directly controlling for the confounding of activity and environment characteristic which the large majority of the empirical literature has failed to do. Not surprisingly invoking such control reduces the size of positive affect associated with green space environments. That it does not remove such affect provides robust (and arguably, incontrovertible) evidence for the positive influence which exposure to such environments has upon human wellbeing.

Both subjective self-reported and objective visual exposure measures were used to test the relationship between experienced well-being and the environments of everyday activities. While a large significant influence of participants self-reported visual exposure to animals on both positive and net affect was found, when controlling for a range of activities this effect does not seem to be present for work-based episodes and is weaker and only significant for positive affect for transport episodes (although this reduction in significance is likely due to the reduced number of observations in these models). For work-based episodes, while no significant effect of subjective exposure to animals was found, a significant reduction in positive affect arose from not being able to see any vegetation. This result echoes previous findings (Chang & Chen, 2005) who report significant positive effects of office plants and views of nature on tension and anxiety. The presence of this significant effect of subjective exposure to vegetation highlights a major advantage of the subjective measures of visual exposure which can be made whether the participant is indoor or outdoor.

In contrast to subjective measures, the objective data on visual exposure are reliant on GPS measures which can be only collected when participants' receivers have a clear view of the sky and as such were only analysed for transport activities. Only the percentage of land covered with water was found to have a significant effect on experienced well-being and while this had a large positive effect, at the $p<0.05$ level it was only significant for the positive affect model. While previous studies have reported that the presence of water can have a positive effect on well-being irrespective of whether it is in a natural or urban scene (White et al., 2010), our result has to be interpreted carefully. The positive effect of exposure to water as measured through isovist fields in everyday environments could be interpreted through evolutionary biophilia accounts such as savannah or prospect refuge theories (see Chapter 1). Alternatively it could be a facet of our measurements of land use whereby the presence of water is indicative of environmental quality in general, with expanses of water typically within park lands and open countryside areas. This highlights the need for more in-depth spatial data regarding the quality of urban environments.

The use of experienced well-being measures promises to reduce recall and retrospective bias introduced by the use of reflective measures of well-being instead of accessing the experiential self directly and thus avoiding reflection on one's emotional state. In this study it has been shown that the positive influence of natural features in participant's everyday lives can be detected with the use of measures of experienced well-being. The authors have also demonstrated a unique method through which objective visual exposure to a range of environmental features can be assessed and incorporated within empirical analyses. This study has shown that natural features such as animals and water in participant's everyday environments can have a positive impact on their experienced well-being beyond the expected effect of activities. While very little correlation between the isovist based exposure measures and participant's subjective exposure reports was found, both could be related to well-being, albeit in different ways. This highlights the subjective nature of participant's experiences of their everyday activities.

In contrast to previous lab based studies this study has shown that activities dominate our experience of well-being, suggesting a lack of ecological validity in much of the empirical literature. Likewise, while some evidence for a positive effect of natural features on experienced well-being was found, no significant evidence of urban features such as roads and traffic having a negative influence on experienced well-being was found. This is unsurprising given the likely habituation to these environmental disammenities by urban residents.

In addition, this study has demonstrating a unique alternative to measuring visual exposure to environmental features in everyday life. While the construction of isovist fields is computationally expensive and can be time consuming, ever improving computing software and hardware should make this type of analysis progressively more tractable. The concept of isovists is already familiar to architects and has, considerable potential applicability to a wide range of urban researchers and planners. While this study has used relatively simple 2D isovists, 3D isovists represent a more realistic approximation of what urban populations actually see in their field of view and is suggested here as a potential extension to this work (Morello & Ratti, 2009). The field of spatial syntax studies has the potential to offer more abstract alternatives to measuring environmental quality than the simple distance and buffer land use measures currently used.

6. Conclusions

6.1. Introduction

"There is a renaissance underway, in which people are waking up to the tremendous values of natural capital and devising ingenious ways of incorporating these values into major resource decisions."

(Gretchen Daily, Stanford University; Daily and Ellison, 2002)[25]

While urban green spaces are a huge source of potential health and well-being benefits for urban residents (Ulrich, 1986, Kaplan & Kaplan, 1989; Whitford et al., 2001; Humpel et al., 2004; Kim & Kaplan, 2004) ever increasing pressures on urban land use means that measurements of these benefits are essential to give them an equal footing next to alternative uses with well-defined market values. As such this thesis set out with two research questions in mind. The first was to investigate economic and psychological methods that can be used to quantify these benefits and the second to assess the role that spatial complexity plays in both of these methods of measuring the benefits of urban green space. In fulfilment of this first aim two strands of empirical work have been presented that build on existing methods for quantifying these benefits using both economic and subjective well-being perspectives. While these two approaches offer different insights regarding the nature of this relationship crucial to both perspectives is the recognition of the central role that space plays in determining the benefits that natural features have on well-being. A plurality of perspectives on the well-being benefits of urban green space offer policy makers the most informed perspective given the strengths and weaknesses of each method. Using a range of perspectives also offers opportunities to advance our understanding of how urban green spaces influence well-being. The second research question identified in Chapter 1 concerns the role that spatial relationships play in both these methods of measuring green space benefits. This question has been addressed through the incorporation of spatial variables at the heart of both the economic and subjective well-being strands reported in this thesis. Results from research in this thesis demonstrate that the often complex nature of spatial drivers of well-being can be parametised and prove to be significant determinants of both economic and subjective well-being assessments of these benefits. In this final Chapter the results of the three empirical studies presented in this thesis will be discussed with reference to these research questions, this includes a discussion of the limitations of the research presented and avenues for future research in this area.

[25] Daily, G., & Ellison, K. (2002). The new economy of nature: the quest to make conservation profitable. Island Press.

6.2. Empirical Findings

6.2.1. Chapter 3

In Chapter 3 it was shown that GIS techniques can be used to take secondary data and tease out spatial relationships between green space and economic values. Through an initial meta-analysis of existing primary valuations a spatially explicit value function was constructed. This was initially applied to a representative sub-sample of cities using high resolution spatial data. Using additional secondary data sources these values were transferred across the whole country providing, for the first time, aggregated values for the whole of the country's urban green space. This forms a useful resource for policy makers as well as demonstrating the potential value of spatially based secondary data analysis. Through controlling for spatial correlations the relationship between green space and well-being was converted into spatial functions allowing it to be applied to areas for which data was not available on specific attributes of the goods. This facilitates the large scale projection and aggregation of such values offering a valuable resource to decision makers. As part of the UK National Ecosystem Assessment results from this empirical study have already had a significant impact on UK policy with the Natural Environment White Paper (UK Government, 2011) drawing heavily on the results of the UK NEA, this included a commitment to carry out follow on work to investigate actions required to secure the most benefits from nature and ecosystems and to develop tools which can assist decision makers in applying the lessons of the UK NEA. In addition to these important policy impacts this study has demonstrated a cost effective spatially explicit methodology for assessing the value of urban green spaces that could be used to assess the value of many spatially confined non-market goods. In fact the authors of this study have been contacted by Ricky Lawton of the Cabinet Office well-being team who have expressed an interest in applying this same spatial value transfer methodology to SWB measures collected by the UK Office for National Statistics. This study makes a valuable contribution to the literature on value transfer which although increasingly making use of spatial dynamics and GIS has yet to exploit these relationships to create valuations of this spatial scale and resolution. This type of spatially referenced value transfer helps to overcome some of the problems of previous value transfers by incorporating spatial complexity into both the estimation of value and of the number of potential receivers of this value in order to improve the aggregation of these values which has previously relied on political jurisdictions. In reference to the aims of this thesis this study has demonstrated how GIS can be used to combine numerous secondary data sets and incorporate spatial complexity to create a cost effective means of deriving monetary valuations for urban green spaces (and other public goods).

6.2.2. Chapter 4

While the NEA analysis made good use of the implicit spatial nature of the relationship between human well-being and urban green space provisioning assumptions regarding the shape of these spatial relationships has been brought into question by results of the second empirical study reported in Chapter 4. As has been seen the observation that values for spatially constrained goods such as parks decay monotonically with increasing distance facilitates the construction of demand functions (Lovett et al., 1997) as well as the establishment of appropriate aggregation areas and benefit functions (Bateman et al., 2006).

The results of this study confirm the potential for public goods such as parks to create local disammenities, an observation that has been made in previous revealed preference studies (Day et al., 2007). To observe these effects a study was designed to collect economic values for parks in different locations using a CVM and then sampled to maximise the variation in distance around these two locations. This allowed for the effects of distance to be controlled for and through the use of advanced statistical techniques allowed the possibility of non-monotonic distance decay relationships to be investigated. This study revealed that whilst distance still plays a crucial role, perceptions of specific locations also matter. Firstly those further away from the more deprived park location expressed a general preference for it over the nearer park due to altruistic motivations. Secondly those nearby to the more deprived park location experienced a local dis-amenity. Whilst it was hypothesised that this is due to perceptions of crime and anti-social behaviour at this location further research would be necessary to confirm such an assertion. This study provides important methodological contributions to both the CVM literature and also the value transfer literature that utilises distance decay functions in the estimation of benefits and visitor numbers.

6.2.3. Chapter 5

While WTP estimates are useful as they fit into cost benefit analysis they suffer from certain recognised challenges. CVM approaches value a bundle of goods which can be difficult to delineate creating challenges for policy makers. Being monetary valuations they are of course bounded by individual’s budgetary constraints and thus could be imperfect estimates of an individual’s utility. They also place an individual in an unfamiliar frame by asking them to value goods which do not typically have market values (Bateman et al., 2008). An alternative approach to quantifying the well-being benefits is to directly measure individual’s self-reported well-being in relation to the presence of certain environmental goods. To this effect the DRM (Kahneman et al., 2004) was used to relate individual’s experienced well-being to isovist based measures of visual exposure to natural features in people’s everyday environments. While several lab based studies have shown that visual exposure to natural features can have a positive influence on well-being such studies fail to account for the contextual effects of everyday life (Ulrich, 1984). The use of more complex spatial measures promises to more accurately estimate visual exposure than point or buffer based estimates. Such methods represent a move away from a provisioning approach to valuation (where benefits are viewed as emanating from goods) to an agent based method which prioritises the benefits actually experienced by individuals in their everyday lives. Such methods have the potential to disaggregate the bundle of green space benefits that are measured by existing economic methods. Results showed that while little relationship could be found between objective, isovist based measures and, subjective self-reported measures of visual exposure, both were found to significantly influence experienced well-being whilst significant individual and episodic influences on well-being were held constant.

6.3. Methodological Implications

Findings of this thesis have contributed to an understanding of how spatial analysis can be used to facilitate the measurement of urban green space benefits in both economic and psychological terms in accordance with research question 1. While assumptions regarding the distance decay of WTP values facilitated the projection and aggregation of these values in Chapter three, Chapter four demonstrated how such assumptions do not always hold through the consideration of such relationships using modern statistical techniques. The significance of space is further illustrated in Chapter five in which to the best of my knowledge individual's visual exposure to their urban environments has been measured for the first time. While the estimation of values for discrete urban green spaces such as parks can inform decision making and policy regarding such goods visits to such sites are relatively rare for the majority of urban residents. As such, everyday exposure to non-formal green spaces such as road side verges and street trees may be more relevant. Advances in GIS and GPS technology make such analysis possible and while the isovist based measures presented in Chapter three represent but a first step such analysis promises to inform policy makers and urban planners about more than just the influence that discrete urban green spaces have on well-being but the general spatial syntax of our cities.

While it was not the objective of this thesis to comment on whether economic or subjective well-being based measures of urban green space benefits are more useful some interesting differences have emerged from the application of both within this thesis. While economic valuation methods are concerned with the value individuals place through the decisions they make subjective well-being measures are ex post and so measure this value after it has been experienced (or at the same time in the case of experienced well-being measures). In practice this creates some interesting methodological differences as economic valuation techniques create less data collection demands in comparison to the application of subjective well-being measures which require information on both the individual's self-reported well-being and measures of their exposure to the environment features being valued. Psychological and economic approaches may access different aspects of the well-being benefits of urban green space with economic approaches likely to access the benefits that come from the anticipation of experiencing or visiting such spaces and from knowing that they are accessible. While subjective well-being measures are able to access the experiential value either after the fact or in real time. This raises the question of whether both could be used in a complementary fashion to get further insights into the relationship between environmental quality and well-being and thus to improve the prominence of the environment within decision making and public policy. To do so would require further research into the overlaps and differences between these two approaches.

6.4. Policy Implications

The allocation of scarce and valuable resources such as urban green spaces needs to highlight its efficient usage. That efficiency can induce concerns regarding distribution and equity. If society values benefits to the poor more than the rich then this should be part of our definition of efficiency. Decision making regarding the provisioning of urban green spaces needs to consider not only the existing spatial and social distribution of such resources but also how best to target new urban green spaces to maximise their received benefits. This is highly important to city planners especially in light of the UK governments plans to increase the number of newly built homes in the UK. The UK government's independent panel on forestry published a report in 2012 recommending the creation of more forested areas, indeed the research presented in this thesis confirms the value of such urban green spaces and provides valuable insights into the effects of positioning of such goods. Such techniques can also be applied to assess the implications of changes in the urban environment such as the growth and shrinkage of urban areas. The use of experienced well-being to measure the benefits that goods such as urban green spaces provide is only effective if such goods actually influence well-being in everyday contexts. The use of experienced utility measures in this context has the advantage of avoiding potential focusing and framing effects present in CV studies as well as avoiding the possibility of protest responses distorting values according to individual's political or moral objectives. While couching assessments of public good benefits in terms of well-being may not yet produce realistic monetary valuations it does allow us to assess such benefits relative to everyday influences on our well-being such as personality and behaviour.

6.5. Limitations of the Studies and Future Directions

Several limitations can be identified with the research presented in this thesis. Firstly time and resource restrictions limited the sample size of all three empirical works reported in this thesis. Limitations and future research directions will now be discussed for each of the empirical Chapters.

Several caveats of the study reported in Chapter three should be acknowledged and examined as avenues of future research. This study could not account for all the benefits that green space are known to provide as essentially a bundle of green space benefits are valued. Deconstructing this bundle of goods would require significantly more information on the characteristics of both green spaces and the population and is suggested as a future avenue for research in this area. This highlights the need for nationwide standards for the collection and maintenance of council green space data, although it is probably more likely that future analysis will use open source data sources such as those provided by open street map as these are quickly becoming more complete and detailed and do not suffer from the beaurocratic restrictions and costs of commercially available spatial data sources. The second major limitation of this study (that is shared by all meta-analysis value transfers) is that the value functions used are only as good as the original studies they are based on, the absence of information on both the availability of substitutes and characteristics of both the green spaces and cities they were based has no doubt hampered the accuracy of this value transfer.

Chapter four hypothesised that the local disamenity observed for a proposed park in the centre of Norwich was a result of fear of crime and anti-social behaviour. One limitation and indeed avenue for future research for this study is to try and establish whether this was the case and to begin to delineate what park and neighbourhood attributes contribute to such local disammenities so that potential disammenities can be identified and avoided.

Chapter five was limited by a restrictive sample size mostly because of the large amounts of pressure that had to be put on this data set. Although initially a fairly respectful sample was collected, teasing apart the relationship between activities and place in the light of poor quality GPS data resulted in a seriously depleted sample size. There are several solutions to this which could form useful avenues of future research. The first is to dramatically increase the total sample size so that variations in environmental exposures can be observed for a range of different activity types. The second is to focus in on certain activities and only collect

GPS and experienced well-being data for these select activities. A good example would be to use transport activities, however focusing on single activities would reduce the effectiveness of the DRM to work as an aid to emotional recall as it would no longer be necessary to recall the whole day's movements and activities. Another area in which this work could be extended is in the analysis of personal visual exposure, while this study is unique in its use of personal isovist fields to measure visual exposure this can be taken further through the construction of 3D isovist fields. Constructing 3D isovists would allow for the volume of space that an individual sees to be estimated together with together more advanced spatial syntax measures (see Morello & Ratti, 2009 for an example of this) to further our understanding of how the environment influences our mood. Such an analysis would allow us to look beyond simple measures of land use to examine the spatial syntax (the arrangement of space) of urban environments. Indeed future work in this area would be wise to follow the lead of Mackerron (2012) in the use of smart phones for the tracking of individuals as these devices are increasingly becoming more advanced and capable than the GPS trackers used here.

6.6. Final Conclusions

Whilst there is considerable debate surrounding how values should be measured both economic and psychological perspectives of value offer useful insights particular for entities that provide such a wide range of different values such as urban green spaces. However to date both perspectives have been deficient in their incorporation of spatial dynamics. This is unfortunate as urban green spaces are inherently spatial resources and thus their received benefits are dependent on their location and configuration relative to that of the population.

The principal novel empirical contribution of this thesis is to demonstrate that the complexities that characterise spatial environmental resources can be encapsulated within both economic and psychological assessments of the benefits that these resources provide. While economic assessment provides values which are highly compatible with economic decision making processes, a well-being approach requires many everyday influences of well-being to be controlled for. While this represents an analytical challenge it facilitates insight into the influences of everyday well-being and allows specific benefits such as those from visual exposure to natural features to be framed within the broader context of the determinants of an individual's everyday well-being. Such an approach can be seen as more useful within a more holistic framework of policy and decision making in which the progress is defined as improving the well-being of society rather than increasing GDP.

In contrasting these two perspectives it is useful to draw on the model of the two selves proposed by Kahneman & Riis (2005) in which two modes of cognition are identified that of the experiencing self and the reflective self (otherwise known as system I and system II). While the use of choice based utility methods from economics can be thought of as accessing the reflective-self experienced utility methods such as the DRM are specifically designed to access the experiencing self. As the experiencing and reflective selves may not always be in correspondence (Fredrikson & Kahneman, 1993; Schreiber & Kahneman, 2000) it is essential for decision makers to be aware of how policy decisions regarding potential influences on well-being such as the availability of urban green spaces influence both selves. As such identifying areas of overlap and interaction between these measures should be a priority.

In addressing the two research questions outlined in Chapter 1 this thesis provides several important theoretical insights into measuring well-being benefits of the environment using the two perspectives outlined in this thesis. Firstly the measurement of well-being benefits ex post (i.e. experienced well-being) may avoid the problems associated with hedonic forecasting (Frederick & Loeweinstein, 1999; Schkade & Kahneman, 1998) faced by decision based methods however it fails to capture the benefits individuals derive from making choices, caring for the benefits others may receive (as was shown in Chapter 4) and from being identified as a citizen who believes in and values public provisioning for the public good. Curiously while decision based (ex-ante) measures such as CVM are capable of capturing this type of non-use and option values are typically rejected by economists as they do not representing economic preferences and thus are not complying with a theory of rational choice. It seems that the problems of utilitarian economics were more complex than originally conceived of by early theorists such as Jeremy Bentham. As Even with a perfect measurement device or 'hedonimeter' (of which the DRM is not) some of these benefits could be missed. In a thought experiment put forward by philosopher Robert Nozick in 1974, participants are asked to choose between real life and being hooked up to an imaginary machine that could give any pleasurable experience that one could wish for (and that these experiences would be indistinguishable from reality). In this thought experiment Nozick argues that if experiencing as much pleasure as possible is the only goal in life then it would be logical to plug in. Of course most people value more than just pure experience and wish to choose to do certain things rather than just have the experience of these things. This importance of self-determination and the benefits of one's identify that stem from flexing agency is a central part of modern conceptions of eudaimonic well-being such as Ryffs psychological well-being measures (Ryff & Singer, 2008). It is likely that to fully capture all of the well-being benefits that urban green spaces provide a hybrid approach is required that includes ex-ante (choice), ex-post (experience) and (what I will term) self-determination aspects.

The second theoretical insight that emerges from the methodological challenge of disaggregating the influence of activities and the environment is the relevance and potential value of employing ecological approaches to perception from environmental psychology. Both decision based and hedonic conceptions of utility presume that value exists purely as a mental construct in a similar fashion to expectancy theory (Driver & Tocher, 1970). Here the decision to visit a green space is presumed to be undertaken by individuals in order to realise a desired goal or outcome that has internal value (i.e. utility maximisation), in this way activities are presumed to be a means to an end rather than an end in themselves. Within this view an individual expresses the internal value they hold for an environmental resource (a good) through making choices according to their preferences. This separation of agency and structure (mind and matter) leads to methodological problems when seeking to quantify the benefits of urban green space as it can result in confounding of activities and environments, that is that the influence of activities and the environments they are performed in often merge together (Driver et al., 1987). This orthogonality of environments and activities was clearly an issue in Chapter 5 and is identified as one of the short comings of this research. An alternative is to conceive of urban green space benefits in a more holistic sense by employing ecological perception theory (Gibson, 1950). Here information is conceived as being ecological in the sense that it is external to the individual so that value does not reside in either the physical or phenomenological world instead value is represented by the concept of affordances (Gibson, 1979). By engaging in perceptual activities the individual discovers or detects affordances in the environment in this sense affordances of the human environment are akin to the concept of niches in ecology. Both decision and hedonic based models of utility result in a provisioning type approach to policy advice, either through the provisioning of options in the former or the provisioning of experiences in the latter. The problem with such an approach is that it is fundamentally reactive, that is, only when a problem with provisioning, such as a gap in provision of some resource is identified is action taking. This results in missed opportunities to increase the benefits that individuals derive from environmental resources such as urban green spaces as the focus is on the supply of experiences or options at the cost of recognising the importance of individual's personalities, perceptions and practices. The application of affordance theory to environmental valuation could be operationalised in terms of both decision and hedonic utility models. For example WTP for recreational affordances could be elicited in which the specific recreational affordances perceived by an individual are valued.

The use of an ecological model in this context would require significant investigation and modification of existing theories and applications, however it is the opinion of the author that such a model would fit well with day reconstruction methods and perceptual measures such as isovists.

7. Appendixes:

Appendix 3.1: Published Version of the study reported in Chapter 3

Environ Resource Econ (2014) 57:251–272
DOI 10.1007/s10640-013-9665-8

The Value of Urban Green Space in Britain: A Methodological Framework for Spatially Referenced Benefit Transfer

Grischa Perino · Barnaby Andrews · Andreas Kontoleon · Ian Bateman

Accepted: 1 April 2013 / Published online: 27 September 2013

Abstract A meta-analysis of studies valuing urban greenspace in the UK is undertaken to yield spatially sensitive marginal value functions. A geographical information system (GIS) is used to apply these functions to spatial data detailing the location of such greenspace resources in five British cities. Changes in monetary values are computed for the six future scenarios used in the UK National Ecosystem Assessment for the period 2010–2060. Different degrees of substitutability between urban greenspaces are considered. These findings are then extrapolated to all major British cities to obtain per household and aggregate valuation estimates for each scenario both with and without distributional weights. While subject to a number of shortcomings in both data availability and methodology, this represents the first systematic and comprehensive attempt to value marginal changes in urban greenspace while accounting for spatial heterogeneity.

Keywords UK National Ecosystem Assessment · Urban greenspace · Spatially referenced benefit transfer

JEL classification Q51 · Q57 · R0

1 Introduction

Urban greenspaces, from small community gardens to major parks like Hyde Park in London, not only shape the 'face' of cities but are an important aspect of quality of life to local residents.

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Appendix 3.2: Data used for Spatial Analysis

Data Used	**Data source and Declarations**
OS Meridian DLUA	http://edina.ac.uk/digimap/ © Crown Copyright/database right 2010. An Ordnance Survey/EDINA supplied service
OS Master-map Topographic Area and ITN Layer.	http://edina.ac.uk/digimap/ © Crown Copyright/database right 2010. An Ordnance Survey/EDINA supplied service
2001 Census England Districts	http://edina.ac.uk/ukborders/ "This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown."
2001 Scottish Council Areas	http://edina.ac.uk/ukborders/ "This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown and the Post Office."
OS Code-Point Polygons (Postcode Polygons)	http://edina.ac.uk/digimap/ © Crown Copyright/database right 2010. An Ordnance Survey/EDINA supplied service
Experian Mosaic Public Sector	http://cdu.mimas.ac.uk/experian/index.htm
National Statistics Postcode Directory (NSPD) 2010 February Version	http://geoconvert.mimas.ac.uk/
Forestry Commission Woods For People	We have a special license with the Forestry Commission for this one. © Crown copyright and database right 2010. All rights reserved. Ordnance Survey licence no 100025498.
Councils Green Space Audit Data (Various)	Supplied by the respective city councils.
CROW Act 2000 - Access Layer Crow Act 2000 - S15 Layer CROW Act 2000 – S16 Layer	http://www.gis.naturalengland.org.uk/pubs/gis/gis_register.asp © Crown Copyright and database right 2010. Ordnance Survey licence number 100022021 Terms of Use: http://www.naturalengland.org.uk/Images/DataTerms_t

	cm6-7878.pdf
OS 1:50,000 Scale Colour Raster (used for background maps)	http://edina.ac.uk/digimap/ © Crown Copyright/database right 2010. An Ordnance Survey/EDINA supplied service

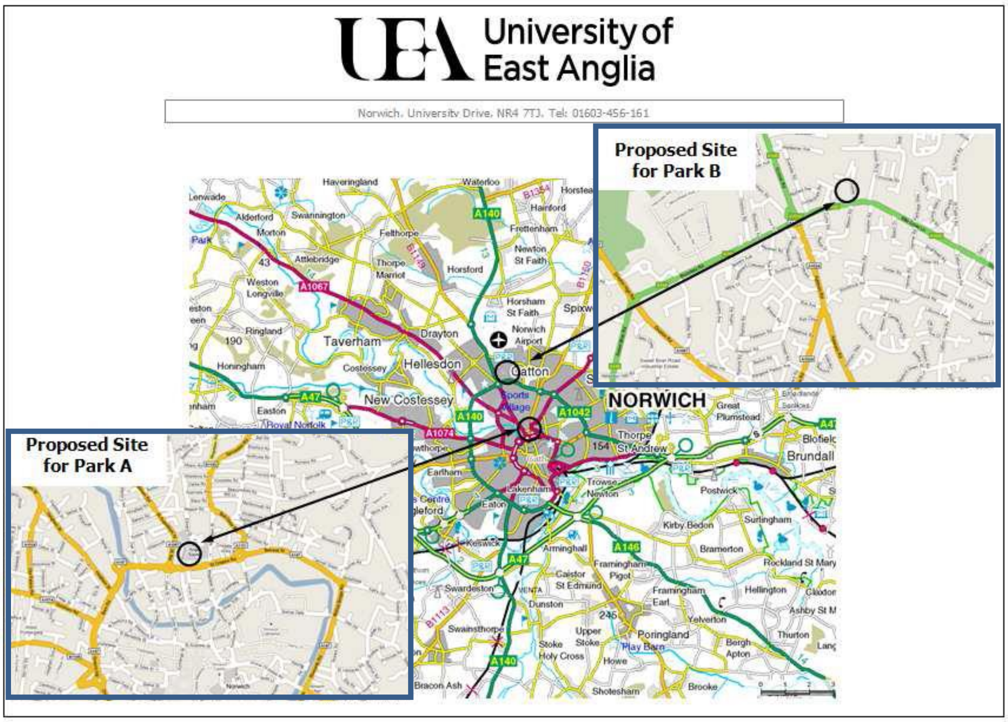
Appendix 4.1: CV Interview Wording and Flashcards

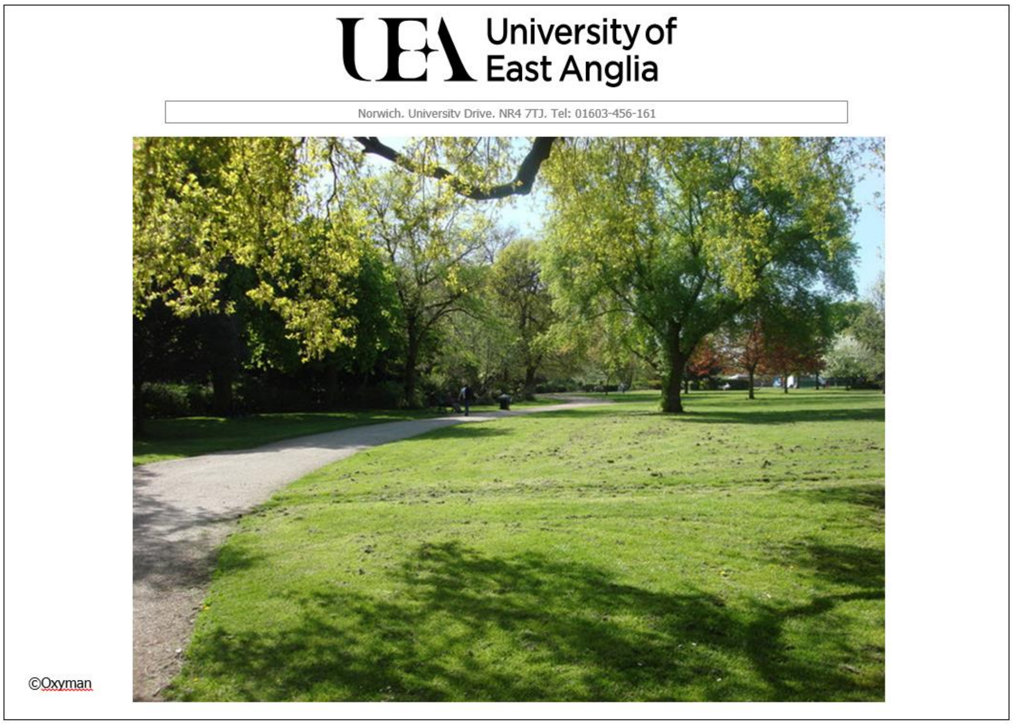
The CV survey was conducted by way of an unsolicited face to face interview at resident's homes. Flashcards were used to show participants the locations and likely appearance of the new parks. Participants were informed that "Both park A and B will be a similar size and provide similar facilities with opportunities for casual recreation (walking, picnicking, ball games and children's play park) as well as natural areas designed to encourage and support a wide range of wildlife". Participants were then asked which of the parks they would choose if only one could be created. Participants were asked to explain their choice in an open ended format question and to categorise their potential usage of the park into one of four categories. Participants were then asked about the frequency, type of park and recreational trips they had taken over the past year.

Interviewers explained to participants that "creating new parks is expensive due to land costs, landscaping and maintenance all of which have to be paid for from council tax. I want to know how much, if anything, your household would be willing to pay for the creation of just Park A." Participants were also reminded that "any extra amount would have to be paid every year and that any amount you agree to pay cannot be spent on anything else so it might not be worth anything to you". To avoid the problems associated with open ended WTP methods participants were presented with a payment ladder flashcard. The payment ladder had a range of payment amounts and participants were asked to start from the top of the card and consider every value and were instructed "tell me the maximum amount if anything your household DEFINITELY would be prepared to pay for the creation of park A/B/both".

Socio-demographic characteristics were also collected and included age, gender, the number of people in the household, the number of people under 18 in the household, total household income and the number of cars available for use by the household. In order to encourage the elicitation of income data the income question used a flashcard presenting 13 different income categories in both per week and per month amounts and was saved till the end of the survey.

Flashcards used to show participants the location of proposed parks (top), the likely appearance of the proposed parks (middle) and the WTP payment ladder (bottom).





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	PER YEAR	PER MONTH
A	Up to £6,000 per year	Up to £500 per month
B	£6,001 to £12,000 per year	£501 to £1,000 per month
C	£12,001 to £18,000 per year	£1,001 to £1,500 per month
D	£18,001 to £24,000 per year	£1,501 to £2,000 per month
E	£24,001 to £30,000 per year	£2,001 to £2,500 per month
F	£30,001 to £36,000 per year	£2,501 to £3,000 per month
G	£36,001 to £42,000 per year	£3,001 to £3,500 per month
H	£42,001 to £48,000 per year	£3,501 to £4,000 per month
I	£48,001 to £54,000 per year	£4,001 to £4,500 per month
J	£54,001 to £60,000 per year	£4,501 to £5,000 per month
K	£60,001 to £66,000 per year	£5,001 to £5,500 per month
L	£66,001 to £72,000 per year	£5,501 to £6,000 per month
M	Over £72,000 per year	Over £6,000 per month

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Increase in Annual Council Tax for Creation of Park A

£0	**£150**
£3	**£160**
£5	**£170**
£10	**£180**
£15	**£190**
£20	**£200**
£25	**£225**
£30	**£250**
£35	**£275**
£40	**£300**
£45	**£325**
£50	**£350**
£55	**£400**
£60	**£450**
£65	**£500**
£70	**£550**
£75	**£600**
£80	**£650**
£85	**£700**
£90	**£750**
£95	**£800**
£100	**£850**
£105	**£900**
£110	**£950**
£115	**£1000**
£120	**£1050**
£125	**£1100**
£130	**£1150**
£135	**£1200**
£140	**£>1200 £..........**
£145	**Other: £............**

Appendix 4.2: Sample Descriptives

Variable Name	N	Min	Q1	Median	Q3	Max	Sample Mean (SD)	Study Area Mean (SD)
Gender (1 = female)	270	0	N/A	1	N/A	1	.54 (CI 95% = 48% - 60%)	.50 (CI 95% = 50.3 – 50.7)
Income (Mid-point of household income category)	270	£3,000	£15,000	£27,000	45,000	£75,000	£28,867 (£19,997) CI = £26,471 – £31,263	£27,251 (£4918)
Age	270	16	29	44	59	93	45 (17.5) years CI = 43 -48	44.9 (CI = 45.8 – 49.4)
No. of Dependents (under 18s)	270	0	0	0	1	5	.69 (1.1) CI = .55 - .82	0.2 (CI = 0.5 - 0.7)
GAC total (Mean of all 9 GAC scale items)	270	2.4	3.6	4	4.3	5	3.97 (.56) CI = 3.9 – 4.04	N/A
GAC Altruistic (Mean of 3 Altruistic items)	270	1.7	3.7	4	4.3	5	3.95 (.65) CI = 3.88 – 4.03	N/A
GAC Biospheric (Mean of 3 Biospheric items)	270	1.7	3	3.67	4.3	5	3.70 (.80) CI = 3.60 – 3.79	N/A
GAC Egoistic (Mean of 3 Egoistic items)	270	2	4	4	5	5	4.25 (.61) CI = 4.18 – 4.33	NA
Distance to nearest park (meters)	270	62	662	1025	1191	2443	981 (514) CI = 920 - 1043	N/A
Distance to Park A (meters)	270	1035	2109	2699	3247	5120	2792 (1038) CI = 2668 - 2917	2273 (1108)
Distance to Park B (meters)	270	388	1866	3014	4390	5743	3068 (1438) CI = 2896 - 3240	3181 (1299)
Use Park A[26]	269	1	2	3	3	4	2.68 (.92) CI = 2.57 – 2.79	N/A
Use Park B3	267	1	2	2	3	4	2.37 (.91) CI = 2.26 – 2.48	N/A

Comparison of our sample with the study area reveals that there are no significant differences between the underlying distributions of the age in our sample and those calculated from the 2001

[26] Categorical variable representing participants expected usage of the proposed park: 1 = Definitely use 2 = Probably use 3 = Probably not use 4 = Definitely not use

census[27] for every postcode in the study area (z = -0.399, p = 0.69). Income values for the study area postcodes were extracted from the Experian mosaic data set. Comparing these with those of our sample with a two sample Wilcoxon rank sum (Mann-Whitney) test shows that the distribution of incomes is different (p 0.0005) having a higher rank in the study area.

The spatial representativeness of our sample relative to the two park locations can be seen by comparing the average distance of all postcodes in the study area to that of our sample. While distance to park B has a similar average value for all postcodes in the study area, for our sample distance to park A is significantly higher for the sample compared to the study area. An independent sample t-test on the distance to park A shows a significant difference between distance to A of our participants and distance to A in the study area (p = 0.0000).

[27] Mean ages were calculated from mid points of census frequency data for all over 18s.

Appendix 4.3: GAC Scale Percentage Responses and Factor Analysis

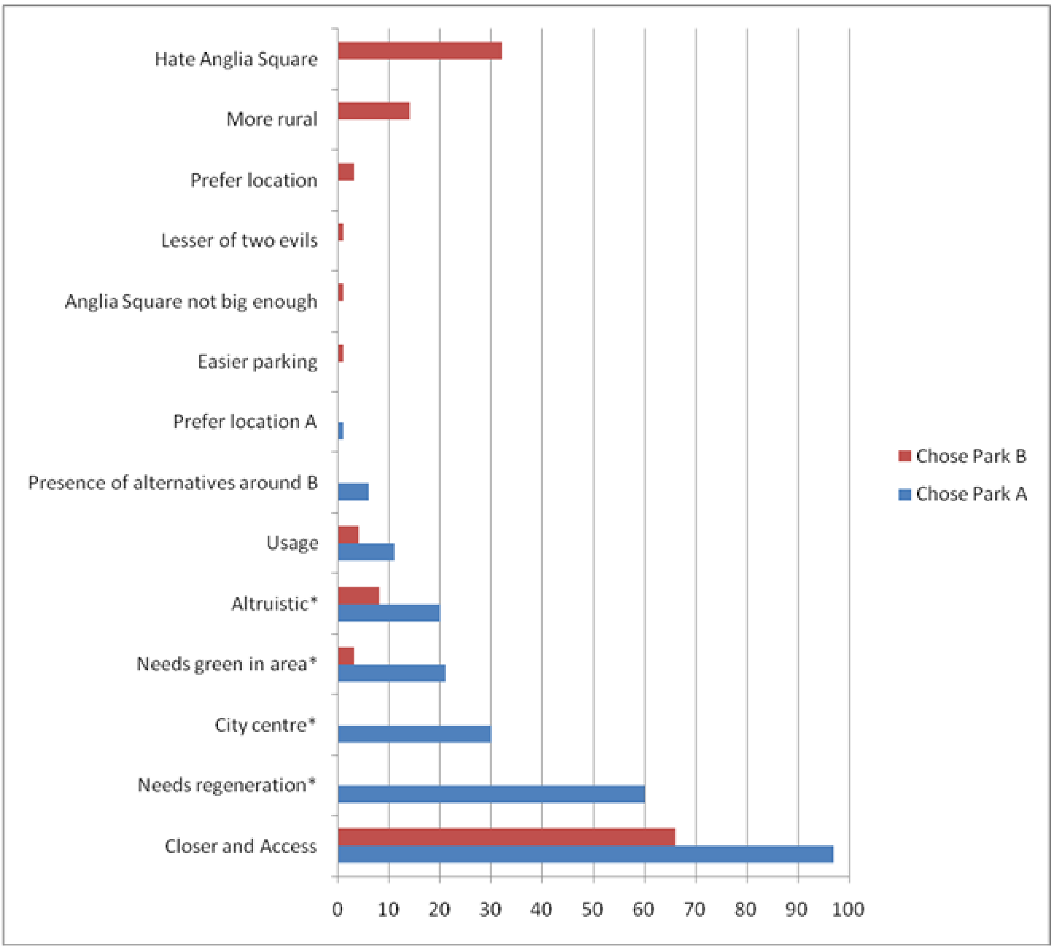
The 9 item GAC scale measures individuals' environmental concern by asking participants how much they agree with statements regarding environmental degradation and protection. The table below shows the GAC items and the percentage of responses for each item.

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
GAC Item	GAC Scale	5	4	3	2	1
Altruistic (GAC 1)	Environmental protection benefits everyone.	43	48	5	2	2
Biospheric (GAC 2)	Over the next decade thousands of species of plants and animals will become extinct	29	42	21	7	2
Biospheric (GAC 3)	Claims that we are changing the climate are greatly exaggerated*	5	22	19	31	22
Biospheric (GAC 4)	While some local plants and animals may have been harmed by environmental degradation, over the whole Earth there has been little effect*	5	15	16	40	25
Altruistic (GAC 5)	Environmental threats to public health have been exaggerated*	3	20	25	36	16
Egoistic (GAC 6)	Environmental protection is beneficial to my health	32	57	8	2	1
Egoistic (GAC 7)	Environmental protection will provide a better world for me and my children	38	51	8	2	1
Egoistic (GAC 8)	Environmental protection will help me to have a better quality of life	36	52	9	4	1
Altruistic (GAC 9)	Environmental damage here harms people all over the world	33	43	16	7	1

* Reverse scored

Factor analysis of the GAC scale items produce two factors with eigenvalues over one, cumulatively they explain 59% of the variation in GAC responses. The rotated factor loadings show that factor one is dominated by the egoistic items 6 7 and 8. Factor 2 is dominated by the biospheric items 3 and 4. The lack of clear dimensionality in terms of the three value orientations confirms the results of (Ryan & Spash, 2008) who found that the GAC scale cannot be relied on to describe the three value orientations. As a result all subsequent analysis will use the mean of all GAC item scores.

Appendix 4.4: Percentages of Park Choice Reasons



The differences in motives for park choice shows that for the CC park non-use based motives are more divisive. While non-used based preferences are still present in those who choose SB (i.e. they dislike the other location) a greater proportion those preferring SB referenced use based motives.

Appendix 4.5: Tobit Models of WTP

	WTP Park A* N = 270 (79 left censored)			WTP Park B+ N = 268 (88 left censored)		
	Linear	Log	Quadratic[28]	Linear	Log	Quadratic
Distance (Linear)	-.0039749 (.0026743)		-.0009867 (.0028632)	-.0051329*** (.0018093)		-.0051366*** (.0017812)
Ln Distance		-6.810845 (7.16576)			-14.51143 (4.419909)***	
Distance²			-6.24e-06 (2.30e-06)***			2.96e-06** (1.39e-06)
GAC	13.02284*** (4.875385)	13.60391*** (4.859375)	11.42336 (4.82753)**	3.22158 (4.495875)	3.1583 (4.456687)	2.706739 (4.45137)
Income	.0002567* (.000132)	.0002533* (.0001324)	.0002114 (.000131)	.0003131** (.000128)	.0003114 (.0001261)**	.0002986** (.0001267)
No. of Dependents in Household	-5.497549** (2.46747)	-5.554504** (2.470393)	-5.66972** (2.429829)	-4.510092* (2.311832)	-4.591721 (2.289304)**	-4.533405* (2.284023)
Constant	-29.97609 (22.0898)	10.35501 (61.54)	-26.68489 (20.15296)	7.106661 (18.26694)	106.2465 (36.94295)***	-12.12288 (18.24875)
R^2	0.0084	0.0078	0.0119	0.0064	0.0077	0.0087

Significance Levels: * = $p < 0.1$, ** = $p < 0.05$, *** = $p < 0.01$

[28] Without mean centering the park A linear distance coefficient = 0.339** and the squared coefficient = -0.000006*** for park B the linear distance coefficient = -0.232*** and the squared coefficient = 0.000002**.

Appendix 4.6: Interaction Models

Predictors	Tobit		GAM	
	CC Park	SB Park	CC Park	SB Park
*D_GAC = 1	54.874 (112.309)	31.173 (67.462)	0.064 (0.117)	2.785 (0.153)
**Ln_Distance	-5.435 (9.717)	-12.103 (6.438)*	Smoothed Distance: Edf = 4.418 Ref.df = 5.449 P = 0.069*	Smoothed Distance: Edf = 1.00 Ref.df = 1.001 P = 0.067
D_GAC* Log_distance	-5.607 (14.285)	-3.885 (8.544)	Smoothed Distance * D_GAC: Edf = 1.860 Ref.df = 2.327 P = 0.092*	Smoothed Distance * D_GAC: Edf = 1.965 Ref.df = 2.045 P = 0.118*
Income	0.0003 (0.0001)**	.0003 (0.0001)**	0.000007 (0.000004)*	0.00001 (0.000004)**
No. of Dependents	-5.292 (2.484)**	-4.401 (2.286)**	-0.191 (0.079)**	-0.207 (0.084
Constant	41.307 (2.237)	99.686 (49.947)**	2.934 (0.145)***	2.785 (0.153)
Psudo R^2	.006	0.008	0.0698 (12.7% deviance explained)	0.067 8.57% deviance explained)
N	270 (79 left censored)	268 (88 left censored)	270	268
Model p	0.027 (Chi^2)	0.011		

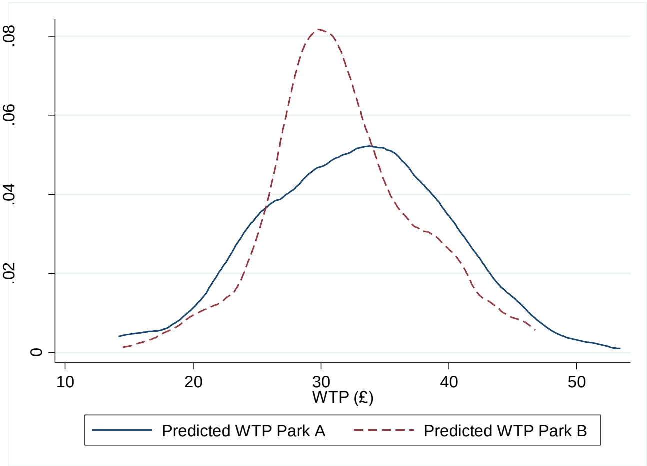
*equals one if GAC if above average. ** Linear distance is used for the GAM models

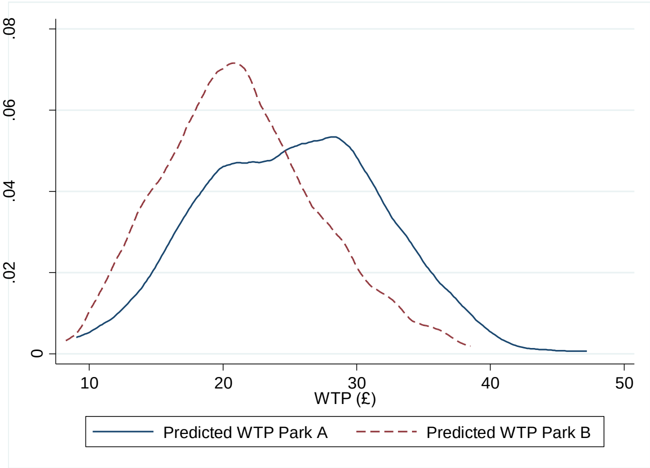
Appendix 4.7: Predicted WTP Descriptives

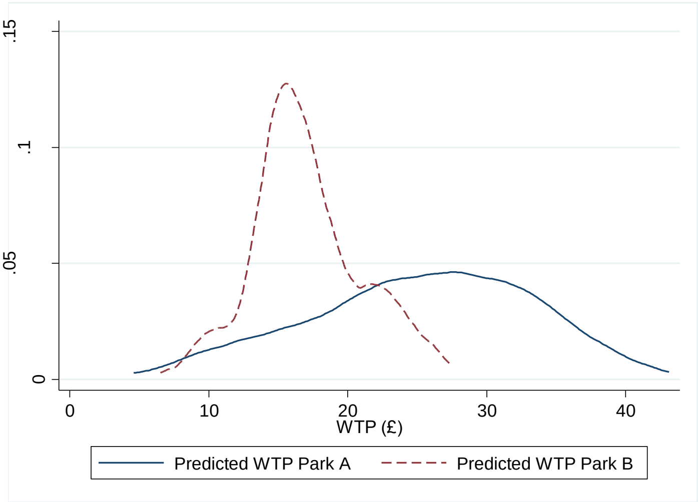
As can be seen from below there is a consistent difference in the predicted WTP values between the two parks. Median WTP for park A is consistently higher than park B and has a broader distribution of WTP values.

	Park A						Park B					
	Min	Q1	Median	Mean (SD)	Q3	Max	Min	Q1	Median	Mean (SD)	Q3	Max
Linear	14.2	27.4	32.7	35.6 (7.2)	37.6	53.4	14.5	28.2	31.0	31.7 (5.8)	35.2	46.8
Log	9.0	20.1	30.0	25.2 (6.7)	30.0	47.2	9.4	16.6	20.1	21.2 (6.4)	24.4	51.8
Quad-ratic	4.6	19.7	25.5	25.2 (8.0)	31.4	43.1	6.5	14.6	16.3	17.0 (3.9)	19.1	27.3
GAM (N = 302)	6.93	17.76	22.53	22.83	27.61	43.45	7.51	14.17	17.08	18.56	21.37	47.18

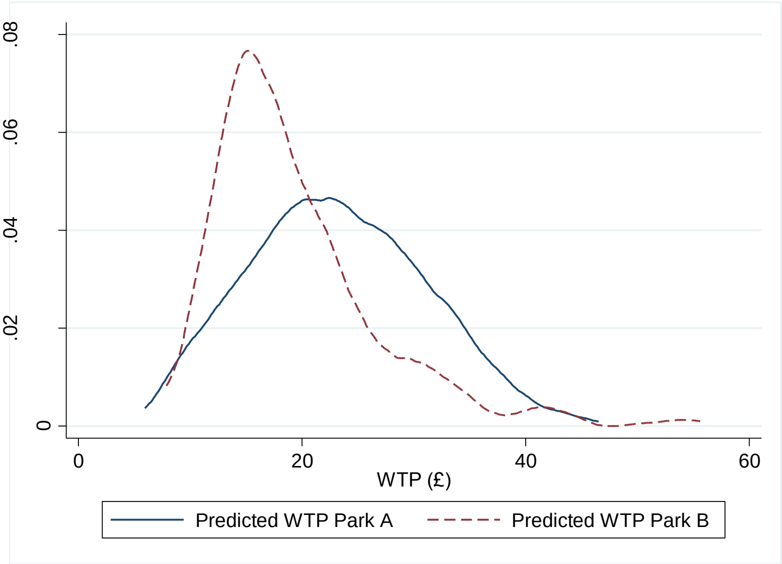
Tobit predicted WTP distributions for parks A and B (top left = linear distance, top right = log distance, bottom = quadratic distance).







GAM predicted WTP values



Appendix 4.8: Spatial Data Used for Aggregation

Spatially referenced out of sample data for the variables used in the Tobit and GAM models above were collated from a range of sources. While it was possible to calculate distance to each of the parks using postcode centroids and the OS ITN, Median household incomes had to be obtained from the Experian Mosaic data sets at the much larger LSOA level. To parameterise the number of dependents in the household for out of sample households, population data from the 2001 census was used to calculate the average number of dependents per household at the census output area scale. Thus, there is significantly less spatial variation in these two measures than in the distance measures. Finally, as no GAC score data was available for out of sample households the mean GAC score was used. These variables were collected for all the postcodes in both the study area (2,743 postcodes) and a 5000 metre road based service area of each respective park centroid (4,192 postcodes for park A and 3,354 postcodes for park B).

Appendix 5.1: Gauss Kernal Smoothing Algorithm (Matlab Script)

The Matlab script below implements a Gauss Kernal smoothing function on GPS coordinate data stored in .csv file format. This has the effect of removing systematic errors from GPS coordinates.

```
FileList = dir('*.csv');
N = size(FileList,1);
for k = 1:N
   % get the file name:
   filename = FileList(k).name
   disp(filename);
    p= csvread(filename)
   % insert your script code here:
end
timesize2=size(time)
timesize=timesize2(1)
sigma=0.000115741
%%%%%calculate bottom vector for each entry (q) subject to other
entries
%%%%%(n)
for q=1:timesize
q
% for each entry =q
for n=1:timesize
bottomlinevec(n)    =  ( exp( - ( ((  time(q) - time(n)
)^2)/(2*(sigma)^2) )    )      ) ;
end
bottomlinesum=sum(bottomlinevec);
bottom(q)=bottomlinesum;
end
%%%%% now do the top
for q=1:timesize
q
% for each entry =q
for n=1:timesize
toplinevec(n)    =  ( exp( - ( ((  time(q) - time(n) )^2)/(2*(sigma)^2)
)    )*lat(n)      ) ;
end
toplinesum=sum(toplinevec);
top(q)=toplinesum;
end
%%%%% now produce top/bottom in vector
for r=1:timesize
    smoothvec(r) = top(r)./bottom(r);
end
```

Appendix 5.2: GIS VBA Script to Create 2-D Isovist Fields

```
Private Sub NewButton_Click()

 Dim pMxDoc As IMxDocument
   Set pMxDoc = ThisDocument
   Dim ObserverX As Double
   Dim ObserverY As Double
   Dim TargetX As Double
   Dim TargetY As Double
   Dim pLayer As ILayer
   Set pLayer = pMxDoc.SelectedLayer
   Dim ObsPoint As IPoint
   Dim TarPoint As IPoint
   Dim ObstrucPoint As IPoint
   Set ObsPoint = New Point
   Set TarPoint = New Point
   Dim visiblePolyLine As IPolyline
   Dim invisiblePolyLine As IPolyline
   Dim isVisible As Boolean
   isVisible = False
   Dim StoreX As Double
   Dim StoreY As Double
   Dim StorePoint As IPoint
   Set StorePoint = New Point
   Dim Sinus As Double
   Dim Cosinus As Double
   Dim m_radius As Double
   m_radius = 300
   Dim i As Integer    Dim pPointCollection As IPointCollection
   'create Rasterworkspace
   Dim sPath As String
   Dim sInName As String
   sPath = "c:\Data"
   sInName = "Buildings50.img"
   Dim pRWS As IRasterWorkspace
   Dim pWSF As IWorkspaceFactory
   Set pWSF = New RasterWorkspaceFactory
   Set pRWS = pWSF.OpenFromFile(sPath, 0)
   'open raster and get default raster
   Dim pRaster As IRaster
   Set pRaster = pRWS.OpenRasterDataset(sInName).CreateDefaultRaster
   'Raster to Surface
   Dim rsc As IRasterSurface
   Set rsc = New RasterSurface
   rsc.PutRaster pRaster, 0
   Dim pSurface As ISurface
   Set pSurface = rsc
   Dim pFSel As IFeatureSelection
   Set pFSel = pLayer
   Dim pFCurs As IFeatureCursor
   pFSel.SelectionSet.Search Nothing, False, pFCurs
```

```
    Dim pFeat As IFeature
    Set pFeat = pFCurs.NextFeature

    'create new Shapefile
    Const strFolder As String = "C:\Data"
    Const strName As String = "ObstrucPoints9" ' Edit as needed. Don't include .shp extension
    'Const strName1 As String = "ObstrucShapes"
    Const strShapeFieldName As String = "Shape"

    ' Open The folder to contain the shapefile as a workspace
    Dim pFWS As IFeatureWorkspace
    Dim pWorkspaceFactory As IWorkspaceFactory
    Set pWorkspaceFactory = New ShapefileWorkspaceFactory
    Set pFWS = pWorkspaceFactory.OpenFromFile(strFolder, 0)

    ' Set up a simple fields collection
    Dim pFields As IFields
    Dim pFieldsedit As IFieldsEdit
    Set pFields = New Fields
    Set pFieldsedit = pFields
    Dim pField As IField
    Dim pFieldEdit As IFieldEdit

    ' Make the shape field
    ' it will need a geometry definition, with a spatial reference
    Set pField = New Field
    Set pFieldEdit = pField
    pFieldEdit.Name = strShapeFieldName
    pFieldEdit.Type = esriFieldTypeGeometry
    Dim pGeomDef As IGeometryDef
    Dim pGeomDefEdit As IGeometryDefEdit
    Set pGeomDef = New GeometryDef
    Set pGeomDefEdit = pGeomDef
    With pGeomDefEdit
      .GeometryType = esriGeometryPoint     'Creates point shapefile
      Set .SpatialReference = New UnknownCoordinateSystem
      'set spatial reference
      ''Set spatial reference for the new shapefile
  pSpatRefFact.CreateProjectedCoordinateSystem(esriSRProjCS_NAD1983N_AmericaLambert)
      '    Set .SpatialReference = pGeoCoordSys
    End With
    Set pFieldEdit.GeometryDef = pGeomDef
    pFieldsedit.AddField pField

    ' Add another field
    ' Add another miscellaneous text field
    Set pField = New Field
    Set pFieldEdit = pField
    With pFieldEdit
      .Type = esriFieldTypeDouble
      .Name = "ID"
```

```
      .Editable = True
    End With
    pFieldsedit.AddField pField

    ' Create the shapefile
    Dim pFeatClass As IFeatureClass
    Set pFeatClass = pFWS.CreateFeatureClass(strName, pFields, Nothing, Nothing, esriFTSimple,
strShapeFieldName, "")

    'Add the shapefile to the map at the end
    Dim pDoc As IMxDocument
    Dim pMap As IMap
    Dim pFLayer As IFeatureLayer
    Set pDoc = ThisDocument
    Set pMap = pDoc.FocusMap
    Set pFLayer = New FeatureLayer
    Set pFLayer.FeatureClass = pFeatClass
    pFLayer.Name = strName
    pFLayer.Visible = True
    pDoc.AddLayer pFLayer
    pMap.MoveLayer pFLayer, pDoc.FocusMap.LayerCount
    MsgBox "shapefile created"

  '  CreatePoints

    Do Until pFeat Is Nothing

      'Load Observer Values
      ObserverY = pFeat.Value(pFeat.Fields.FindField("POINT_Y"))
      ObserverX = pFeat.Value(pFeat.Fields.FindField("POINT_X"))

      'Calculate Target Values
      'XoffSet = Abs(ObserverX * (Cos(90)) - (ObserverY * (Sin(90))))
      'YoffSet = Abs(ObserverX * (Cos(90)) - (ObserverY * (Sin(90))))
      For i = 0 To 100
      Sinus = Sin((3.14159265358979 * 2) * (i / 100))
      Cosinus = Cos((3.14159265358979 * 2) * (i / 100))
      TargetX = ObserverX + m_radius * Cosinus
      TargetY = ObserverY + m_radius * Sinus
      ObsPoint.PutCoords ObserverX, ObserverY
      TarPoint.PutCoords TargetX, TargetY
      'y = y + 300
      'MsgBox "Value of myField is " & TargetX, vbOKOnly
      'MsgBox "Value of myField is " & TargetY, vbOKOnly
      'MsgBox "Value of myField is" & pFeat.Value(pFeat.Fields.FindField("POINT_X")),
vbOKOnly
      ObsPoint.Z = pSurface.GetElevation(ObsPoint) + 1 ' observer is 1m (MA start point offset)
above the ground.
      TarPoint.Z = pSurface.GetElevation(TarPoint) + 0 ' target is 0m (MA end point offset)
above the ground
```

```
        pSurface.GetLineOfSight ObsPoint, TarPoint, ObstrucPoint, visiblePolyLine,
invisiblePolyLine, isVisible, False, False
       ' MsgBox "Value of myField is" & ObstrucPoint.x, vbOKOnly
       ' MsgBox "Value of myField is" & ObstrucPoint.y, vbOKOnly

        'Add ObstrucPoint to shapefile
        If ObstrucPoint Is Nothing Then
        StoreX = TargetX
        StoreY = TargetY
        Else
        StoreX = ObstrucPoint.x
        StoreY = ObstrucPoint.y
        End If
        StorePoint.PutCoords StoreX, StoreY
        'StoreX = TargetX
        'StoreY = TargetY
        'Create a polygon geometry
        Dim pNewFeat As IFeature
        Set pNewFeat = pFeatClass.CreateFeature
        Set pNewFeat.Shape = StorePoint
        pNewFeat.Store
        Next i
        'close the polygone
        'Dim pPolygon As IPolygon
        'Set pPolygon = pPointCollection
        'pPolygon.Close

        'create a new feature in the layer data source
                Set pFeat = pFCurs.NextFeature
    Loop
End Sub
```

Appendix 5.3: Neuroticism and extraversion scale (taken from the Big Five Inventory, John & Srivastava, 1999).

Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who likes to spend time with others? Please write a number next to each statement to indicate the extent to which you agree or disagree with the corresponding statement e.g. if you believe you are a talkative person place the number 5 next to talkative to indicate that you strongly agree.

Disagree Strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
1	2	3	4	5

I see Myself as Someone Who….

__ 1. Is talkative	__ 9. Tends to be quiet
__ 2. Is depressed, blue	__ 10. Is emotionally stable, not easily upset
__ 3. Is reserved	__ 11. Has an assertive personality
__ 4. Is relaxed, handles stress well	__ 12. Can be moody
__ 5. Is full of energy	__ 13. Is sometimes shy, inhibited
__ 6. Can be tense	__ 14. Remains calm in tense situations
__ 7. Generates a lot of enthusiasm	__ 15. Is outgoing, sociable
__ 8. Worries a lot	__ 16. Gets nervous easily

Appendix 5.4: Empty Model of Net Affect for all Single Activity Episodes

Appendix 3: Variance Component Model (empty model) of net-affect for all single activity episodes, level 1 n = 1340, level 2 n = 195 individuals (1 to 19 observations per individuals mean = 6.9). Intraclass correlation = 0.28993, Log restricted-likelihood = -2823.45.

	Coef.	Std. Err.	P
Constant (grand mean)	1.900	0.100	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	1.335	0.192	
Episode level variance (level 1)	3.295	0.137	

Likelihood ratio test vs Linear Regression p = 0.000

The coefficient estimate for the constant in this model represents the grand mean (that is the average net-affect across episodes and individuals) while the p value indicates unsurprisingly that the grand mean is significantly different from zero.

Appendix 5.5: Empty Model of Positive Affect for all Single Activity Episodes

Appendix 4: Variance Component Model (empty model) of positive affect, level 1 n = 1321, level 2 n = 195 individuals (1 to 19 observations per individuals mean = 6.8). Intraclass correlation = 0.373, log restricted-likelihood = -2143.764.

	Coef.	Std. Err.	P
Constant (grand mean)	3.129	0.070	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	0.717	0.095	
Episode level variance (level 1)	1.203	0.050	

Likelihood ratio test vs Linear Regression p = 0.000

Appendix 5.6: Empty Model of Net Affect for Work Only Episodes

Appendix 5: Empty model of net affect for work only single activity episodes, level 1 n = 283 episodes, level 2 n = 115 individuals (1 to 7 episodes per individual mean = 2.5). Intraclass correlation = 0.441, log restricted-likelihood = -588.401.

	Coef.	Std. Err.	P
Constant (grand mean)	0.914	0.168	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	1.962	0.399	
Episode level variance (level 1)	2.490	0.257	

Likelihood ratio test vs Linear Regression p = 0.000

Appendix 5.7: Empty Model of Positive Affect for Work Only Episodes.

Appendix 6: Empty model of positive affect for work only single activity episodes, level 1 n = 284 episodes, level 2 n = 115 individuals (1 to 7 episodes per individual mean = 2.5). Intraclass correlation = 0.491, log restricted-likelihood = -439.958.

	Coef.	Std. Err.	P
Constant (grand mean)	2.686	0.103	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	0.788	0.158	
Episode level variance (level 1)	0.817	0.086	

Likelihood ratio test vs Linear Regression p = 0.000

Appendix 5.8: Empty Model of Net Affect for Work Only Episodes.

Appendix 7: Empty model of net affect for transport only single activity episodes, level 1 n = 366, level 2 n = 133 (1 to 8 episodes per participant mean = 2.8). Intraclass correlation = 0.511, log restricted-likelihood = -738.453.

	Coef.	Std. Err.	P
Constant (grand mean)	1.531	0.152	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	2.165	0.385	
Episode level variance (level 1)	2.075	0.191	

Likelihood ratio test vs Linear Regression p = 0.000

Appendix 5.9: Empty Model of Positive Affect for Work Only Episodes.

Appendix 8: Empty model of positive affect for transport only single activity episodes, level 1 n = 367, level 2 n = 133 (1 to 8 episodes per participant mean = 2.8). Intraclass correlation = 0.584, log restricted-likelihood = -567.780.

	Coef.	Std. Err.	P
Constant (grand mean)	2.861	0.102	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	1.050	0.169	
Episode level variance (level 1)	0.747	0.068	

Likelihood ratio test vs Linear Regression p = 0.000

Appendix 5.10: Empty Model of Net Affect for Transport Only Episodes With GPS Data.

Appendix 9: Empty model of net affect for transport only single activity episodes with GPS data, level 1 n = 202, level 2 n = 101 (1 to 7 episodes per participant mean = 2.0). Intraclass correlation = 0.553, log restricted-likelihood = -455.678.

	Coef.	Std. Err.	P
Constant (grand mean)	1.648	0.177	0.000
Random effects	Estimate	Std. Err.	
Individual level variance (level 2)	2.327	0.475	
Episode level variance (level 1)	1.878	0.243	

Likelihood ratio test vs Linear Regression p = 0.000

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